NIAGARA ROCKS, BUILDING STONE, HISTORY and WINE

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American Geophysical Union and Geological Association of Canada

Field Trip A3: Guidebook

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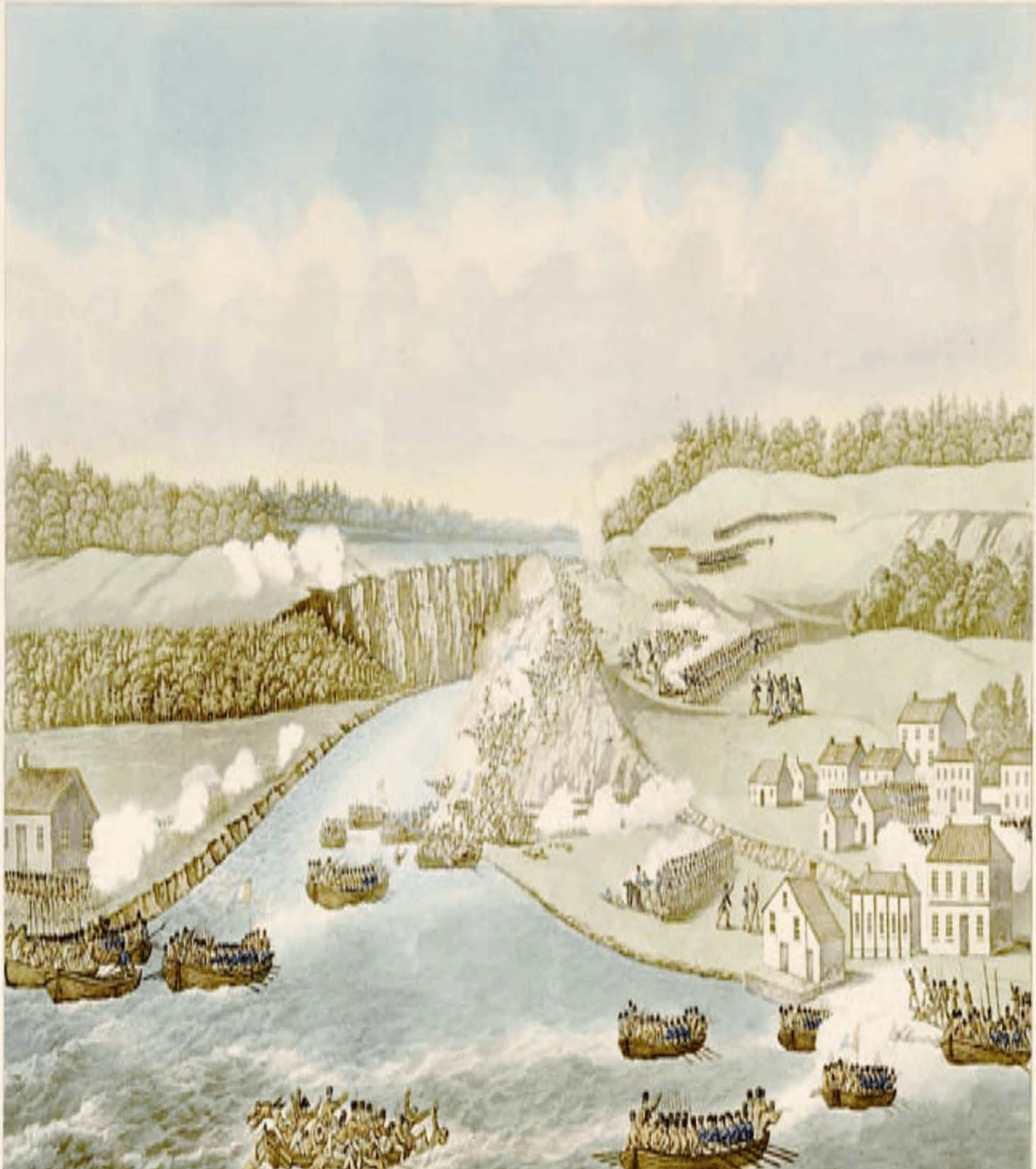


THE BATTLE OF QUEENSTON, OCT.[r] 13TH 1813, Cover: **The Battle of Queenston Heights, 13 October, 1812** (Library and Archives Canada, C-000276).

The cover engraving made in 1836, is based on a sketch by James Dennis (1796-1855) who was the senior British officer of the small force at Queenston when the Americans first landed.

The war of 1812 between Great Britain and the United States offers several examples of the effects of geology and landscape on military strategy in Southern Ontario. In short, Canada's survival hinged on keeping high ground in the face of invading American forces. The mouth of the Niagara Gorge was of strategic value during the war to both the British and Americans as it was the start of overland portages from the Niagara River southwards around Niagara Falls to Lake Erie. Whoever controlled this part of the Niagara River could dictate events along the entire Niagara Peninsula. With Britain distracted by the war against Napoleon in Europe, the Americans thought they could take Canada by a series of cross-border strikes aimed at Montreal, Kingston and the Niagara River.

At Queenston Heights, the Niagara Escarpment is about 100 m high and looks north over the flat floor of glacial Lake Iroquois. To the east it commands a fine view over the Niagara Gorge and river. Queenston is a small community perched just below the crest of the escarpment on a small bench created by the outcrop of the Whirlpool Sandstone. York Road (Highway 61) follows the bench. Fruit is grown here today as it was in the early nineteenth century, indeed the area is not too different from what it looked like in 1812 so it is possible to visualize the battlefield in a way not possible at Lundy's Lane in Niagara Falls where most of the moraine ridge on which the battle was fought which was quarried away for sand and gravel. Queenston was commercially significant because boats from Lake Ontario would land here to discharge their goods which were than taken on Portage Road south around Niagara Falls and thence to Lake Erie. The small community of Lewiston, on the American side played a similar strategic role with a regular ferry service between the two across the fast flowing Niagara River.

At 4 am on October 13th 1812, American troops under Major General Van Rensselaer were ferried over to the Canadian side. A British sentry noticed them and quietly raised the alarm. The Americans landed but a British artillery redan (crescent-shaped earthwork surrounding an18-pounder cannon) sited on the cliff top and commanding the gorge and river below created carnage among the landing troops. Some were ordered to "ascend the heights by the point of rock and storm the battery". They managed to climb up through trees in sufficient numbers and took the lightly-guarded redan. By this time, just as dawn was breaking, reinforcements under General Brock began arriving from Fort George at the mouth of the Niagara River downstream. Brock was a British hero, having just taken Detroit months earlier with no loss of life but in an impetuous and ultimately costly charge to retake the redan he was killed, as was his second in command Colonel Macdonell. The spot is today marked by a cannon, steps away from the Niagara Parkway as it descends the Escarpment above Queenston.

By early afternoon, Sir Roger Hale Sheaffe brought up reinforcements from Fort George moving out of sight and climbing the escarpment (at Sheaffe's Climb). A large 24 pounder cannon at Vrooman's point, a mile downstream, was firing at long range on the American boats. The threat of being attacked (and scalped) by Mohawk warriors unsettled the poorly trained US troops on the escarpment and at 4 pm Sheaffe attacked moving east ward toward the Niagara River through orchards and along what is now the Bruce Trail. The Americans panicked and surrendered at the lip of the gorge, some preferring to jump down the cliff to the river below where many drowned or were shot. About 500 Americans were killed or wounded and 900 taken prisoner. Sheaffe unfortunately failed to follow up by attacking Fort Niagara, the American redoubt downstream at the mouth of the river; the next year he was forced to surrender to a much larger American force that landed by boat at Fort York (Toronto). Despite this set back, the success at Queenston buoyed confidence in Upper Canada that American aggression could be overcome. The war ended in stalemate in 1814 paving the way for 200 years of peace. Macolmson (2003) gives a full account in his book *A Very Brilliant Affair*.

The current Brock Monument was erected in 1853. It has an interesting history: originally built in 1824 construction was interrupted to retrieve a copy of a newspaper by the radical Queenston journalist, William Lyon Mackenzie that had been buried in the cornerstone. Then the monument was badly damaged during the rebellion of 1838 by a bomb supposedly planted by one of Mackenzie's supporters. The present construction dates largely from 1853. Queenston dolomitic limestone seems to have been the main stone used. The monument was closed to the public during extensive repairs in 2008.

NIAGARA ROCKS, BUILDING STONE, HISTORY and WINE

INTRODUCTION

The Niagara Peninsula is a large place surrounded on three sides by water and with a long and complex history both geological and cultural. Niagara-on-the-Lake is some 80 km east of Hamilton, and 40 km north of Lake Erie. To cover this region in a one-day field trip, we will narrow our focus to only a few topics and places. We have chosen the Silurian bedrock formations of the Niagara escarpment, and their use as building stones in the nineteenth century; the history of settlement beginning with Empire Loyalists in the 1790s; interrupted briefly by the War of 1812 (see Appendix 3); and the development of selected towns either on Lake Ontario (Hamilton, Jordan, Beamsville), or along the Niagara River (Queenston, and Clinton, which was the original heart of what is now Niagara Falls, ON), and along the Welland Canals (St Catharines, Merritton, and Thorold). Dominating all these communities is the Niagara Escarpment, whose presence gave shelter first to rich fruit orchards on the slopes facing Lake Ontario, and, since 1970, the flourishing “terroirs” of modern wineries.

We will briefly discuss the Quaternary history of the Niagara River, a topic covered in two earlier field excursions led by Keith Tinkler (1993, 1998) and in the section on Glacial History provided below.

The principal late eighteenth to early nineteenth century settlements in Ontario took place on land suited to farming along the Niagara River. A small colony of settlers was also established on the north shore of Lake Erie near Long Point. The British military established Niagara-on-the-Lake (originally called Nassau, then Newark, site of the British Fort George and Fort Mississauga) in 1779 to support Loyalists fleeing the American War of Independence. Toronto was later founded in 1793 as a military garrison (Fort York).

The region south along the Niagara River to Niagara Falls (originally known as Township Two, or Stamford, including the villages of Drummondville and Clifton), was soon settled, and then opened to the tourist traffic. The first hotels on the Canadian side (the Pavilion, 1822; Ontario House, Clifton House) were built in the 1820s and 1830s – but of wood not stone. Charles and Mary Lyell stayed at the Clifton House during Lyell’s second visit to Niagara Falls in 1841.

Niagara-on-the-Lake did not have easy access to stone but in Queenston the Whirlpool sandstone forms a separate small escarpment below the main Niagara escarpment, and was quarried before 1820 to provide stone for local houses. Queenston was also important as the beginning (or end) of the Niagara Portage road. Freight delivered to the dock there were moved by wagon to Chippewa, where they could be moved up the Niagara River to Lake Erie and beyond. Above the escarpment, the famous Queenston quarries were established at least as early as 1838, and provided an excellent building stone (Gasport Member of the Lockport Formation, a crinoidal dolomitic limestone: it, or a very similar stone was used in the Gibraltar Point lighthouse in Toronto in 1806, the

Buffalo Lighthouse in 1833 and the facade of the Commercial Bank in Toronto in 1843).

The following Figure shows the road network and early settlement names, at about 1820. Bear in mind that the roads at that time very of very poor quality, the best, and most important being the Portage Road from Queenston to Chippewa. This provided the main link in Canada between Lakes Ontario and Erie, and was the main reason for the early prosperity of Queenston.

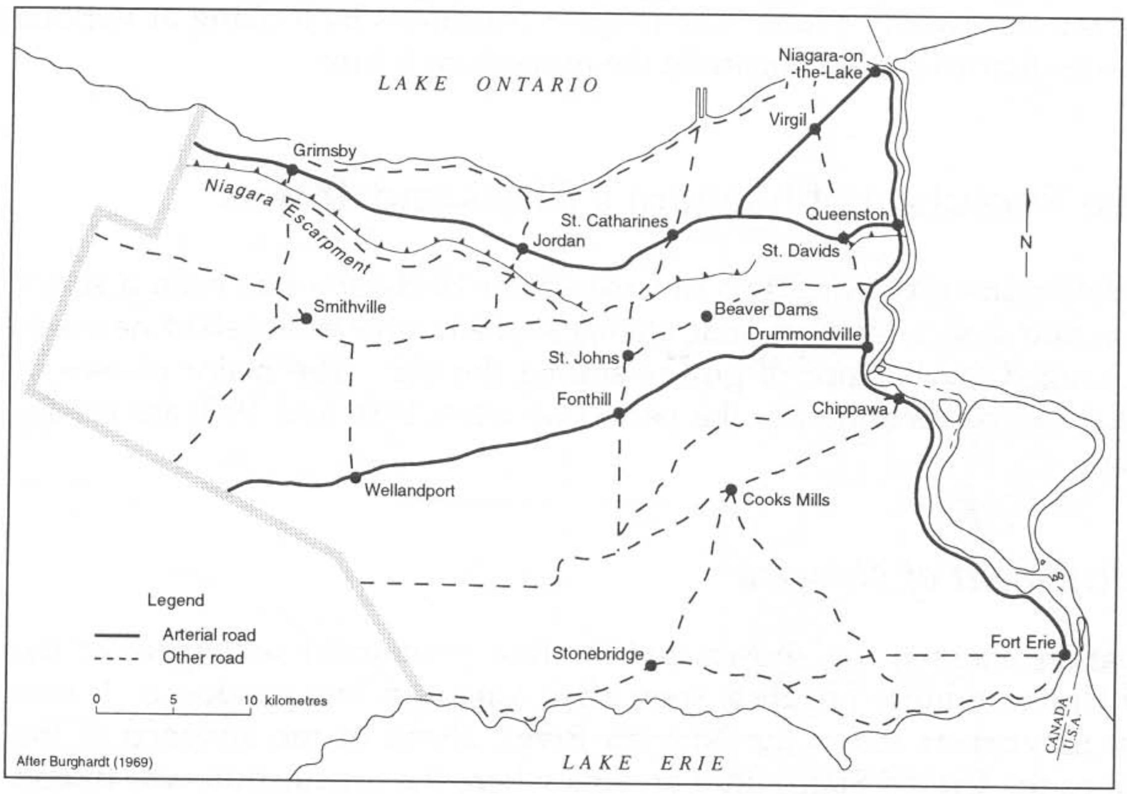


Figure 1 Early settlements and roads (from Gayler, 1994)

In the 1820s the first Welland canal was built, and by 1850 it had been replace by the second canal, built with stone locks. During the 1850s several railroads were also constructed. Despite efforts to keep the Queenston Chippewa corridor open to trade, it was largely replaced by the industrial development in communities along the Welland canal (St. Catharines, Merritton, Thorold, and Welland). Queenston declined as a centre for trade, but Clifton and Niagara Falls (Drummondville) prospered as a result of the tourist trade, brought by the railroads and (on the American side) by the Erie canal. Note the suspension bridge and rail link with the USA at Clifton, on the map below.

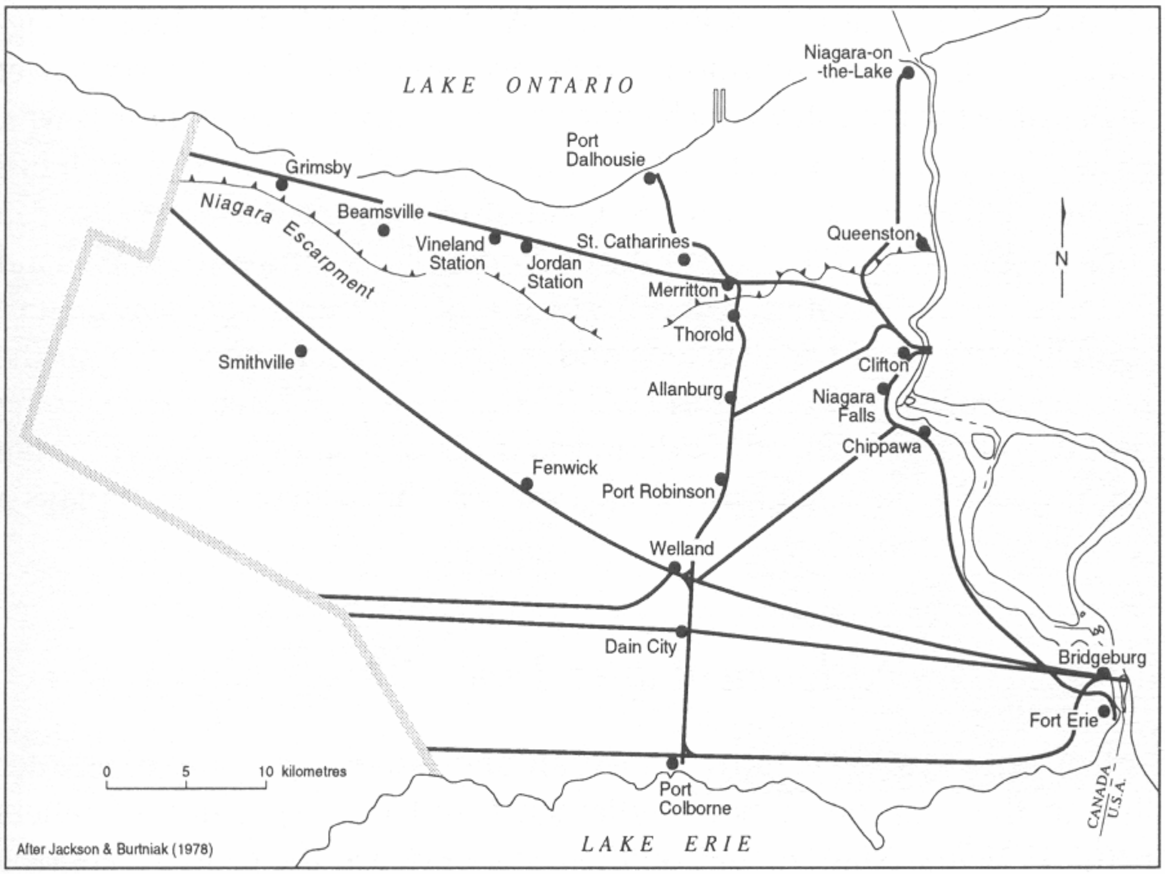


Figure 2 Early (post 1850) railways and settlements and the Welland canal (from Gayler, 1994). For a map of the four Welland canals see Figure 11.

Figure 3 is a part of a map in the 1876 Atlas by Page, H.R., (*Illustrated Historical Atlas of the Counties of Lincoln and Welland*). Note the names of the townships at that time. The towns of St. Catharines and Merritton were separate towns within Grantham Township. The town of Thorold was in the northeast corner of Thorold Township. Stamford township included the separate communities of Stamford, Clifton and Drummondville (just west of Niagara Falls but not named on the map). The only bridge across the Niagara was at Clifton, where it carried the Great Western railroad across to the USA. The Erie and Ontario railroad was still operating connecting Niagara-on-the-lake, Queenston (Quenstown on this map), Clifton, Chippewa, and Fort Erie. The old Niagara Portage Road can be seen running from Queenston to Stamford and from Drummondville to Chippewa: it ran inland to avoid the numerous gullies on the west side of the Niagara Gorge.

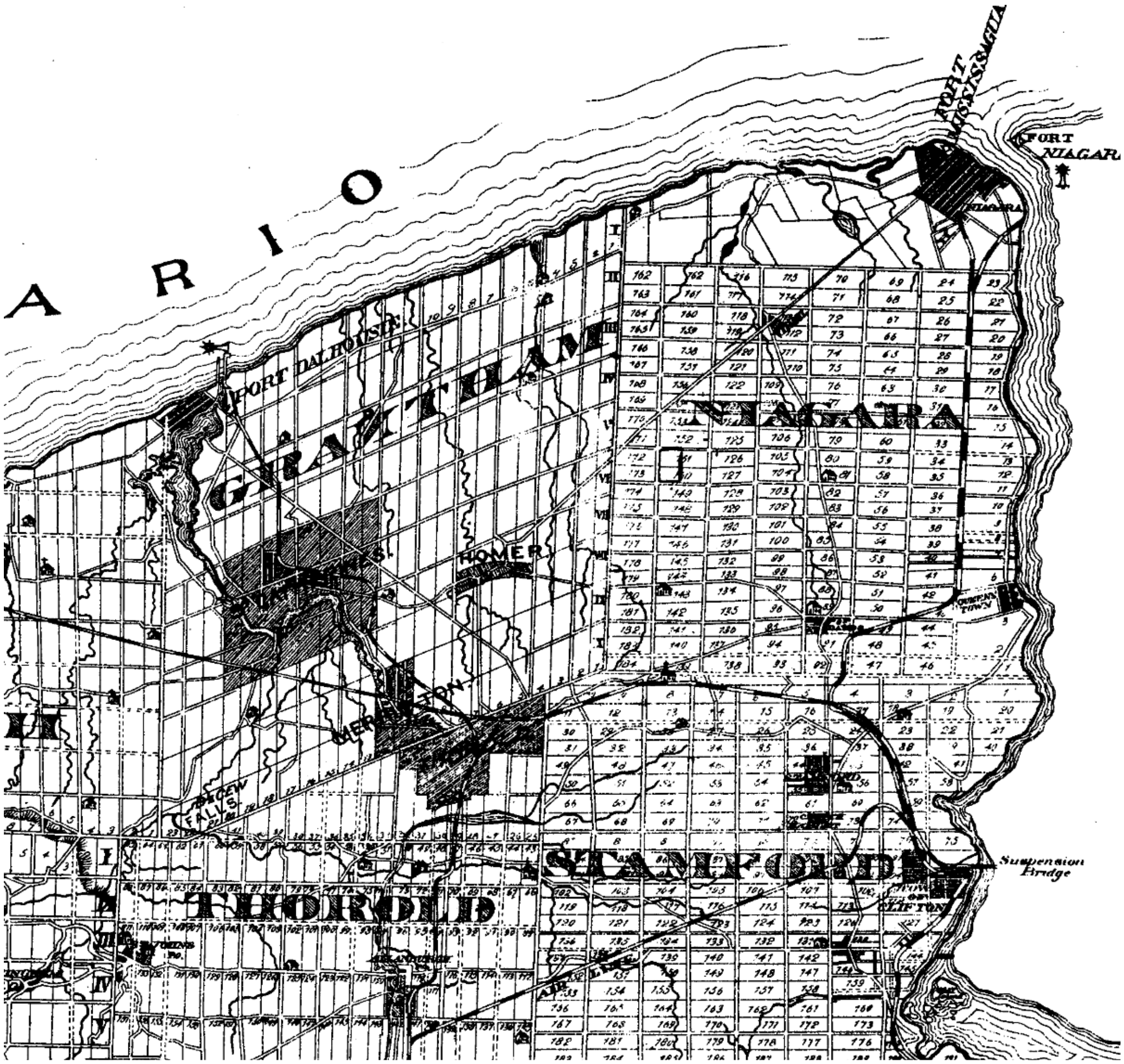
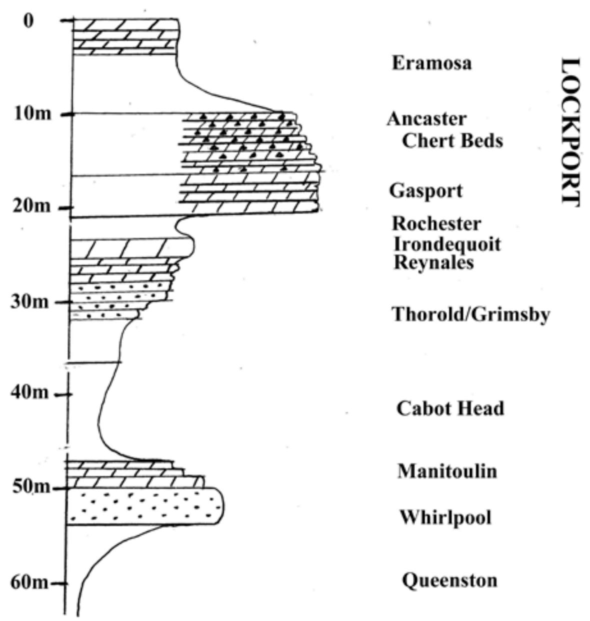


Figure 3. Part of a map in the 1876 Atlas by R.R. Page, (*Illustrated Historical Atlas of the Counties of Lincoln and Welland*)

BEDROCK GEOLOGY NEAR HAMILTON

The major geological feature in the Niagara Peninsula is the *Niagara Escarpment*. It was formed by a long period of erosion acting on sedimentary rocks, originally deposited some 400 million years ago, then uplifted and eroded over millions of years – so it is much older than the glaciations that have affected its morphology. The reason the escarpment exists is that there are rocks resistant to erosion (dolomites) overlying more easily eroded rocks (shales). The escarpment itself is not always a single feature. On the “mountain” above Hamilton and in Ancaster there is a smaller escarpment, above the main Niagara escarpment, called the *Eramosa Escarpment*. And in some places (Queenston, Forks of the Credit) a lower sandstone unit makes a separate small escarpment.



Geologists classify sedimentary rock strata into units of different age, and the main ones are shown on Figure 4. At one time the Lockport was considered a Formation (smallest mappable unit), divided into three Members (Eramosa, Ancaster Beds, Gasport). But the recent trend is to recognize the Lockport as a Group, composed of four Formations (see below).

Figure 4 The Geological section at Hamilton.

The geological map (Figure 5) shows the distribution of the bedrock in the Niagara peninsula.

Note the distribution of the Lockport, with the Gasport and Goat Island at the top of the Niagara escarpment, and the Eramosa a little further south. The “Lower Silurian – Clinton and Medina” makes a small separate escarpment to the north of the Niagara escarpment, near St. Catharines.

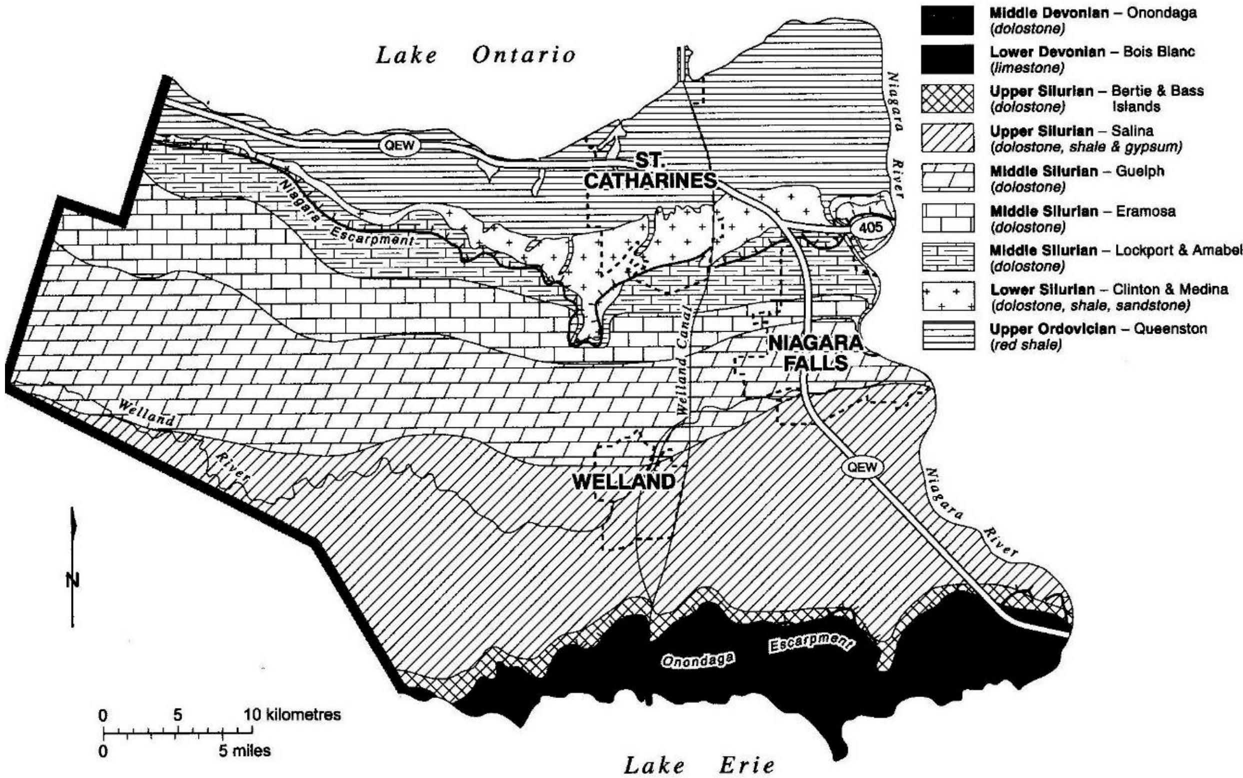


Figure 5 Bedrock Geology of the Niagara Peninsula (from Haynes, 2000)

The main units quarried for building stone near Hamilton are the Eramosa Formation of the Lockport Group, and the Whirlpool Formation. The red Queenston shale was used for making bricks. The two types of stone quarried are quite different: the Eramosa stone is a dolomite (calcium magnesium carbonate), and the Whirlpool is a sandstone (made of quartz, silicon dioxide). Originally both materials were soft: the Eramosa consisted of sand and mud made of calcium carbonate, most of it produced by organisms; and the Whirlpool was pure white quartz sand. But because of burial for long geological ages, the calcium carbonate mud was converted into dolomite rock, and the white sand was cemented into strong, hard sandstone. In the figure, dolomite is indicated by the "oblique brick" ornament, sandstone by a dotted ornament, and shale is left blank.

Both the Eramosa and the Whirlpool made good building stones. The Eramosa was quarried from the Eramosa escarpment, on the mountain about a mile south of the main Niagara escarpment. All the old quarries are now built over, but the rocks can be seen exposed along road cuts on the "Linc" highway. The same unit was quarried for building stone in Ancaster and Waterdown, but not very extensively further east in the peninsula. The Whirlpool was quarried In Hamilton and Stoney Creek at several quarries along the face of the escarpment. It was also quarried in Dundas, Queenston, and (in the late nineteenth century) extensively in the Credit River region. It was particularly prized because it could be cut into regular blocks as “ashlar” (dimension stone). Good sandstone blocks could be used as quoins (at the corners of walls), and as sills and lintels for doors and windows. The price was frequently 10 times that of lesser, irregular blocks of stone (called “rubble” by builders). Its excellence was recognized as early as 1851 by William Logan. It is worth quoting Logan’s summary in 1863 (*Geology of Canada*, p.814-815):

> “In [Ontario], a belt of sandstone strata, known as the Grey band [Whirlpool], is traced, with some interruptions from Queenston to Collingwood...The thickness of this band of sandstone varies from ten to twenty feet or more; the separate beds being from a few inches to two or three feet. It is fine grained, compact, and sometimes nearly white in color, at other times light grey, occasionally with a greenish tinge; and it furnishes an excellent material for building purposes...University College at Toronto, and many other buildings both in that city and in Hamilton, are constructed of this sandstone. It is extensively quarried for these purposes at Georgetown, in Esquesing [now Halton Hills] on the Grand Trunk Railway; and also at Hamilton and its vicinity, at Dundas and at Waterdown, where the band is ten of twelve feet thick.... At Nottawasaga...it is employed for the manufacture of grindstones and whetstones...”

It should be noted that most of the work on southern Ontario reported in *Geology of Canada* was not carried out by Logan himself but by Alexander Murray in 1843, 1848, and 1849, with further work in 1861 by Robert Bell.

Neither of the local buildings stones proved to be ideal for carving. The local dolomites have the advantage that they resist weathering better than many imported limestones, but they do not split or cut easily into regular blocks: so they are generally used as “rock faced” blocks or rubble. The Whirlpool sandstone is very strong and so only a few varieties are easily carved. It is composed almost entirely of silica, so it is very resistant to weathering, but it is subject to “black soiling” – a dark organic-sulphate coating deposited by industrial pollution (particularly smoke from burning coal). In Hamilton, carved ornaments were rather rare, and were generally cut in imported stones such as Ohio sandstone, or Indiana limestone.

Stone Houses in Hamilton/Wentworth

The table on the next page gives the number of domestic houses built of stone in each community, taken from the Canadian censuses: The 1901 figure for Wentworth N includes Brant N, and for Wentworth S probably includes both Barton and Ancaster. Hamilton built far more extensively in stone than any of the communities we will see in the Niagara peninsula. We will have time to examine only one historic building: the <u>Water Works</u> built of the two main building stones used in nineteenth century Hamilton.

region\date	1851	1861	1891	1901
Wentworth County				335N+262S
Barton	17	38	55	
Flamboro East (including Waterdown)	13	38	79+29W	
Dundas Town	28	34	43	
Ancaster Township	16	41	61	
Hamilton City	150	322	324	

Further east along the escarpment, from Winona to Beamsville, there are significant changes in the nature of the bedrock formations. The Eramosa (and the overlying Guelph) become thinner bedded, shalier, and less suitable for building. The Gasport, which is thin bedded in the Hamilton area, become thicker bedded and make a suitable building stone. We will see an example Inverugie in Beamsville but the Gasport reaches its full development as a crinoidal dolomitic limestone only at Thorold and Queenston (and in New York State along the escarpment to Lockport and beyond).

BEDROCK GEOLOGY OF THE ST.CATHARINES/NIAGARA REGION

A section across the escarpment near St. Catharines is shown below (Figure 6): it uses the conventional Ontario stratigraphy. Note that much of the bedrock both above the escarpment and on its face is obscured by Quaternary sediments principally till and proglacial lake muds and beach deposits.

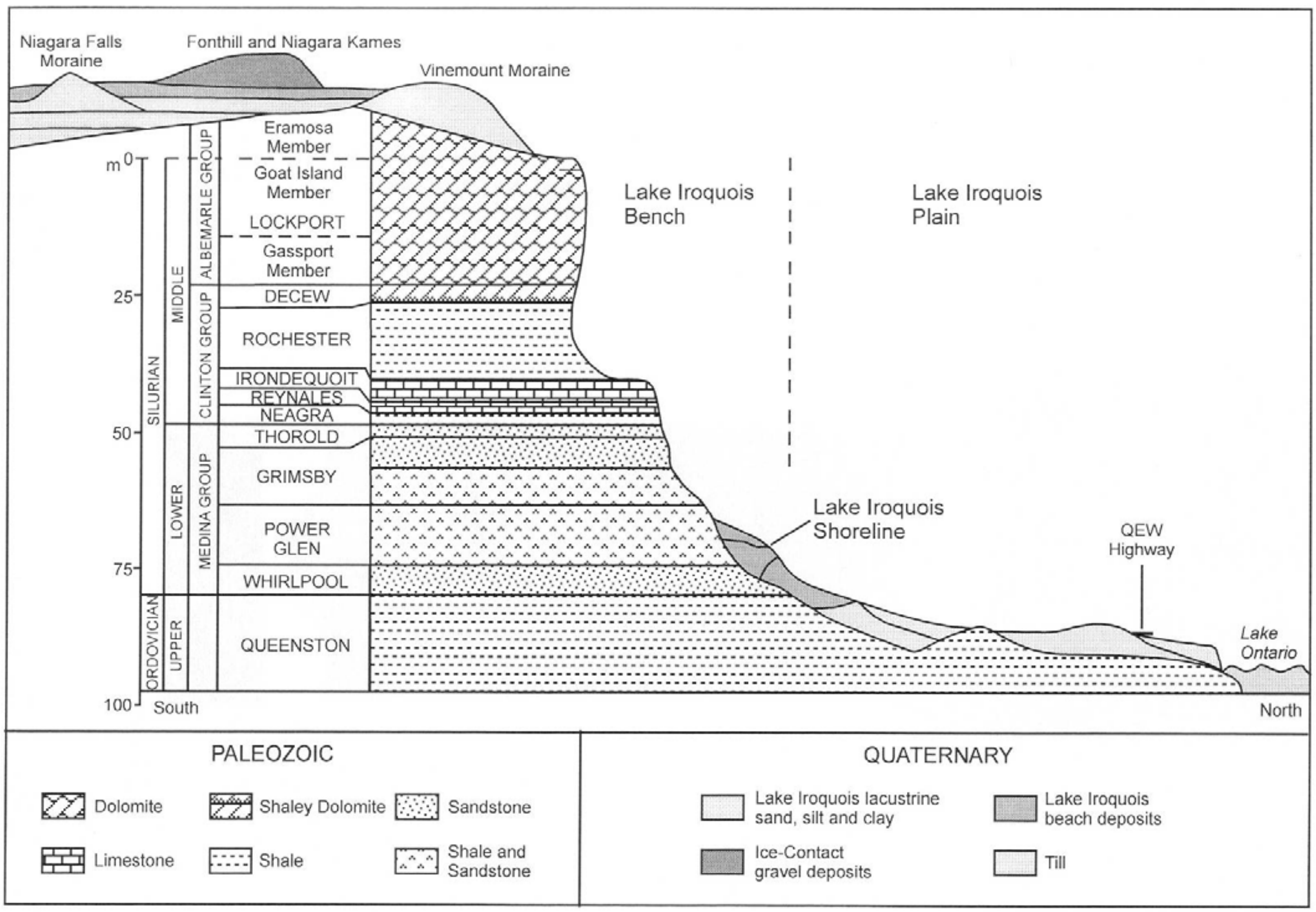


Figure 6 Geological section across the Niagara Escarpment near St. Catharines (modified from Haynes, 2000)

The main changes in the bedrock from the Hamilton area are:

The *Guelph Formation* is much thinner bedded and shalier than north of Hamilton (so it is poorly exposed, and not used as building stone). The *Eramosa Formation*: is not clearly divided into a shaly lower and a medium bedded upper dolomite, so it does not make a separate escarpment. The *Goat Island Formation*, equivalent to Ancaster Chert Beds, still contains chert, but less than in Hamilton area. It is a fine grained dolomite, with some chert, and was used locally as a building stone. The *Gasport Formation* a crinoidal dolomitic limestone: the lower part, thick-bedded with large scale cross-bedding, makes an excellent building stone ("Queenston stone"), quarried at Queenston and in Thorold. The *De Cew Formation* is a thin, but well developed "cement stone", i.e., argillaceous dolomite, with spectacular convolute lamination. Tiplin and Seibel (in Tiplin, 1988, p.196-197) described how this was quarried by Isaac Usher, an immigrant from Kansas. The quarry operated from 1885 to 1905. The *Rochester Shale* is much thicker than in the Hamilton area. The *Clinton Group* includes the Irodequoit and Reynales and are recognizable both at Hamilton and Niagara though recent studies indicate a more complicated stratigraphy in the Niagara area than near Hamilton. The *Cataract (or Medina) Group* shows a stronger development of grey and red sandstones. Originally interpreted as the "Medina (or Grimsby) delta," it is still interpreted as a prograding clastic wedge, but Duke and others (*International Association of Sedimentologists Special Publication* 14, p.339-375) have demonstrated that many of the sandstones are marine sheet sands redeposited off shore as storm deposits. Thicker sandstones, found in local channels, are the source of much of the mottled red Grimsby sandstone that was used as building stone in Grimsby and Thorold. The *Power Glen (or Cabot Head) Formation* is a marine shale, with minor carbonates. There is no Manitoulin Formation above the Whirlpool Formation.

A detailed stratigraphic section for the Lockport Group (which, in U.S. practice, now includes the Guelph) is shown on the next page. This group, with the Grimsby and Whirlpool sandstones, supplied most of the building stone used in the Niagara region.

Stromatolites are wavy or cabbage-like structures, formed by algal/microbial filament mats growing on carbonate mud sea floors. Most of the carbonate rocks were originally either muds or sands. Wackestones were poorly sorted, mud supported carbonate sands; packstones were better sorted, grain supported, carbonate sands, and grainstones were carbonate sands with very little mud between the grains. Stromatoporoids may superficially resemble stromatolites but they were invertebrate animals related to the sponges. Bioherms are mound-like growths ("reefs") built by organisms, and biostromes are tabular growths, more or less in situ.

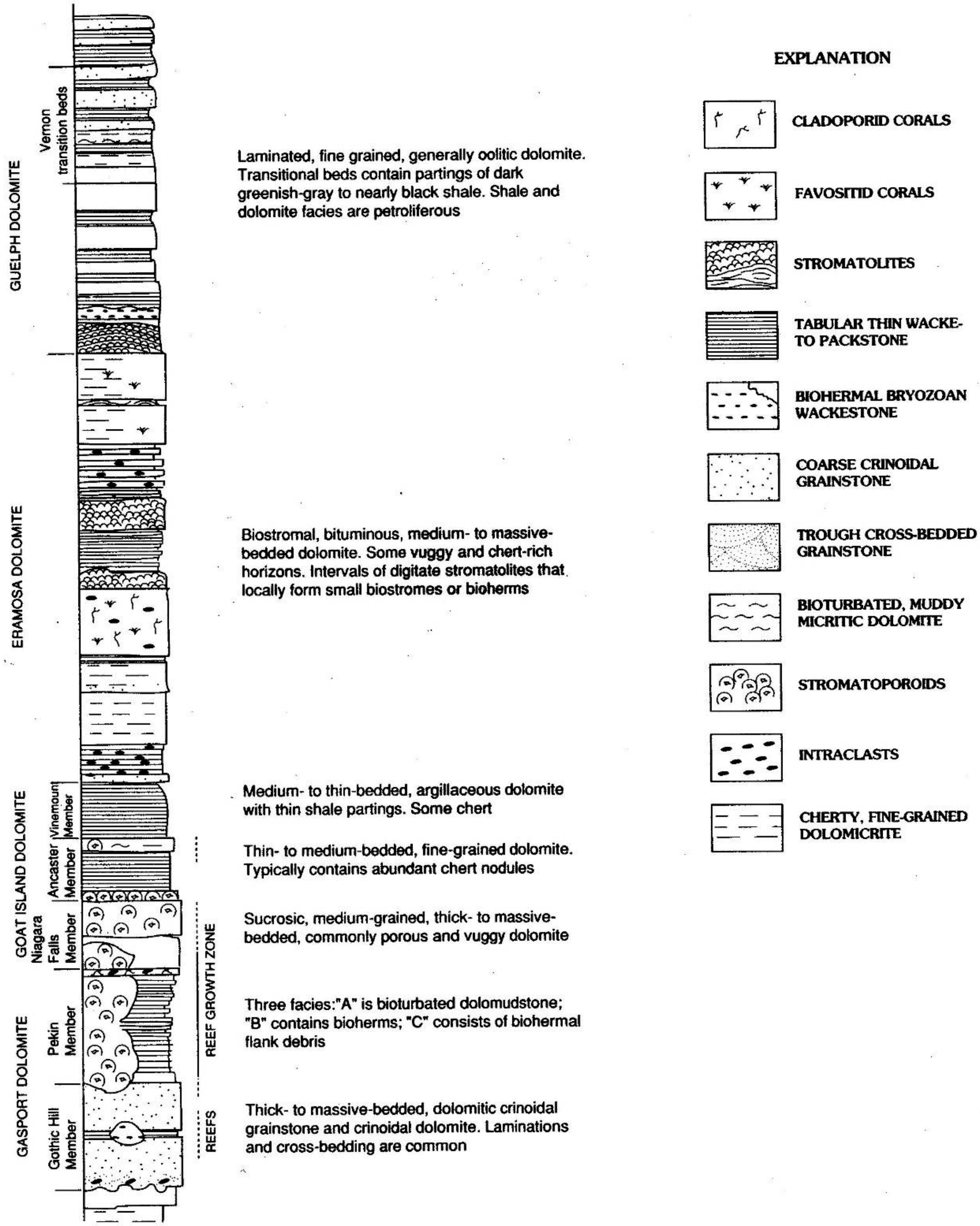


Figure 7 The Lockport Group in the Niagara region: a composite section, from Brett and others (*US Geological Survey Bulletin 2086, Figure 25, 1995*)

Stone Houses in Lincoln and Welland Counties

The table below shows that few stone houses were built in the Niagara peninsula, compared with Hamilton/Wentworth. Note that "Niagara" is the present Niagara-on-the-Lake, and the county included Queenston (which had the largest number of stone houses).

County/Township	**1851**	**1861**	**1891**
Grantham	3	13	15
Grimsby	10	13	22**
Louth	4	2	5
Niagara	17	20	49
Niagara town	4	4	13
St. Catharines	6	14	29*
Lincoln Co Total	**45**	**72**	**126**
Stamford	9	9	20
Thorold	12	13	5
Thorold village	6	15	17
Welland Co. Total	**39**	**65**	**81**

* In 1891, there was a separate entry of 9 stone houses for Merritton village
** In 1891 Grimsby was included in Wentworth Co.

Though there were fewer stone houses built, there was a greater variety of building stones used, including the Whirlpool sandstone (Queenston), The Grimsby sandstone (Grimsby, St. Catharines, Thorold), the Gasport dolomitic limestone (Niagara Falls, Thorold) and the Goat Island dolomite.

STONE MASONS

Data in the 1871 Census (“Heads of Households”) show that the masons were predominantly born in England or Ontario. Immigrants from Ireland, Scotland and Germany were also well represented.

In the Niagara District there were only three masons: all born in Ontario of English origin

In the Welland District (included Bertie, Clifton, Chippewa, Crowland, Fort Erie, Humberstone, Stamford, Thorold, Welland) there were 48 masons, 21 stone cutters (or stone masons), and 4 stonecutters: for a total of 73. Their places of birth were: England, 19; Ireland,8; Scotland, 11; Germany, 14; Ontario, 10; USA, 6; Others, 5.

In the Lincoln District (included Clinton, Grimsby, Grantham, St. Catharines), there were 41 masons, 12 stone cutters (or stone masons): for a total of 53. Their places of birth were: England, 21; Ireland, 9; Scotland, 2; Germany, 5; Ontario,10; USA, 4; Others, 2.

These data (and those from Hamilton/Wentworth) show that, contrary to a prevailing myth, the stone masons in this part of Ontario were NOT predominantly Scottish. The Niagara region had a rather larger number of Ontario-born masons, compared with Hamilton-Wentworth, which probably reflects the earlier settlement history of the Niagara region.

Maurice Craig’s book (1982) *The Architecture of Ireland* has some material relevant to southern Ontario, particularly for those regions (e.g., Niagara) where the Scots were a distinct minority. About the early nineteenth century in Ireland, he wrote:

> "A very noticeable change had taken place not so much in architecture itself as in the practice of building. It is much more obvious than many changes brought about by theory or mere fashion. Its social and technical causes remain obscure. We have already seen that an interest in the textural quality of masonry for its own sake was widespread in the early Christian period but faded in mediaeval times. Such interest in the seventeenth century is still restricted to coigns and openings and other small features. The monolithic lintel, for example, disappears towards the end of the twelfth century and is not seen again until nearly half-way through the nineteenth but now dressed on its top surface and ends instead of only on its soffit and front face...
> "...[earlier] unsurpassed standards of masonry were achieved but the command of varied textures: random rubble, coursed rubble, irregularly squared ashlar, rock-faced, dragged or hammer-dressed, which spread with great rapidity in the early nineteenth century, is something different. It may have been stimulated by the gathering volume of engineering work from the middle of the eighteenth century onwards: canal-building, bridge-building, the construction of great harbours...and the construction of the railways beginning [in Ireland]...in 1831."

This is exactly what happened in southern Ontario. The textures he lists are all well exemplified by what we see, whereas some of the distinctive textures of Scottish buildings are seen only rarely in Ontario. It is time the Irish (and also the English, where there was probably a similar development) got their due credit for the masonry of Ontario buildings!

QUARRIES

Grimsby-Beamsville area

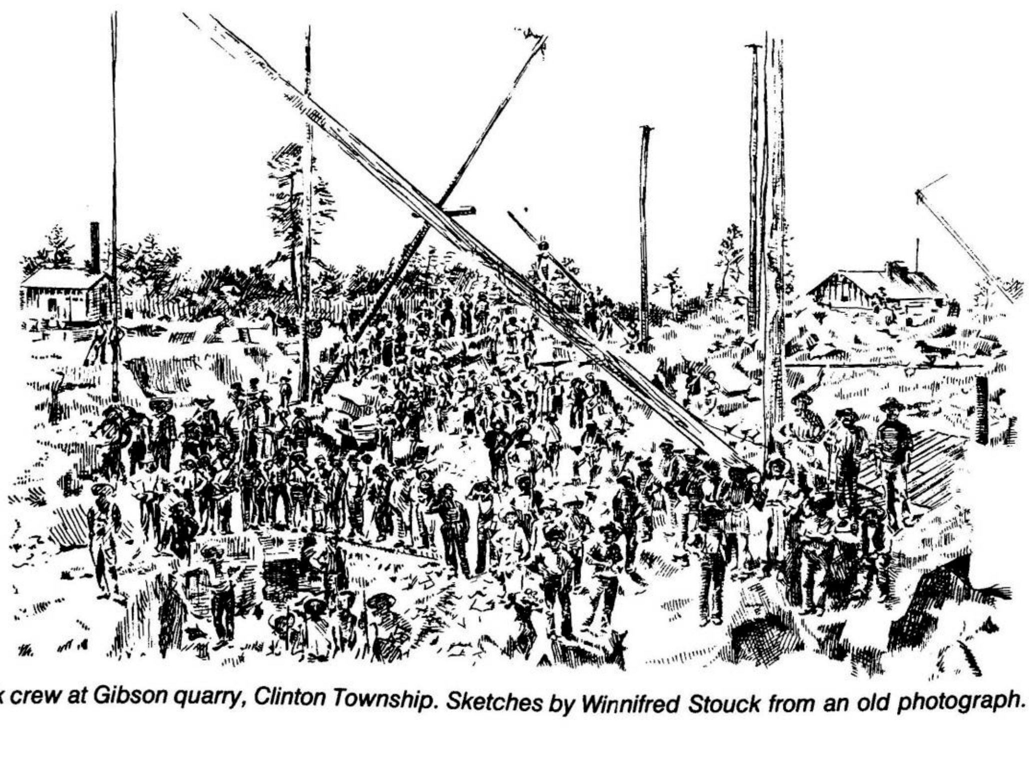
Rannie's book (*Stone from the Mountain*, 1987; now available at http://www.ourroots.ca/) is the only local history that gives details of the local stone masons, and quarry owners, and their contributions to the local economy. In the Grimsby-Lincoln area the pioneer quarry owner was Robert Lillie Gibson (1834-1884), who emigrated from Scotland with his parents and family in the 1860s. He was in Windsor and St. George before settling in Grimsby perhaps in 1866 (he is not listed in the 1871 census). At the time of the 1881 census, he was listed as a "contractor" and was living in Grimsby with his Irish wife, Fanny, and had six children, aged 2 to 12 (all born in Ontario). He was able to open several new quarries and develop a successful business mainly because of the need for stone for use by the railroads, both as rubble to improve the stability of the rail beds, and as building stone to replace the wooden bridges. The line from Hamilton to Niagara had been constructed in 1853, and needed upgrading in the 1860s. After Robert's death the business was taken over by his nephew, William Gibson (1849-1914), who later was elected to Parliament in 1892, and became a Senator in 1902. He supplied stone for the construction of the third Welland canal in the 1890s, and was active in many businesses, besides stone production. He constructed a stone mansion, Inverugie, which we will visit on this field trip.

The Gibson quarries included property in Lot 10, Concession 2, Township of Grimsby: it supplied the stone, a red and green-grey variegated Grimsby sandstone (Medina) for the former Imperial Bank building at the top of the hill (on the highway at Jordan), his own house at Grimsby, and the St. John's Presbyterian Church, at 10 Mountain Street in Grimsby, built by Shaffer Bros using stone donated William Gibson's son Jack Gibson in 1928, and extended using the same stone in 1957. A similar quarry probably also supplied the stone for St. Andrews, which we will visit. St. Andrews was built in about 1820, so before Gibson took over the quarry.

Much of the stone from Gibson's quarry was used by the Great Western Railway. Stone was brought down the mountain on light rails laid down Mountain Street, across

Main, along Elizabeth to Victoria Park, and from there along a causeway to the east side of Forty Pond (Rannie, 1987, p.19). From there it was taken by ship to Toronto or St. Catharines. Though the stone could be used as rubble, most was not suitable for building stone. Miller (1892) gave details of the quarry: it was in the gorge of Fifty Mile Creek, and extended for half a mile below the falls, occupying an area of 18 acres. At that time no dimension stone was being taken out.

Robert Gibson opened a second quarry in 1884, this time in Lockport dolomite, above the escarpments in Concessions 5 and 6, lots 13 and 14. Robert's nephew Robert Lillie had been brought to Canada in 1870 as bookkeeper, and took charge of the new quarry. Most of the building stone came from the quarry on the west side of Quarry Road. After Robert Lillie Gibson's death, however, the Clinton quarry became the property of William Gibson. A sketch of the Clinton quarry is given by Rannie (1987, p.31; see also the description in Miller, 1892, p.97; 1904, p.74; and in Goudge, 1938, p.249). The sketch is reproduced below. A tramway was constructed in 1884 from the quarry to the Grand Trunk Railway station at Beamsville. In 1891, 160 people were employed, at a cost of $7,500 per month. Miller described two workable beds of grey limestone, 7-8 feet thick, and judged the upper to be better. He remarked that the stone was all cut by hand, and was used by the Grand Trunk Railroad.



Work crew at Gibson quarry, Clinton Township. Sketches by Winnifred Stouck from an old photograph.

Figure 8 The Gibson quarry in Beamsville (from Rannie, 1987)

Production of stone ended a few years after a strike in 1906, by which time William

Gibson was more involved in politics in Hamilton than in quarry management. The stone from Gibson's quarry in Clinton Township is Lockport dolomite, similar to Queenston stone, and was described by Parks (1912, p.249-250), as "particularly adapted to heavy construction...Most of the output was used in bridge and culvert construction on the Grand Trunk railway; it was also used in the [third] Welland canal and in the construction of the St. Clair tunnel." Goudge described it as "... fine to medium grained, buff to light bluish in colour with occasional dark streaks. On weathering it assumes a grey colour."

Queenston-St. Catharines-Thorold

Quarries in the <u>Thorold area</u> were described by Parks (1912, p.246-249). The *Walker Brothers quarry* at Merritton (Lots 31 and 32, concession 10, Stamford township) yielded a stone similar to Queenston stone (Gasport): Parks claimed it was used in the Armories in Hamilton, Toronto, Chatham and St. Catharine's; in the <u>Imperial Bank</u> (which became the CIBC in 1961) in Niagara Falls (which we will visit) and St Catharine's, in the Frenchman's Creek bridge, and in Niagara boulevard. Seibel (in Tiplin, 1988, p.198-200) described the same quarry, and reproduced an air photo, taken in 1901. John Walker, a "marble carver" opened the quarry in 1887. The location was close to the third Welland canal, which made shipment of stone blocks relatively easy. It could then be sold in Toronto for $9 a toise (about 7 cubic metres). The quarry also produced crushed stone, the first steam driven crushed was installed in 1905 and it was replaced by an improved plant in 1929 and another in 1947. By the 1927, no more building stone was being produced but the production of crushed stone had greatly increased. Seibel claimed that the quarry supplied almost 40,000 tons for use in constructing the Queen Elizabeth Way. Goudge (1938, p.251) mentioned that it was coarse grained with pink stained crinoid stems. This is the same quarry described in 1892 by Miller as Brown's quarry.

Belton's Quarry in Louth supplied the stone for Power House no.1, just above the Falls. Goudge (1938, p.251) described a quarry in lot 15, concession 10, Grantham township, which was known as the *Grantham quarry* "formerly used for building stone..." It was also described by Parks (1912, p.248-249) as the "Kearney and Campbell" quarry.

The *Peninsula Limestone quarry* in Thorold (lots 44 and 45, concession TL) was also described in detail by Hewitt (1964b, p.7-10). It exposed 20 feet of Gasport: the top 6 feet were stripped and used for crushed stone, and the rest was quarried for building stone. The stone is very similar to that in the Queenston quarries.

The stone from these quarries was all very similar to that quarried at the Queenston quarry. There were also quarries in the region producing Grimsby sandstone:

Parks (1912, p.140) mentioned a quarry "close to the tracks of the Niagara Central railway north of Merritton" which produced mottled stone used locally and also "shipped to Cleveland and other American cities." Presumably this was Grimsby sandstone: Parks mentioned that it was used in the Riordon paper mills, the old cotton mill (now The Keg; which we will see on this trip) and Town Hall in Merritton, and in the Packard Electric Light Co. building in St. Catharines. Another quarry, in Rockway (west of St Catharines) produced similar stone, which was used in St. Patrick's Church in Niagara Falls, the paper mill in St. Catharines, and the Solomon Grave house on Ontario St, St. Catharines. Maplehurst, a mansion built in 1885 by Hugh Keefer, was also built of Grimsby sandstone, probably from one of these two quarries.

There were also two quarries, probably in Whirlpool, and Thorold-Grimsby sandstone, in Jordan: the stone was used mainly by the railroads, but some was probably used to construct St. John's Church (which we will see on this trip).

According to Parks, in about 1910 the Queenston (St. Davids) area was producing stone from two major quarries, but only one was a major producer of building stone. The Queenston quarry supplied stone for the Customs' House and Post Office in Niagara Falls (which we will see), the Post Office in St. Catharines, Power houses in Niagara Falls, the Goat Island bridge, Brock's monument, the second and third Welland canals, etc., and since Park's time continued to be a major supplier of high quality building stone until the end of the twentieth century. Goudge (1938, p.252) mentioned that a new quarry opened in 1931, just "east of the south end of the main quarry..." At the end of the twentieth century the quarries were still operated but mainly to produce crushed stone: by 2006 even the production of crushed stone has ended.

The first scientific description of the Queenston quarries (there were seven at that time) was given by Miller (1892). He remarked " it is said that the quarries were first opened during the construction of the Grand Trunk Railway," were operated in 1874 by Belden, Denison , to supply stone for new locks on the Welland canal, and then from 1878-1881 by Hunter, Murray and Cleveland. After that the quarries were operated by P.A. Johnston (who was employing 75 men in 1890), and the land was owned by William M. Hendershot. A fanciful depiction of the quarry as it was in 1876 was depicted in the Lincoln and Welland Counties Atlas published by H.R. Page. It is shown below (also see Tiplin, 1988, p.190). Note that a spur line from the Great Western Railway ran into the quarry, and trimmed blocks were loaded using derricks onto flat bed carriages. According to Miller two bands were exploited, the upper being a lighter grey and coarser grained than the lower, which he considered to be superior. The post offices of Cornwall, Niagara Falls and St Catharines were constructed of that stone. There is no evidence that saws were used to cut the stone at that time, as they certainly were in the twentieth century. Instead, blocks were split from the outcrop using the traditional "plug and feather" technique, and trimmed by hand. In the nineteenth century, the quarry employed as many as 600 men, but not all were skilled stone-cutters.

A brochure (apparently produced in about 1929) extolling the merits of "Queenston Silver Grey Dolomite" gives slightly different details of its history. It claims that the first known owner was John Brown: he contracted out the operation of the quarry, which from 1871 to 1878 employed 600 men. Tiplin (1988, p.193) stated that John Brown was a Scottish contractor who moved to Queenston from the U.S. in the 1830s. From 1878 P.A. Johnson took over (at first in partnership with Murray). In 1897 a joint stock company was formed, and fourteen houses were constructed nearby to house the quarry workers. From 1905 to 1924 the quarry was operated by the Lowery interests.

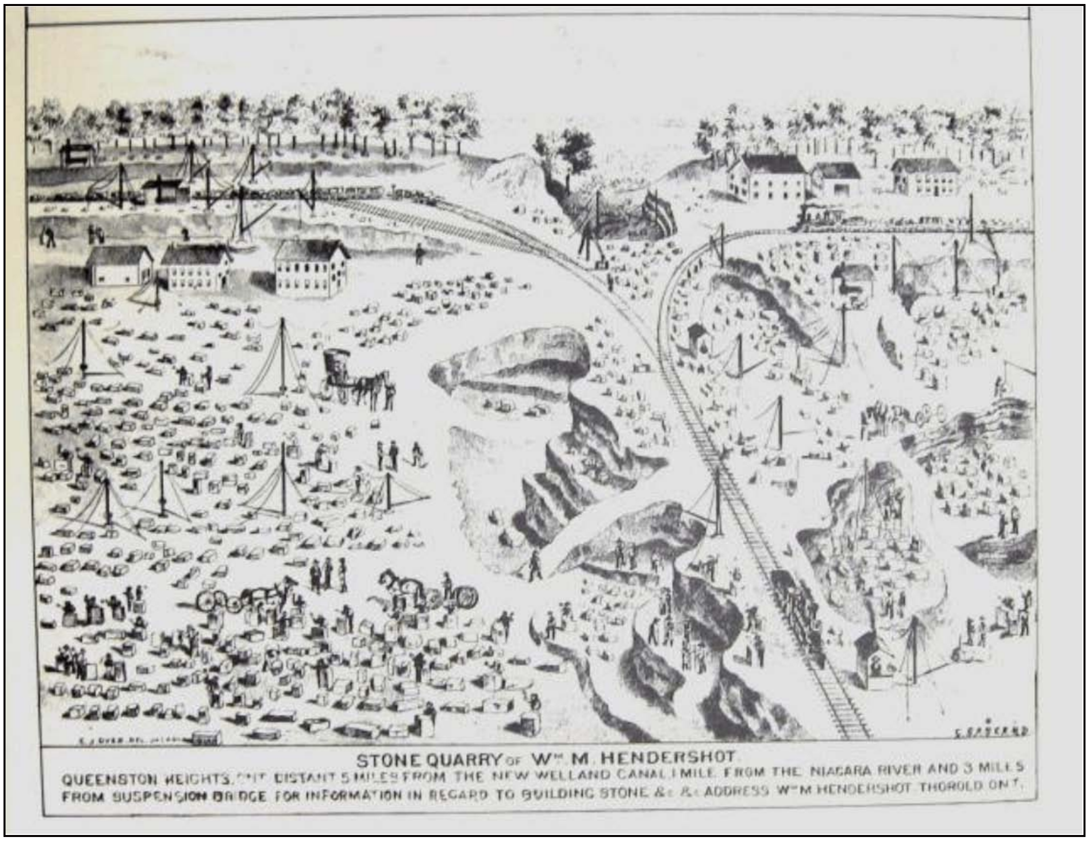


Figure 9 The Queenston quarry, as depicted in the Lincoln and Welland Atlas of 1876.

The Canada Crushed Stone company took over in 1925, and it was the efforts of this group that made Queenston stone one of the most widely used building stones in Canada. In the nineteenth century, most of the stone was sold for use in the Welland Canal and to construct railway bridges. The brochure also lists the following early uses: 1837 Queenston International Bridge foundations; 1840, Court House, Niagara-on-the-Lake (along with Whirlpool sandstone); 1846, Locks for the second Welland Canal; 1856, Brock's Monument; 1860, Culverts and Bridges (old) Great Western Railway; 1872-1876, Welland Canal; 1878, Gate and fence at the Governor General's residence, Ottawa (this seems to the first use in a building distant from the source); 1880-1890, Welland Canal; 1882, Post Offices in St. Catharines and Niagara Falls; 1896-1900, Power House in Niagara Falls, NY; 1902-1908, Power Houses in Niagara Falls, ON; 1904, Bridges in Niagara Falls ON. To this list may be added the east block of the Parliament buildings in Ottawa, Canada House in London, England, and some of the buildings at McMaster and Queens University. Hewitt (1964b) gives further details about the history and mode of operation of the Queenston quarries, in the twentieth century including several photographs.

The Queenston quarries produced the best building stone in Ontario, in some respects comparable with Indiana limestone. Queenston stone is a well sorted crinoidal limestone, with or without large fossils, but often showing clear traces of bedding or cross-bedding. It has been partially dolomitized and well cemented by calcite. It is freestone and can be split or cut into regular blocks of large size. It can even be carved, though it is coarser and harder than Indiana stone, so less favoured as an ornamental stone. Its compressive strength is twice that of Indiana stone, its porosity is less, so the specific gravity is higher (2.65 compared with 2.33 for Indiana stone). Tiplin claimed that in Niagara it weathered better than the Indiana limestone that was used in the Toronto Power Generating Station.

Though the history of the Queenston quarries is generally traced back only to 1837 (Goudge (1933, p.76), Queenston stone, or something very similar to it, has been quarried at least since the beginning of the nineteenth century: The Gibraltar Point lighthouse in Toronto was built with Queenston stone in 1809, and the Buffalo lighthouse was built from it in 1833 (it is the second oldest surviving building in Buffalo, see: http://www-cs.canisius.edu/~meyer/photoalbum/).

It is surprising that the Queenston stone, and its use in the second Welland canal (beginning in 1846) was not mentioned by Logan (1863). This is probably because the surveys of southern Ontario (by Alexander Murray, with additional information provided by Robert Bell) on which this part of his book is based, were carried out much earlier than the date of publication.

John Thompson, for whom Thompson's Point is named (it overlooks the Whirlpool and will be visited on this trip), built a stone house in 1802 and a stone barn in 1806 (now demolished, but see the photograph of the barn in Tiplin, 1988, p.189). He opened a quarry at the face of the gorge, and built two lime kilns to produce lime. Nearby was another quarry operated by Thomas McMicking, now a 3 m deep pond on the Whirlpool golf course. As McMicking was a stone mason, the quarry probably produced building stone. Both these quarries probably worked the thinner bedded upper part of the Gasport dolomitic limestone. Further south, at Clinton and Drummondville, the local stone is Goat Island, an inferior stone, which was used nonetheless in buildings such as Christ Church (built in 1865), and the Stamford Town Hall (built in 1874). (http://www.infoniagara.com/recreation/hiking/brock.html)

Besides the famous Queenston limestone quarries, Bob Watson has established that Whirlpool sandstones was also quarried at Queenston, in at least two quarries: (i) one at the end of York Street; (ii) North of the stone house at 1755 York Road. In the part of the Niagara escarpment in Ontario, as further east in New York State, the Whirlpool sandstone consists of about 5-6 m of thick bedded, coarse sandstone, mostly trough-cross-bedded, with shale units above and below, so that it makes its over small escarpment. Thus it can be readily quarried, in contrast to the difficulty experienced where there is a single steep escarpment (as at Hamilton). Besides its use in Niagara-on-the-Lake, it was extensively used in early stone buildings in the village of Queenston. According to their web site, the retreat house at Mount Carmel, Niagara Falls, was also built (in 1899-1926) using both sandstone and limestone from Queenston.

THE WELLAND CANAL

In the early nineteenth century easy transportation of bulky and/or heavy materials was largely confined to ships operating on Lake Ontario. The first steamship, the Frontenac, was built at Kingston in 1816. Transportation from Montreal to Kingston was by boat, but required several difficult portages, and Lake Erie could be reached only by making use of the "Portage Road" around Niagara Falls. The first improvements required the construction of canals, which in turn required labourers, both unskilled and skilled (masons, "miners" skilled in excavation, carpenters, and others).

The *Erie Canal* built in New York State between 1817 and 1825 was the first major canal in the area: the locks were largely constructed from stone. It ascended the Niagara escarpment at Lockport, NY, and ended at Buffalo, where boats could continue on up the Niagara River to Lake Erie. A link with Lake Ontario (the Oswego canal) was built at Syracuse in 1828. Other canals connecting with Lake Erie were developed in Ohio between 1825 and 1850.

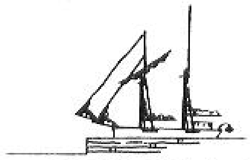
In Canada, canal building was stimulated by the need, felt particularly after the War of 1812, for a communication and supply system in Ontario that was not vulnerable to attack from the United States. The St. Lawrence between Montreal and Kingston, and the Niagara River and its Portage Road were clear examples of such vulnerability. An alternative route from Montreal to Lake Ontario was possible, using the Ottawa River, and the Rideau-Cataraqui system, but both routes needed extensive canals to provide easy military access. Work on the Ottawa River canals began in 1819 and was essentially completed by 1834 (Legget, 1988). Work on the *Rideau Waterway* (Legget, 1972) began in 1826, after more than 10 years of planning, amply documented in Legget's book: it was completed in 1832, and made use of the local Ordovician limestones. These canals were built by the British army, but also employed a large civilian labour force, many of them recent immigrants. In 1855, the settlement at the end of the Rideau Canal, previous named Bytown, was changed to Ottawa, and shortly afterwards it became the capital of Canada.

The *Welland canal*, however, was constructed more to deliver water to power the mills built by William Hamilton Merritt (1793-1862) in St. Catharines, and provide commercial competition for the Erie canal, than to allow military access to Lake Erie.

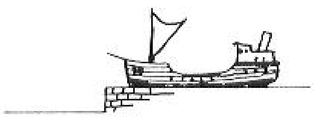
Merritt's priority for the first Welland canal seems to have been to provide water to drive his mills in St Catharines, by way of a feeder channel from the Welland River. The first Welland canal was begun in 1818, and completed in 1829: the locks of the first canal were made of wood, but stone, mostly Gasport dolomitic limestone, was used extensively in the second (1841-1845) and third canals (completed 1887). Jackson (1976, p.260) records that in 1840 11,000 cubic yards of cut stone was required (and, earlier in 1837, that 3000 cords of "good hard limestone" were required for road construction).

Work on the Grand River Canal system began in 1833. Parts were completed by 1842, when the "Indian Chief" began a passenger service on the Grand River, but the connection to Brantford was not completed until 1848. Work was begun on canals on the St. Lawrence (the Cornwall, Beauharnois and Williamsburg canals), to permit ships to sail between Montreal and Lake Ontario. As many as 5000 workers were employed in 1843-1845, and the system was completed in 1848. Completion in 1846 of the Lachine canal at Montreal, provided not only access to Atlantic ships, but also water power to drive industrial development for what was then Canada's most important city (Kilbourne, 1960, p.9-10). By 1862, locks on the St Lawrence permitted passage of ships 186 feet long, and 9 feet deep, which roughly matched the capacity of the second Welland canal, but did not permit passage of ocean-going vessels. The modern Seaway was completed only in 1959.

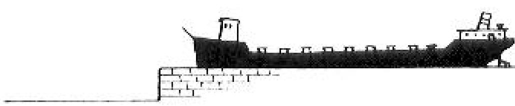
On this trip we will be able to view the locks of both the modern canal, and of the second canal. Figure 10 shows how the canals grew larger over the years and Figure 11 shows the different routes taken.



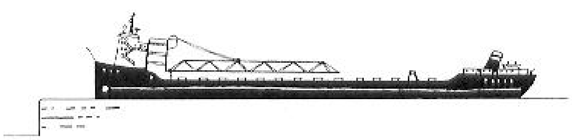
FIRST CANAL Construction 1824-1829; 39 Wooden Locks; Lock Length-34m; Width-6.7m; Average Lift-2.6



SECOND CANAL Construction 1842-1845; 27 Stone Locks; Lock Length-46m; Width-8m; Average Lift-3.6



THIRD CANAL Construction 1875-1887; 26 Stone Locks; Lock Length-82m; Width-13.7m; Average Lift-4.3



FOURTH CANAL Construction 1913-1932; 8 Concrete Locks; Lock Length-262m; Width-24.4m; Average Lift-14m

Drawings by Robert Shipley

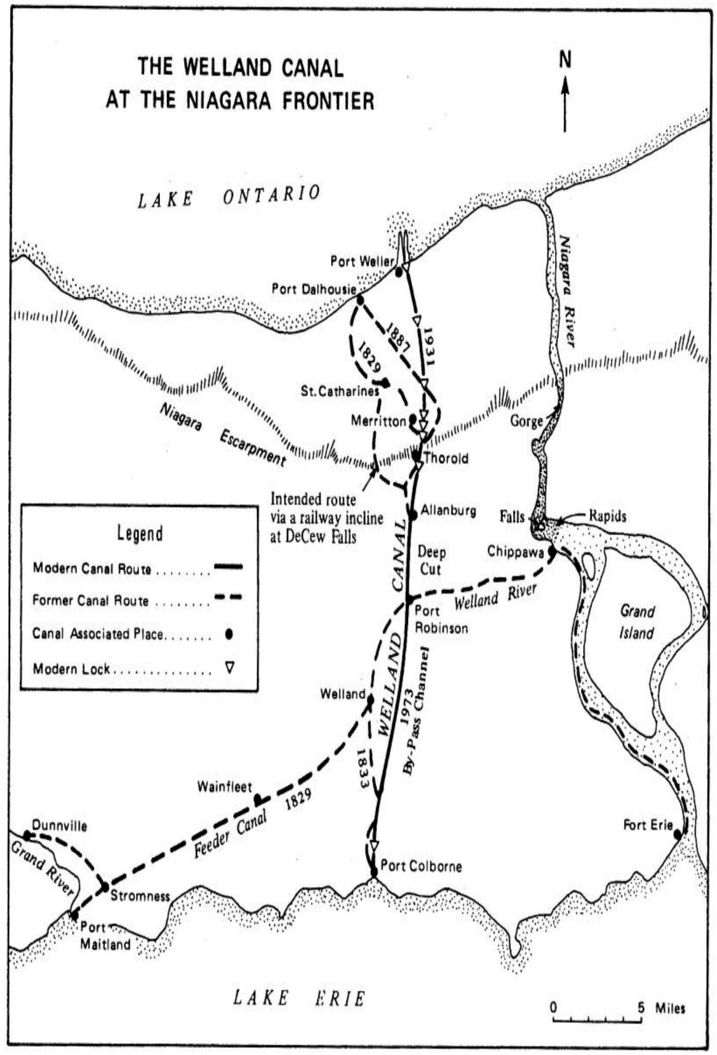


Figure 10 (from Shipley, 1987)

Figure 11 (from Jackson, 1988)

GLACIAL HISTORY OF THE NIAGARA PENINSULA

The Niagara Peninsula has been glaciated numerous times during the Pleistocene. The Niagara Escarpment bears testimony to a long history of glacial modification but there is only a stratigraphic record of the final stages of the last (Wisconsin) glaciation. The glacial geology and geomorphology of the peninsula is dominated by the deposits of large ice-dammed lakes formed during a brief four thousand year long phase of ice retreat beginning around 16,500 ybp (years before present) (Feenstra, 1981; Barnett, 1992). Much of what is known of the deeper glacial stratigraphy of the peninsula has been determined from searches for suitable landfill locations, the need to remediate former dolostone quarries on the Escarpment used as landfills (Birks and Eyles, 1997) and construction of various phases of the Welland Canal.

Growth of the Laurentide Ice sheet

The Laurentide Ice Sheet (LIS) was initiated in northern Quebec perhaps as early as 90,000 ybp, expanded into Ontario after 60,000 ybp but did not cross the Great Lake basins until after 23,000 ybp (Eyles and Westgate, 1987). Sediments preserved near Toronto at Scarborough Bluffs and in the Don Valley Brickyard indicate that large proglacial lakes were ponded in front of the advancing ice sheet. These deposits show the effects of floating ice in the form of iceberg scours and till-like ice rafted sediments, and large storm waves (Eyles et al., 2005 and refs therein). Some older sediment was trapped within the buried gorge at St.Davids. Radiocarbon dates from there (Hobson and Terasmae, 1969) and Scarborough indicates that the ice sheet did not cover southern Ontario until late in the glacial cycle after 23,000 ybp. The maximum extent and volume of the ice sheet (33 x 10^6 km^3 or equivalent to some 70 m of sea level fall) occurred at 18,000 ybp during what is called the Nissouri Stadial (Dyke, 2004).

Tills that had been earlier ascribed to early and middle Wisconsin glaciation in mid-continent have now been pushed back to the Illinoian indicating a long ice free interval in the lower Great Lakes region from the end of the Illinoian (c. 110,000 ybp) until c. 25,000 ybp. The climate during the early and middle Wisconsin period undoubtedly was cool to cold. Locally, parts of the Niagara Escarpment cap rock have been ‘cambered’ down over underlying shales weakened by periglacial ground ice. Large fissure caves (e.g., Collingwood) occur in the cap rock indicating gravitational movement and extension of the cap rock, and some are filled with till. There is also evidence of rock falling onto snow patches on the face of the escarpment forming small moraine-like ‘protalus ramparts’.

Effects of glaciation on the Niagara Escarpment

The Escarpment between Niagara and Georgian Bay shows a serrated planform with about 25 're entrant' valleys (Straw, 1968). These contain only small underfit streams and steep 'theatre headed' back walls very similar to canyons in the American SW. Spring sapping is a very active process along the headwalls and promotes headward extension of the valley by undermining the dolostone cap rock. Intersection of re entrant valleys has created several large 'outliers' of Silurian strata each with their own cap rock, along the Escarpment (e.g., Milton). The larger re entrant valleys at Hamilton (Dundas Valley) and St. Catherines (Twelve Mile Creek) are structurally controlled above deep seated basement lineaments such as terrane boundaries in the underlying buried Shield (Eyles, et al., 1993). The floor of the Dundas Valley reaches 63 m *below* sea level. Evidence across Southern Ontario indicates reactivation of these lineaments during the Paleozoic (Paleozoic strata are offset) and many are seismically active at the present day. The larger valleys are likely part of much older mid-continent drainage system that predates glaciation and erosion of the Great Lake basins (Flint and Lolcama, 1985). Modern day drainage patterns in Southern Ontario are heavily controlled by joints in bedrock and sediment indicating a strong neotectonic control on landscape development (Eyles et al., 1997). 'Pop-ups' are a common feature on exposed bedrock surfaces reflecting high compressive stresses in response to plate movement. A surge of interest in jointing occurred in the 1980's in response to concerns with contaminant migration during investigations by the Ontario Waste Management Corporation for long-term waste disposal facilities in low permeability lake sediments of the Haldimand Clay Plain (Eyles, 1997; pp.59-63; see below).

The maximum extent of the LIS is recorded on the Peninsula by coarse-grained, bouldery sandy silt till (variably named Catfish Creek Till, Northern Till). Erratic boulders are derived from the c. 1 billion year old Grenville Province of the Canadian Shield which is exposed some 150 km to the north. This till is highly overconsolidated, rests on bedrock and is usually not exposed at surface but its boulders have been extensively reworked into younger deposits particularly as lags along shorelines of later glacial lakes formed during ice retreat. 'Field stones' were cleared from fields, then dressed and used for buildings. Most of these are banded gneisses (from the Central Gneiss Belt), granites, pegmatites and occasional marbles from the Central Metasedimentary Belt.

Retreat of the ice sheet from the Niagara Peninsula

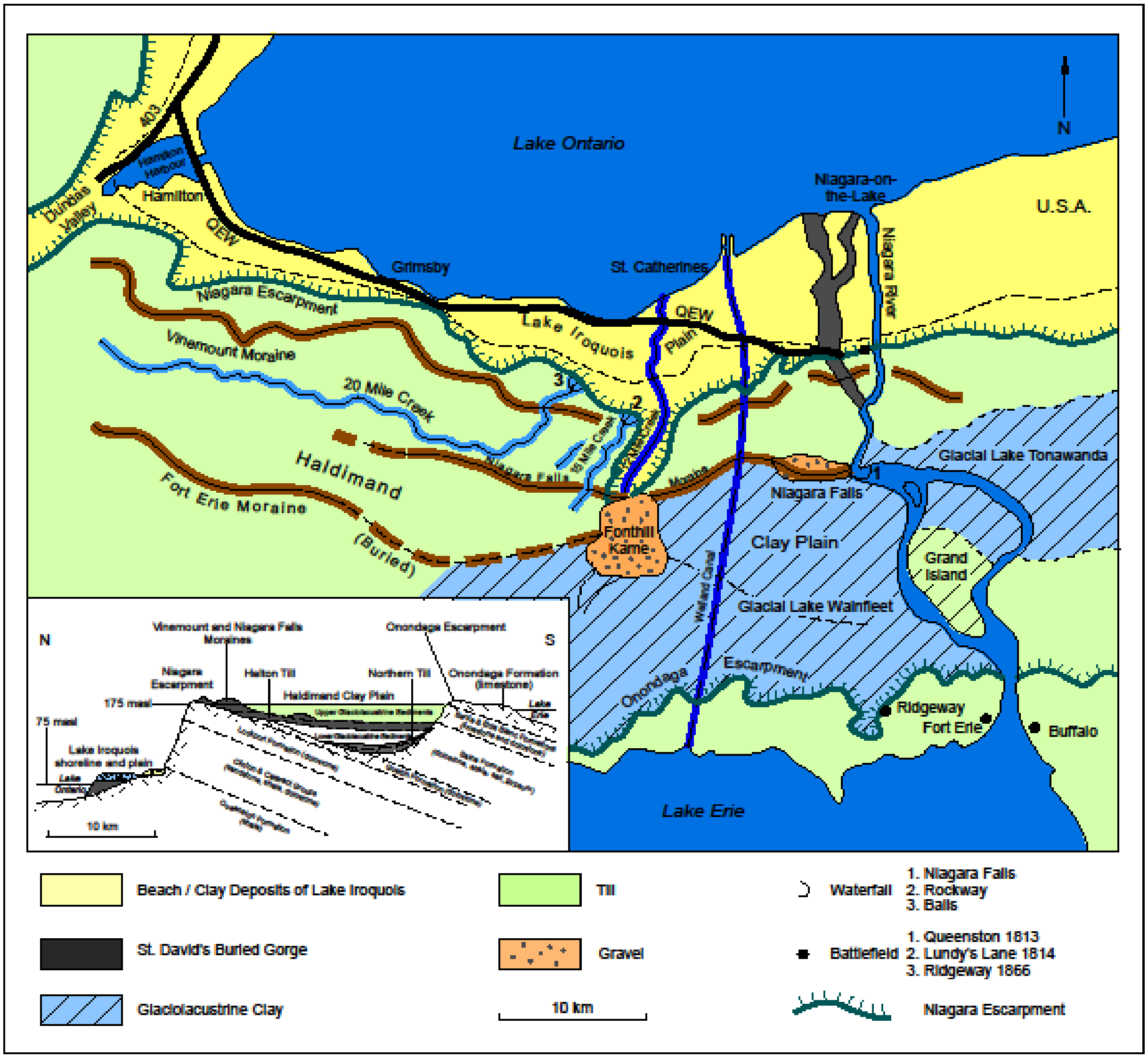
Deglaciation of the Niagara Peninsula consisted of a series of oscillatory retreats (interstadials) when ice withdrew from the Erie Basin, and readvances (stadials) into large ice dammed lakes flooding all or part of the Peninsula. Traditionally this behaviour is ascribed to fluctuations between cool (stadials) and warmer (interstadial) climates but these are more likely the response to dynamic changes in mass balance in the ice sheet resulting from calving in deep lakes. These short lived readvances involved narrow tongues (lobes) of fast flowing ice within the LIS and are directly analogous to ice streams within the modern Greenland and Antarctic ice sheets.

The initial retreat of LIS from its late Wisconsin maximum (Erie Interstadial) occurred at approximately 16,500 to 15,000 ybp. This saw ice withdraw to the Niagara Escarpment with glacial Lake Leverett to the south. During the subsequent Port Bruce Stadial, ice advanced to cover the peninsula leaving complexes of till and glaciolacustrine sediment deposited in glacial Lake Maumee at the western end of the Erie basin and notably exposed in cliffs near Port Stanley. With retreat during the Mackinaw Interstadial and subsequent advance a large lake with a complex history of water depth changes (lakes Whittlesey-Warren I, II, III) covered the Niagara Peninsula leaving a broad flat clay plain (Haldimand Clay Plain) south of the Niagara Escarpment (Fig. 12). The proximity of the Haldimand Clay Plain to major industry centers of Hamilton and Toronto was a key in the decision in 1985 to locate a long term landfill facility for hazardous wastes at West Lincoln. This was based on the view that clays would provide suitable natural attenuation. Research showed extensive fracture systems and rapid migration of contaminants into the underlying dolostones and the search was abandoned.

During the Port Huron Stadial (after 13,000 ybp) the ice front lay along the Niagara Falls Moraine and built a massive fan-delta at Font Hill (Fig. 12). Sediments within the hummocky Vinemount Moraine consist of ‘deformation tills’ (Halton, Wildfield Tills) created by reworking of glaciolacustrine sediment by the ice margin. Again, this is consistent with data from the Antarctic where fast ice flow and the formation of dynamic ice streams is facilitated by ice moving across wet sediment.

Final ice retreat after 13,000 ybp exposed the Niagara Escarpment and ponded glacial Lake Iroquois (named by J.W. Spencer after the Indian trails that followed its shore) in the Ontario basin between about 12,500 and 12,250 ybp. Its shoreline lies some 35 m above the modern level of Lake Ontario (though regionally tilted to the northeast as a consequence of glacioisostatic rebound). It runs along the foot of the Niagara Escarpment which today overlooks a broad Iroquois lake plain to the north (Coleman, 1936). The shoreline coincides for much of its length with the edge of a bedrock terrace marking the outcrop of the Whirlpool Sandstone (Fig. 6). With drainage of glacial Lake Iroquois, water ponded in the Erie Basin behind the Niagara Escarpment (early Lake Erie and lakes Wainfleet and Tonawanda; Fig. 12) spilled northwards over the escarpment’s lip initiating Niagara Falls some 12 km north of its present location. The mean annual recession rate is thus ~ 1 m (but see below).

Figure 12 Glacial map and section of the Niagara Peninsula



HISTORY OF THE NIAGARA RIVER AND GORGE

It is remarkable just how little is known of the evolution of the Niagara Gorge considering its prominence in the history of geology and popular culture (see Tinkler 1993, for an excellent summation). Little new data has been collected for virtually a century and most of the literature consists of reworked ideas and conjecture. The time is ripe for a comprehensive study using new methods for dating rock surfaces, geophysics and drilling that would place Niagara Gorge in the context of the broader preglacial, glacial and post glacial evolution of the Great Lakes basins.

The manner of the formation of Niagara Gorge is simple. Niagara Falls cascades down a 54 m drop over the lip of the Niagara Escarpment provided by the hard Lockport Dolostone. The average flow of the river is about 6000 $m^3 s^{-1}$. The falls are in retreat due to the sapping of soft Rochester Formation shales that underlie the cap rock. At the base of the falls, a 30 m deep plunge pool has been carved into soft sandstones and shales of the Queenston and Whirlpool formations. Historic rates of recession of the falls have slowed to centimetres at the present day because large amounts of water are siphoned off for hydroelectric power generation. About 50% of the daytime water flow and 75% of the night time flow are delivered (by canals) to the Adam Beck (Canadian) and Robert Moses (US) power generating stations downstream. A new tunnel is being constructed on the Canadian side from above Niagara Falls to Adam Beck but as of early 2009 the project is behind schedule because of extensive and unanticipated bedrock fracturing. This begs the question whether the location of the Niagara River (and buried gorge at S. Davids) are structurally controlled above Proterozoic lineaments in the underlying Shield that have a long history of movement (e.g., Eyles et al., 1993).

The realization in the early nineteenth century that Niagara Falls has retreated south from a position near Queenston on the Niagara Escarpment, to its present position, dramatically altered how Victorians viewed the planet. It confirmed the emerging concept of an Earth that was evolving and had not been ‘made’ as we see it today. As early as 1789, it had been proposed by Robert McAuslin that the gorge was the result of the falls retreating over many thousands of years. Sir Charles Lyell the English geologist, working with James Hall of the New York State Geological Survey, popularized this concept in the 1840’s. According to some, the Earth was thought to be young but Niagara Gorge could not have been cut in anything less than 8,000 years. Lyell then pointed to the rocks into which the gorge was cut to further emphasize the great antiquity of the planet. He is also credited with discovering an ancient gorge buried under glacial sediments (St. Davids Gorge). This was proof that planet Earth was not created as we see it today but had a long history of its own. Slow processes (such as undermining of the cap rock by the falls) have enormous effects over geologic time.

Father Hennepin was the first European to see Niagara Falls (in 1678); his descriptions suggest they have retreated about 300 metres since then. His visit is commemorated by a plaque along the Niagara parkway 5 minutes walk downstream from the falls, at the point where they lay in 1678.

Postglacial changes in Niagara River discharge and the geomorphology of the Niagara Gorge

The Niagara Gorge varies in form from north to south being subdivided into an Old Narrow Gorge, a Lower Great Gorge, the Whirlpool Rapids Gorge and Upper Great Gorge (Fig. 13). The last named is the widest (350 m). The various sectors along the gorge have been tied by some researchers to changes in discharge from the upper Great Lakes. For example, in the early postglacial at the initiation of the Falls at Queenston, water from the upper lakes drained eastwards through the still glacio-isostatically depressed Lake Nipissing basin and thence down the Ottawa River, robbing water that would otherwise flow through the Niagara River. This is thought to be reflected in the narrowness of the Old Narrow Gorge. Others argue however, that water from glacial Lake Agassiz flowed into the Erie Basin in the early postglacial overriding any reduction in flow created by the Nipissing outlet (Tinkler, 1993).

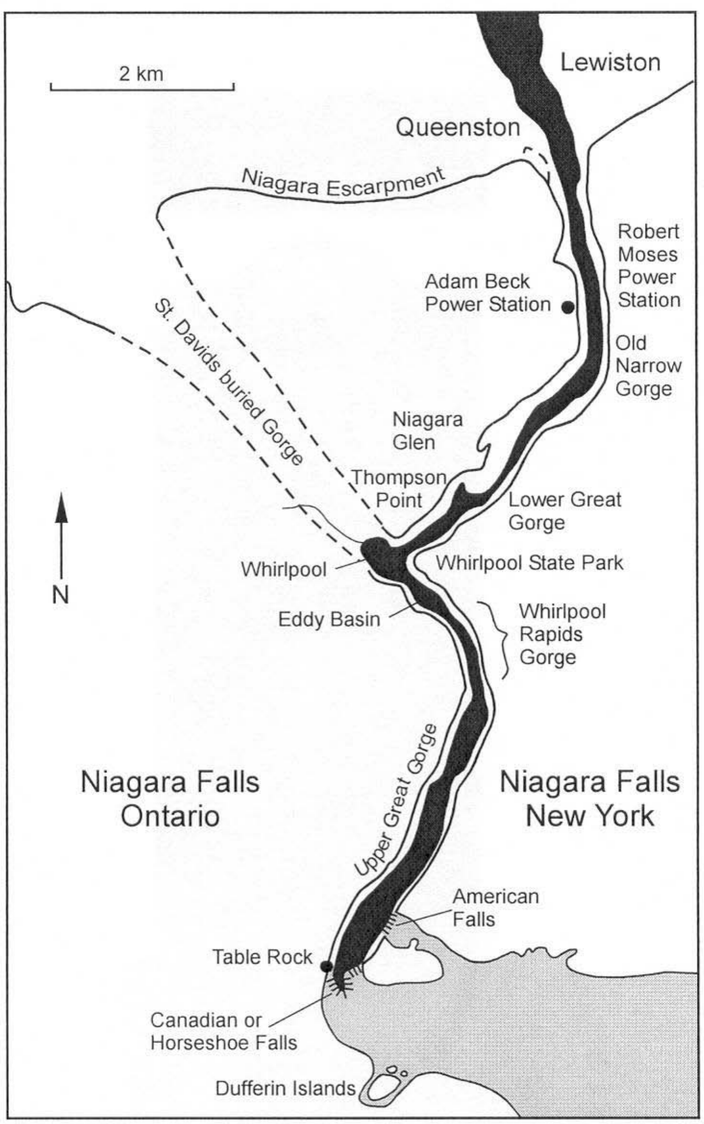


Figure 13: Niagara Gorge

About 5000 years ago upper Great Lakes water was eventually decanted back through Lake Erie to the Niagara River as the Nipissing area rebounded thereby increasing the discharge of the Niagara River (Jackson et al., 2000). The greater width (350 m) of the Upper Great Gorge may be the result of this marked increase in flow. There is a major difficulty here because at the time of the supposed increase in flow, Niagara Falls then lay in the area of the Whirlpool. The Whirlpool Basin marks where the modern river is eroding into the softer glacial sediment fill of an older gorge (St. Davids Buried Gorge) which intersects the present gorge (Flint and Lolcama, 1985). How much of the gorge upstream of the Whirlpool is 'old' having simply been flushed of its glacial fill? Some suggest the entire Whirlpool Rapids Gorge is entirely 'old' and was rapidly re excavated by the river. In this version, only the Upper Great Gorge is 'new'.

What has been entirely ignored in previous discussion of the relationship between gorge dimensions and discharge is the effect of *geology*, notably changing cap rock thickness and lithology. The geology between Queenston and Niagara is not uniform with considerable local changes in facies and thickness within Silurian strata which one might infer has had some effects on recession rates and gorge characteristics.

Rock fall is an ongoing process acting to widen the gorge throughout its length. On the eastern (US) side of the river just downstream (north) of the Rainbow Bridge and the Schoelkopp Geological Museum is the scar in the gorge sidewalls made by the collapse of a power plant in 1956. Very large undated rock falls occur at Niagara Glen.

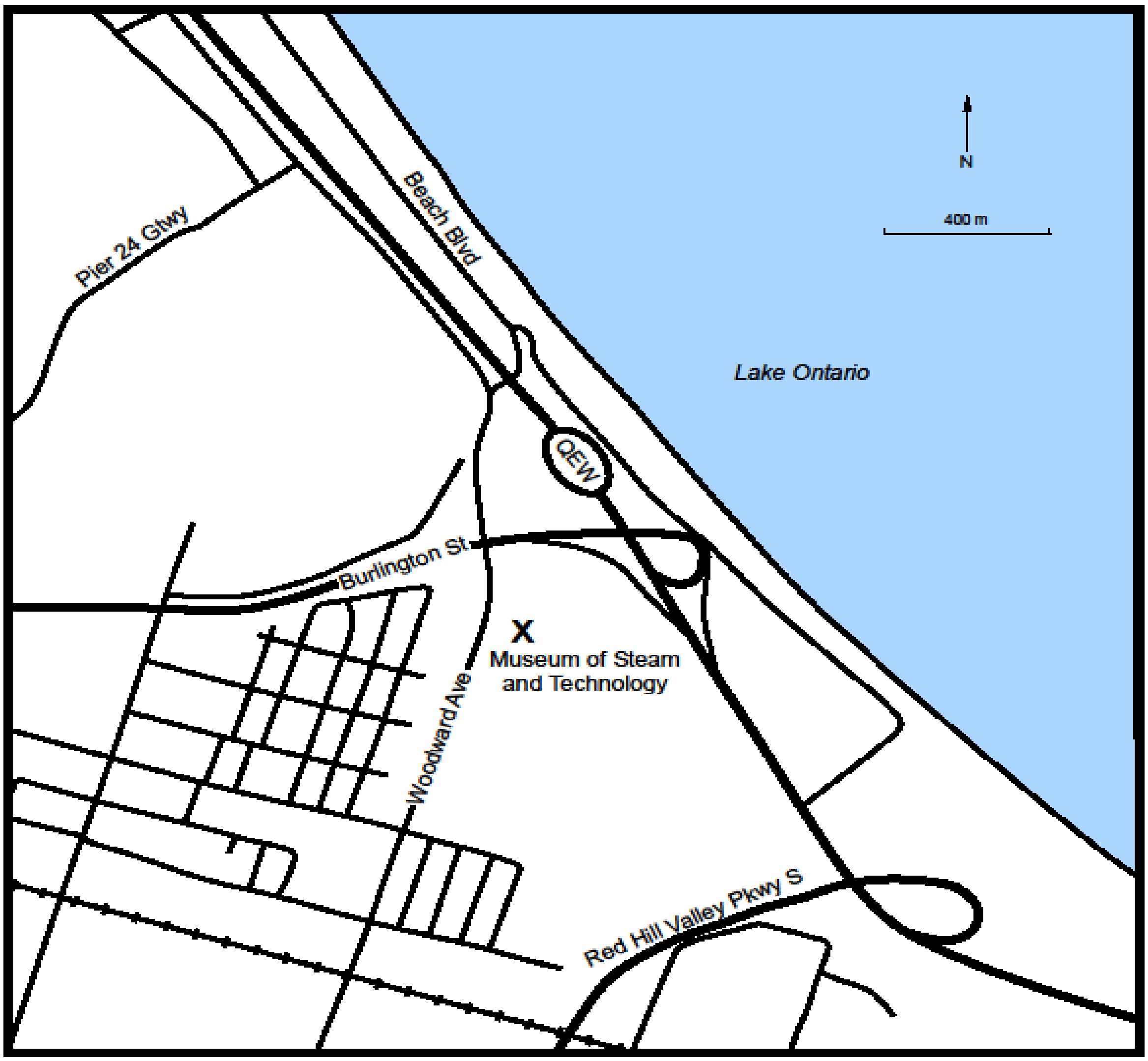
TRIP ITINERARY

Note: Since guidebooks are frequently used after the event by people who can pick and chose which stops to visit, this itinerary includes descriptions of several buildings that we will NOT have time to visit on this trip. These descriptions are in a smaller font, enclosed by square brackets [...].

Biographies, and information about Wine, War of 1812 History, and The History of Geological Investigations, are given as Appendices below.

Bus leaves South Entrance of Toronto Convention centre at 8.00 am, arrives at Exit 89 (QEW) at Burlington Street in Hamilton about 9.00 am.

From Burlington Street take the first exit onto Woodworth Avenue to the Museum of Steam and Technology.



Stop 1. Hamilton Waterworks (Duration 45 minutes.)

<u>900 Woodward Avenue, the Hamilton Waterworks</u> includes a stone engine house and boiler house, and a 150 foot brick chimney with a massive stone base. It was designed by Thomas Keefer and built in 1859, of two different types of stone: bioturbated yellow-brown Eramosa dolomite, and grey Whirlpool cross-bedding and laminated sandstone. According to the museum staff, both were quarried in Stoney Creek. The base of the stack includes many very large blocks of sandstone with both a smooth and rock-faced

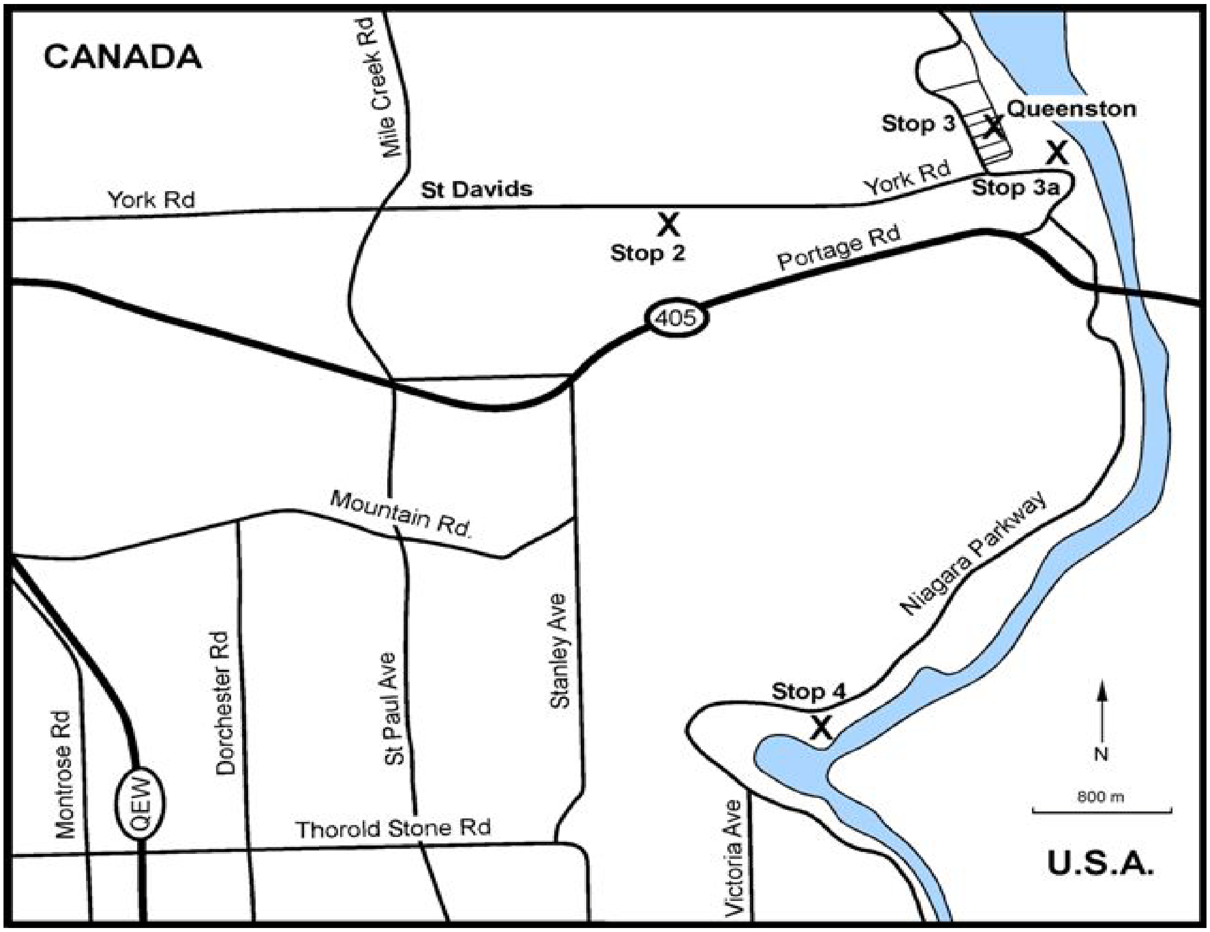
finish. The Whirlpool sandstone is coarser and thicker bedded than that seen in most Hamilton houses; it was probably quarried near the base of the Niagara escarpment, either below Albion Falls or below Felker Falls. There are outcrops of Whirlpool at both localities. The Eramosa probably came from a quarry above the escarpment near Rymal.

An informative booklet, “Hamilton’s First Pumphouse,” is produced by the museum: it includes a brief biography of Thomas Keefer (see also Appendix). Chapple (2006, p.107) points out that its construction resulted from the cholera epidemic of 1854. The master mason was George Washington, and the exterior style is classical. Inside, the technology was advanced for the time. A massive stone structure was required to support the 90-ton beam engine, constructed in Dundas, and still in working order. The exterior of the building has recently featured as the (fictional) Toronto morgue in the TV Show “Murdoch Mysteries” (the Irish pub built of rubble stone and a handsome Victorian mansion also supposedly in Toronto, are located in downtown Hamilton).

Note: there is plenty of free parking and easy access to the exterior.

To rejoin the QEW turn right out of parking and drive for 3 km on Woodworth to reach turnoff for QEW Niagara. Drive about 50 km to Exit 38B (Glendale Avenue NORTH). Go north to York Road and turn right (east). Continue on York Road, past Chateau des Charmes (at 3 km) and St David’s (at 5 km). Just before Concession 2 road, note the <u>old Railway embankment</u> on the right, built in 1854 as part of a bridge for the improved <u>Erie and Ontario Railroad</u>. It consists of large trimmed blocks of crinoidal dolomite (NOT Queenston stone, which is not as thoroughly dolomitized), perhaps brought from quarries closer to Beamsville. The Erie and Ontario was originally built in 1835, using wooden rails and horse drawn cars, to offset loss of trade along the Niagara Portage, due to construction of the First Welland Canal in 1829. The improved railroad, using steam power and iron rails, was constructed beginning in 1852, but was abandoned in 1959.

(Total driving time 45 - 60 minutes) continue to:



Stop 2. 1755 York Road, the Davis-Prest (now Watson) House (Duration 30-45 minutes.)

It was built by William Davis, a loyalist from Massachusetts, in 1819 using Whirlpool sandstone quarried from the edge of the minor escarpment just north of the house (which is also the Lake Iroquois shoreline). The sandstone blocks are rough finished, trimmed and coursed. The front door has steps of Queenston stone, side and fan lights, with an arch-and-keystone of Queenston stone above. The windows have sills of Queenston stone but the lintels and voussoirs are Whirlpool. The house and property is currently being extensively restored and improved by Bob Watson. Chapple (2006, p.21) pointed out that the house "captures the very essence of loyalist style" and that its sophisticated design and refined craftsmanship is exceptional for a farmhouse.

[Almost next door is 1717 York Road, a more modest, one and a half story, house, was built in 1820, also by William Davis. It too is built of rough trimmed, coursed Whirlpool sandstone. Sills and front steps are Queenston.]

Follow York Road to its end at the Niagara Parkway. Turn left , and then right on Kent Street. At the corner of Kent and Queenston is one of the older stone buildings in Queenston, a barn dating from early in the 19th century. Turn left on Queenston and proceed for several blocks to a point that offers a fine view of Willowbank. We will leave the bus here and walk up to the house. The bus continues up Queenston Rd until it joins the Niagara Parkway, then turns left, and left again (near Dee Rd) to enter the Willowbank estate.

Stop 3 Willowbank , 14,487 Niagara River Parkway (Duration about 30 minutes.)

Willowbank is a Classical Revival mansion, built in 1833-1835 by Alexander Hamilton, son of Robert Hamilton, the founder of Queenston (see Appendix). It is now the School of Restoration Arts, founded to "teach the special skills needed to restore and preserve heritage buildings." According to Chapple (2006, p.24) this most spectacular of all the Queenston stone houses "captures the essence of Greek Revival style" and it location is suggestive of an ancient temple. The house was designed by John Latshaw (see Appendix), who lived in Drummondville (not the town in Quebec, but then a village near Niagara Falls). Blake and Greenhill (1969, p.30) give some interesting details of the way the design changed as the house was built.

Most of the stone is Whirlpool sandstone, most visible in rough surfaced, but carefully sized, courses on the sides of the building. Window voussoirs are also Whirlpool but the sills are Queenston stone. Finished, "rusticated" ashlar is also used in the masonry that supports the wooden pillars. At the back, a fine grained brown-weathering dolomite, with much crinoid debris, perhaps Goat Island or Eramosa is also used.

Drive south on Niagara Parkway, up the Niagara escarpment. A good view may be obtained from the Parkway across the Niagara River, and at the top of the escarpment, on the right is the Brock monument, marking the location of the Battle of Queenston Heights, during the War of 1812. We will park here from a brief stop. A staircase leads down to an "1812 Redan" with a cannon used in the battle.

Continue south on the Niagara Parkway, past the Floral Clock and Adam Beck Power Station 1 (at 3 km from Willowbank), built 1901 to 1903. Power Station 2 was built 1922 to 1930. Both were constructed of concrete not stone. Adam Beck was not the first hydroelectric power station built in Niagara: that honour belongs to DeCew Falls (near St. Catharines) which was built in 1898. Also see remarks about the Toronto Power stations south of Niagara Falls, built in 1901to 1905 (see below, Stop 5). DeCew Falls supplied power to the Cataract Power Company of Hamilton, contributing greatly to the economic growth of the city.

Continue past the view over gorge at 0.6 km, and Niagara Glen access on left and golf course on right at 2.5 km, to parking at 3.5 km (Use the *second* access road on left, immediately opposite the sign for the Whirlpool Restaurant):

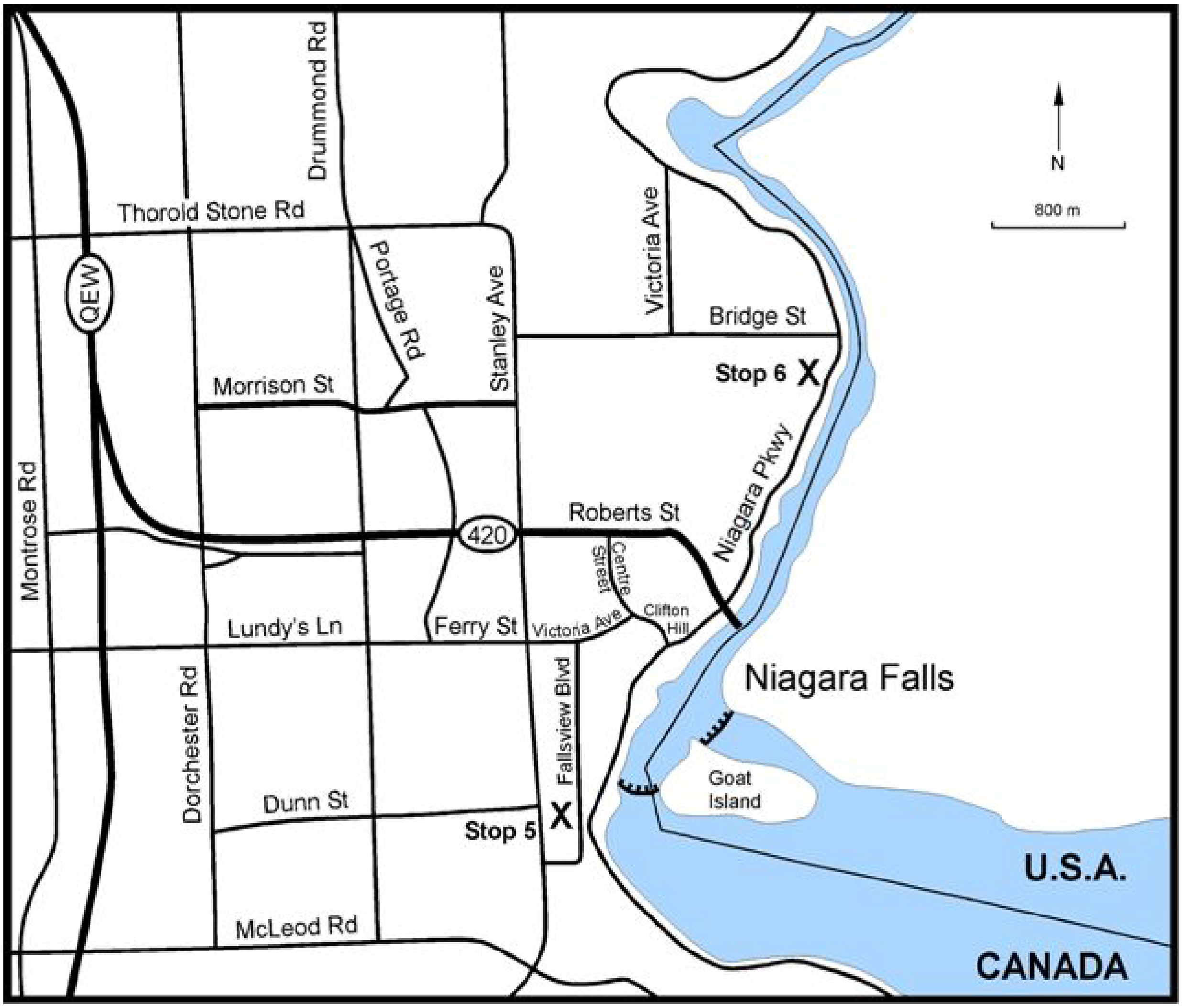
Stop 4. Whirlpool overview (Duration 30 minutes.)

This has an excellent viewing platform close to the parking area which gives a view of the modern Niagara Gorge and the buried St. Davids Gorge discovered by Charles Lyell in October 1841 (Fig. 13). There will be a brief discussion of the origins and age of these gorges and Niagara stratigraphy (see Introduction). The site, known as Thompson's Point, was originally the site of an early quarry (see description given earlier in the Guidebook). The Niagara River in the Whirlpool is about 13 m deep. During the day, water circulates in an anticlockwise direction. Water that leaves the basin on its Canadian side actually flows under water entering the basin from upstream to emerge as huge upwellings on the American side. In contrast, during the night, water levels in the river drop by about 3 m (as more water is taken off by hydroelectric plants upriver) and the circulation in the basin reverses. As the level of the river begins to rise early in the morning the basin reverts back to its normal anticlockwise flow.

Return to bus, go south on Niagara Parkway and turn at 1.5 km from last stop turn right (north) on Whirlpool Road. After it joins Stanley Avenue, continue on Stanley for 1.6 km, crossing Highway #405, then turn left on Niagara Townline (#61), and turn left onto Highway #405 at the sign for QEW Toronto. After #405 merges with QEW, exit at Glendale North. Cross the QEW. Turn left onto York Road, then right on Airport Road. Continue north to the junction with Niagara Stone Road and turn right. The entrance to the next stop is just on the right.

Lunch Stop. Southbrook Vineyards (Duration one hour and 20 minutes). Lunch will consist of salad and pizza, accompanied by a tasting of Southbrook wines, with commentary. For a History of Niagara Wines see Appendix 2. The Niagara Stone Road was one of the first roads built by settlers that did not follow an Indian trail. It was originally built in the early 1800s to shorten the distance from Niagara-on-the-Lake and the settlements west along Lake Ontario, and called the "swamp Road." It was "planked in the late 1840s, and "stoned" later.

After lunch turn left out of parking on Niagara Stone Road, then turn left on Airport Road and return to the QEW (Niagara). Follow the QEW to Highway #420, keep in the right lane, and turn right (south) on Stanley Ave toward Niagara Falls. There are several possible sites from which to view the falls. We will probably use the Minolta Tower on Fallsview Rd, reached by turning left on Ferry Street, then right on Fallsview.



Stop 5. Niagara Falls (Duration 30 minutes.)

This is a "tourist stop" at the top of the Minolta Tower which provides an excellent overview of Niagara Falls and surrounding region. The Font Hills Kame is clearly visible on the skyline. For a brief geological account of Niagara Falls and Gorge see the notes on the Glacial History of the Niagara Peninsula.

[For those jaded travellers (not on the official field trip) who have often seen Niagara Falls, but are following this guide on their own, we suggest parking south of the Falls taking a short walk to the south to look at:

The Toronto Power Generating Station, a large classical design building on the Niagara Parkway above Niagara Falls which began generating power in 1905. It was the brain child of William Birch Rankine, a lawyer originally from Geneva, NY. Water was diverted into the power station from the Niagara River, and discharged by tunnel beneath the falls. Power was supplied to Fort Erie in 1907. In 2009 it will be turned over to the Niagara Parks Commission, but there seem to be no immediate plans to convert it into a museum. The stone used was a coarse variety of Queenston stone. Further south again there beautiful gardens, including a Fragrance Garden and a large Greenhouse. Across the Parkway is the Toronto Powerhouse. It was built in 1901 by the Ontario Power Company, with a magnificent row of columns composed of Indiana limestone. A wing dam was used to collect water from the river, and a tunnel 33 feet in diameter and 2000 feet long underlies the building. It is no longer used to generate power, but is not open to the public.

Close by, are Mount Carmel, the small Our Lady of Peace Church, and the Loretto Centre. In the hustle and commercialism of modern Niagara, these are (or were) amazingly quiet centres for spiritual renewal, operated mainly by Roman Catholic nuns.

The Mount Carmel buildings were constructed of Queenston stone and Whirlpool sandstone. They were built over six years and opened as a Carmelite monastery and hospice in 1899. The stone used was a coarse laminated Whirlpool sandstone, with Queenston dolomite trim. It became a seminary in 1920, and also served as a high school and college. In 1979 is became a retreat house, used by other denominations (including Buddhists) as well as by Catholics. The chapel with its rose window was added in 1926. The buildings were damaged in a fire in 1967.

Loretto was built of Lockport, probably also Gasport, in 1861, and served as a convent, school and retreat centre, operated by the Loretto sisters. It was bought in 2006 by Sheraton, which operates the nearby Fallsview Hotel. The small church nearby, built in 1837-1839 as St. Edward's, was renamed Our Lady of Peace in 1861. It has been staffed by the Carmelites since 1873. The building stone is fine grained dolomite rubble with some chert, so almost certainly Goat Island dolomite quarried nearby. A small burial ground, north of the church, was reserved for the Loretto nuns.]

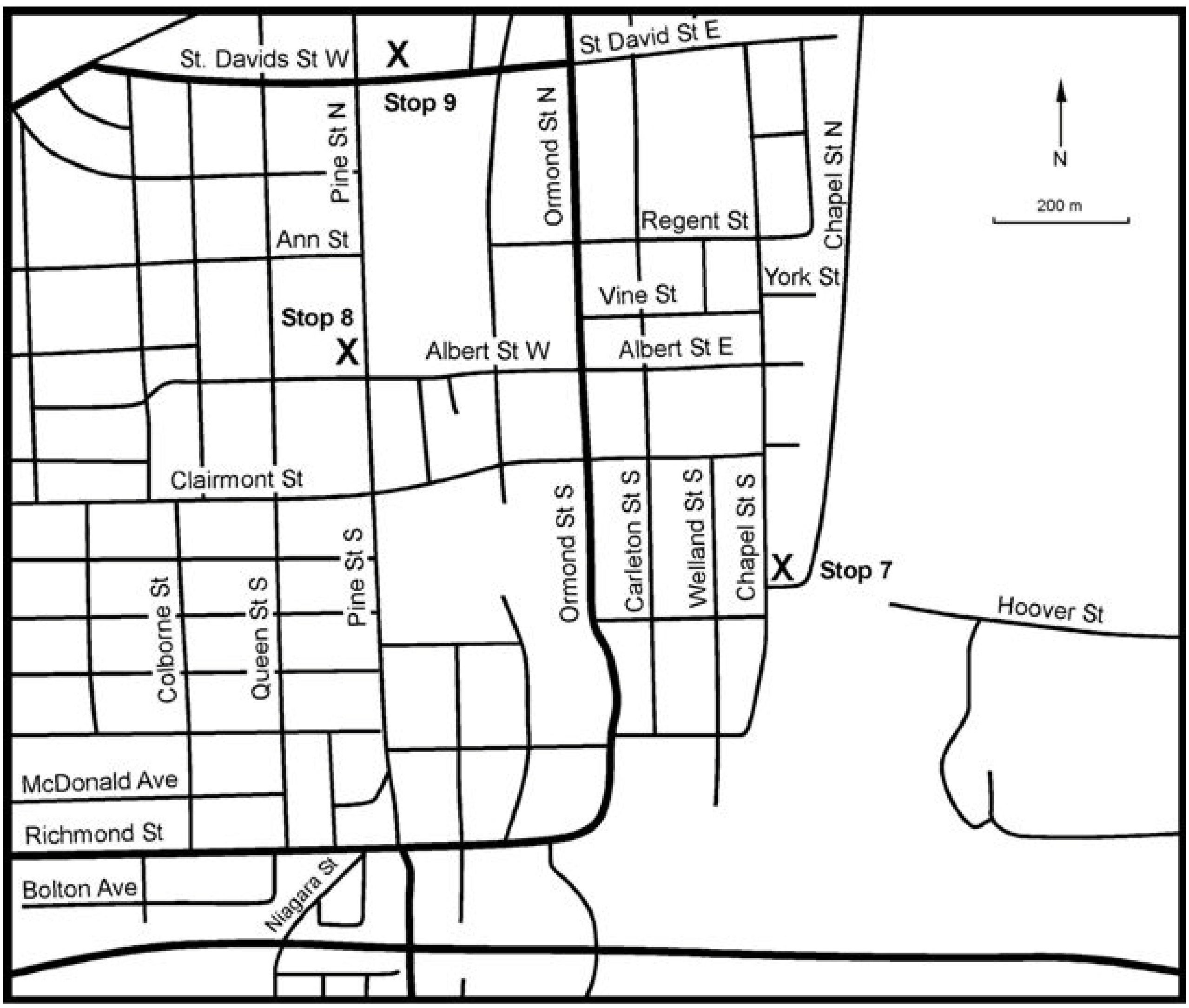
Return to bus, and drive north, turn right on Murray St to the Niagara Parkway. Drive north past the Rainbow Bridge and turn left on Park Street (just before the Whirlpool Bridge), then park in the vacant lot opposite the Old Post Office at the junction of Park St and Zimmerman.

Stop 6. Buildings on Zimmerman (Duration 30 minutes.).

4190 Bridge Street now the Law Offices of Ryall, Walker (at Bridge and Zimmerman), was formerly the Imperial Bank Building, constructed of cut Gasport in 1906 (Niagara Public Library website). According to Parks, the stone came from the Merritton quarry (Can we tell the difference between this and "genuine" Queenston stone?). One side is red brick. The Imperial Bank (originally the private Zimmerman Bank) was incorporated in 1875, and in 1961 merged with the Bank of Commerce to become CIBC. The Bank of Commerce traces its origins back to the Bank of Canada, incorporated in 1858. Worth a quick look, particularly as this is a variety of "Queenston stone" that did NOT come from Queenston; but we will spend most time at:

The old Customs House and Post Office, 4852 Zimmerman (at Park) was built in 1883, mainly of Queenston stone, at a cost of $30,000. The first floor was used for the post office, the second for customs, and the janitor lived on the third. Later the building was used by the police and magistrates (Jay and Long, 1981). A lesser quality stone, shalier, with silicified fossils was used as rubble (so it is probably Goat Island Formation, and it may have come from the same quarry as the better quality Gasport). The small building to the north is very similar and was probably built about the same time. The building is now boarded up. Boileau (2006, p.27, 124) identifies the architect as Sir Thomas Fuller, who also designed post offices in Hamilton, Galt, and Goderich amongst others: not all of these have survived. From the state of repair (including the slipped voussoirs illustrated by Boileau) this one will not survive much longer either.

Go north on Zimmerman (or Erie), then left (west) on Bridge Street to Stanley Avenue and turn right (north). Follow Stanley until it goes off to the right, then continue straight on Thorold Stone Road. Follow this (Highway #57) until it becomes Highway #58 and passes through the Thorold Tunnel under the modern Welland Canal. Take the Pine Street North exit, and go north. Turn right on Richmond/Ormond, then right again on Portland St. Turn left on Chapel St and park outside:



Stop 7. Welland Canal Lock 7 Viewing Centre (Duration 20 minutes.)

This stop has a view of the modern Welland Canal (built of concrete). Lock 7 is the last lift to the top of the escarpment. The second canal was west of here (between Front St and the modern Pine St) and the third canal was east of the modern canal. Refreshments can be purchased here, and many free tourist brochures are available. Next door, at #42 and #40 Chapel Street, are two old stone houses probably built for lock workers. They are worth a quick look. They probably date from about 1850.

Continue north on Chapel Street. Turn left on Clairmont St. Pass St Johns and St Andrews churches.

[St John the Evangelist Anglican Church, 12 Carleton St S, constructed 1853-1856, largely due to the efforts of Rev. Thomas Brock Fuller, who was the adopted son of Rev. William Leeming (of Chippawa). Kivas Tully was the architect. Fuller had been appointed rector of an older St. John's in 1840, and he later became the first Bishop of Niagara. The spire was added to the tower in 1878.The main stone is a banded bioturbated fossiliferous dolomitic limestone (perhaps Eramosa). It has weathered badly and has been partly plastered over. The window sills and voussoirs use a better quality, crinoidal dolomitic limestone, probably Gasport. Renovations have been carried out including one in 1967, and another that is in progress. The porch is new, constructed of a brown-weathering fossiliferous limestone, probably not local (imported from the USA?).

St. Andrew's Presbyterian Church (26 Clairmont St) was built in 1883-1884, replacing a brick building which is still standing at 17 Ormond St. N.. The architect was W.R. Gregg of Toronto. The stone is mostly a fine grained banded dolomite, with a few chert nodules (so probably Goat Island). The sills, lintels, and quoins are made from a coarse, fossiliferous dolomitic limestone (Gasport). The walls are "random coursed rubblestone...divided by raised square ribbon mortar joints, with quoins accenting the attractive windows and doors" (LACAC report). The Church Hall, designed by Nicholson and MacBeth of St. Catharines was built in 1927 using very similar stone, although no chert nodules are in evidence.]

Cross Carleton, Ormond, and Front Streets and turn right (north) on Pine. The next stop is on the right just beyond Albert St, about 0.3 km from the turn onto Pine.

Stop 8. Welland Mills 20 Pine Street North (Duration 20 minutes.).

The Welland Mills (20 Pine St, north of Albert) were built in 1846-1847, and have recently been renovated. The Thorold LACAC website (accessed February 2008) stated: "The Welland Mills is the most architectonic of industrial buildings in the Niagara Region from the first half of the 19th century, one of the most notable in Ontario...Its handsome proportions, simple bold detail, regularity and well-executed masonry represent the best of the period." It was built by Jacob Keefer (see Appendix) and was at that time adjoining the second Welland canal. Front Street, just east of the Mills and parallel with Pine Street, was so named because it fronted onto the Second Canal. The mill was capable of producing 300 barrels of flour per day, and the storehouse had a capacity of 70,000 bushels of wheat and 5,000 barrels of flour. The cooper shop alone employed 12 men.

The stone is Gasport dolomitic limestone ("Queenston stone" but probably not from the Queenston quarry) with many large fossils: a better quality stone (probably from the same source) was selected for the quoins, sills and lintels.

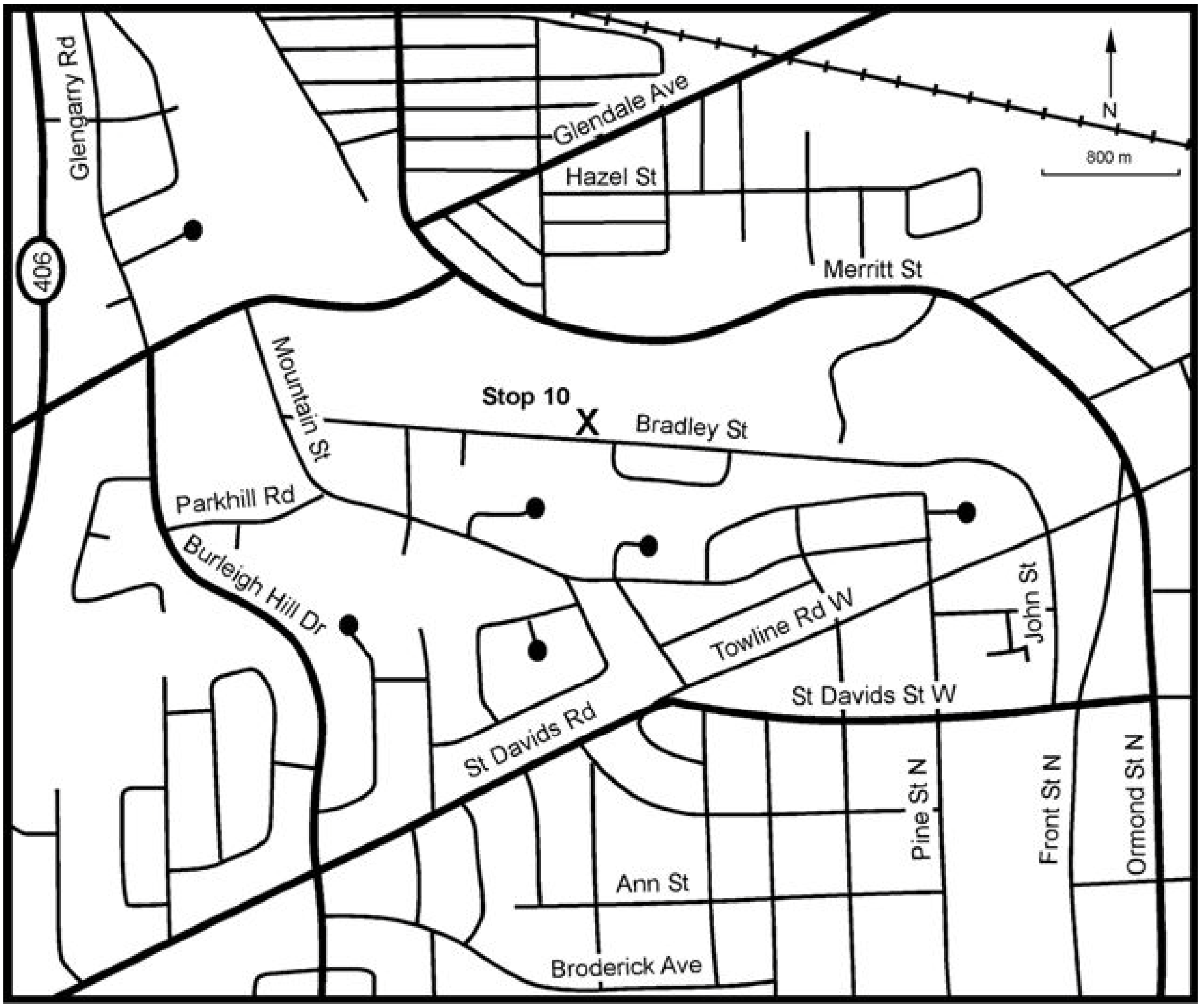
Return to Pine St, turn right and continue north three blocks to St Davids St. Turn right and then left to park at:

Stop 9. Maplehurst (Duration about 20 minutes.)

Maplehurst (14 St. David St W) is a mansion built in 1885 by Hugh Keefer, grandson of George, and son of John. The Keefer family included several prominent citizens: George Keefer served in the Lincoln Militia during the war of 1812, and was an original stockholder in the Welland Canal Company (established 1824). His son Samuel supervised construction of the stone locks for the second canal; another son Thomas was active in canal and railroad construction (See Appendix). Jacob Keefer founded the Welland Mills (still standing on Pine St. in Thorold in 1845. Hugh Keefer was active in the stone and brick industry, both locally and in Vancouver. The family would have had a fine view of the second Welland canal.

Maplehurst is built of fine grained, laminated red Grimsby sandstone, with green grey reduction patches, probably from the Merritton quarry. It included extensive use of coarse, fossiliferous Gasport dolomitic limestone as a trim. Maplehurst has recently been restored to its former glory, and is now a hotel and restaurant ("the Keefer Mansion Inn").

Return to St Davids and turn right on Pine Street for one block, then right on Townline Rd and left on John Street. Follow John Street north until it turns left (west) and becomes Bradley. Pause at about 0.8 km to let off passengers to examine the Second Canal Locks. At 0.3 km further north is 79 Bradley Street, a double house, constructed of red Grimsby sandstone (with greenish sandstone that weathers yellow brown, used for quoins. It is one of two houses built for the lock keepers. Pause near here to left off passengers, then continue to Parking lot 0.3 km further west on the right side of Bradley St. The second lock-keepers cottage, overgrown with ivy is opposite the parking spot.



Stop 10. Mountain Locks Park on Bradley St. (Arrive about 5.15 pm. Duration 30 minutes).

Mountain Locks Park was the site of seven locks built of regular metre-size blocks of Gasport dolomite for the second Welland Canal, completed in 1845. The locks were 8.1 m wide and almost 46 m long. Boats were raised 28 metres in this flight of locks. 27 locks were required for the entire canal. The locks in the park were originally numbered from 15 to 21. We will examine Lock #20, which can be crossed on a small footbridge, and then walk down the path to rejoin the bus.

According to Jackson (1997, p.52) the limestone for the locks was obtained from the quarry at Queenston, shipped down the Niagara River, then via Lake Ontario to the first Welland canal. Exploitation of Queenston stone thus began at least as early as 1841, though the stone does not seem to have been widely used for building in most of southern Ontario until the 1890s, when it was no longer in much demand for canals and railroads.

Also worth noting briefly at this stop are two lock-keepers cottages built from red Grimsby sandstone. The upper one is near the foot bridge, and the lower is near the parking lot. The lower cottage is overgrown with ivy, and a small quarry behind it exposes Thorold sandstone.

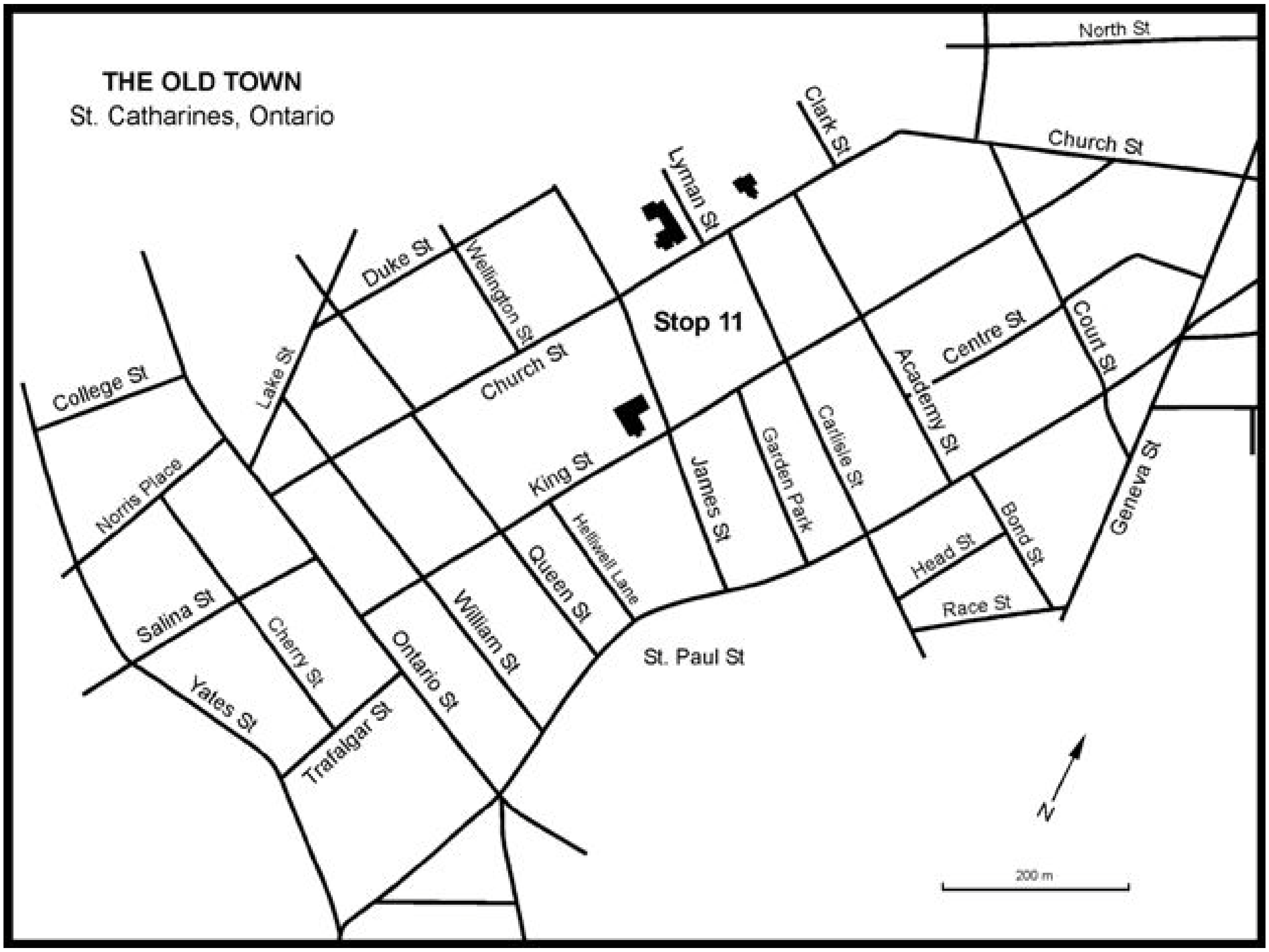
Board the bus and continue north down Bradley, turn right on Mountain, then right again at the traffic lights on Glendale Avenue. We will pass The Keg on the right, then turn left on Merritt St., pass the Lybster Mill, and follow Merritt St. past the old Merritton Town Hall and over the bridge to turn left at the traffic light on Oakdale Avenue.

[The Keg was originally the Merritton Cotton Mills, 344 Glendale Avenue,. It was rebuilt after a fire in 1881, using Grimsby sandstone from the Merritton quarry, with a trim of Gasport dolomite. It is now a steakhouse, one of the most popular locations in the Keg chain.

The Lybster Mill, one of Canada's pioneer cotton mills which was built in1866 and has recently been extensively restored. It was built of fine grained, light coloured dolomite (perhaps Goat Island Member of the Lockport, or Guelph dolomite: the stone is unusual for this region). A few large fossils can be seen.

The Merritton Town Hall, on Merritt St, at Walnut (just south of the railway and east of the first and second canal) was built in 1879 for a cost of $3000. It is now a community centre, and was earlier home to the St. Catharines Historical Museum. The stone is red Grimsby sandstone, from the Merritton quarry, with Queenston stone as a trim. An addition was built in 1950 to house fire engines.]

Follow Oakdale north. It roughly follows the route of the Second Welland Canal (to left of road). Turn left (west) at 2.0 km on Westchester, cross bridges (at 2.8-3.5 km) and turn right on St Paul (at 3.7 km). Turn left on James St (at 4.0 km) cross King St and park behind:



Stop 11. Old Courthouse at King and James. (Duration 30 minutes.)

The former Lincoln County Courthouse at King and James was designed by Kivas Tully (see Appendix) as the St. Catharines Town Hall and completed in 1850. In 1864 St. Catharines became the county seat of Lincoln, and the James St addition, to the east (northeast), was designed by John Latshaw (see Appendix) as the Courthouse and built in 1865 (Latshaw also designed the Stamford Township Hall, Ruthven, and Willowbank). The building served as the courthouse until 1881, and is presently a theatre. The front of the original building was constructed from “Queenston stone”, and so was the east wing (some blocks contain large fossils such as tabulate corals). The west side (part of the original building?), was built of Kingston limestone, and the rear (added later) of red brick. The basement on the east was constructed of a bioturbated dolomite (?Eramosa) and on the west of Grimsby sandstone. The east wing and rear were added in 1865. A detailed discussion of the architecture, and plans of the original building were given in MacCrae and Adamson (1983, p.141-143). Originally the basement was given over to the fire engineer and equipment, and a police office and jail. The first floor was used mainly for the town market and the second floor for the town hall proper (assembly room). There was a major renovation in 1998.

[Close by but not close enough to visit on our trip, are:

St. Catherine of Alexandria Cathedral, on Church Street west of James Street, was rebuilt after the original wooden church was burned down by an arsonist, in 1843-1845 using donations of money and labour from Irish canal workers (during delays in canal construction); wings were added in 1859 and 1870, and further modifications made in 1888-1895. Several parishes were established specifically to minister to the many Catholic Irish who arrived in Ontario in the 1820s to work on the Welland and Grand River canals. Many had earlier worked on the Erie Canal. In the 1830s Catholic parishes were established in St Catharines, Niagara-on-the-Lake, Niagara Falls, and Thorold. After the Irish famines in 1845-1850, more immigrants arrived, increasing the proportion of the Catholic population of the Niagara Peninsula to about 15%. The Diocese, however, was not formally established until 1958.

The architectural development (though not the names of the architects) is recounted in the official history, issued for the 15oth Anniversary of the founding of the parish in 1832 (*The Cathedral of St Catherine of Alexandria*, 1982). The first church measured 40 by 80 feet and had a square tower at the south front. The east wing was added in a more clearly Gothic style in 1859, followed by the west wing in 1887, and in 1888-1895 the tower was taken down, a new tower and steeple (with a new bell, ordered from Baltimore) was added at the southwest corner, and the church extended south somewhat. The stone is mainly Gasport, but with many other types of stone used, particularly at the back, including sandstones.

St. George's Anglican Church, next to the Cathedral on Church Street just across James Street, was built between 1836 and 1840, after a fire destroyed the original church. The original church, built in 1796 was the first church in St Catharines, and was a "union church" used by several different Protestant denominations. Much of the "new" church is now covered with plaster, but the tower and front were restored in 2006: the stone is Kingston stone. At the back some red sandstone can be seen, and the trim at the front is Queenston stone. The small carvings around the front door are also in Queenston stone (the lack of detail shows the difficulty of carving in this stone].

From the parking lot, turn right onto King Street. At the end of King turn left on Ontario St., then right onto St Paul St. Cross the bridge over Twelve Mile Creek, and keep driving west on St Paul St (Highway 81), past the Catholic Church near Pelham St, then over the railway bridge, and on past Creekside and Rockway Glen about 10 km to Jordan.

If we have time we will stop at St. John's in Jordan. Turn left (south) up the hill and then sharp left (opposite the Public School) into St. John's Church.

Stop 12a St. John's Church, Jordan (Short stop about 15 minutes).

St. John's Anglican Church, 3685 McKenzie Drive was built in 1841, mainly of a light grey sandstone, which is probably Whirlpool. A few fossils are seen in some blocks, however, so it may also include Thorold sandstone, and certainly includes a few blocks of red Grimsby, and some purplish stone that may also be Grimsby. According to Doors Open Niagara 2006 "The church is a blend of Gothic Revival with classic proportions."

(A leading modern winery Flat Rock Cellars is only 1 km further along Highway #81 from here.)

Parks (1912) described two quarries in Jordan: (i) the Biggar quarry "is situated where

Sixteenmile creek cuts the Escarpment...on both sides of a ravine...” but the product was used only locally; and (ii) the Thompson quarry, adjoining Biggar’s: “some of this stone was used in the construction of bridges on the Great Western line...” This quarry is in grey sandstone, “at a lower horizon” and may have been Whirlpool. Perhaps it supplied the stone used for St Johns.

Return to highway 81 and continue west. The ivy covered building at the corner of King and 19th Street, now the Antique Lighting store at 3738 King Street was built of bioturbated dolomite and Grimsby sandstone. This was originally the Imperial Bank, and the red sandstone came from Gibson’s quarry in Grimsby. 3 km west is Vineland (Victoria Avenue), and 6 km west we enter Beamsville. One km further, just west of Barlett/Aberdeen Rd is:

Stop 12b Inverugie (Duration 30 minutes).

Inverugie, the mansion constructed in the early 1890s by William Gibson (1849-1914); see Appendix) became part of the Great Lakes Christian College in 1954. Inverugie (now Perry Hall) was built from Lockport, probably a thoroughly dolomitized Gasport, with small pores. No doubt the stone came from his quarry above the escarpment (see Appendix). Its characteristics are in contrast to the typical “Queenston stone” (a dolomitic limestone, but also Gasport) that we will see later in the trip. Two other buildings now on the campus were also largely built from Lockport dolomite: the present Daycare Centre and Georgian Hall. The lower part of Georgian Hall includes some field stone of Shield derivation – which is unusual for this part of southern Ontario, as the large boulders in the till of the Ontario lobe are mostly local dolomite. Shield-derived fieldstone was available only further to the northwest (e.g., Paris, Galt).
Continue west on Highway 81. 2.4 km on is Mountain View Road. Turn left, and left again at Locust, for:

Dinner Stop: East Dell Winery and “The View” restaurant. Arrive 7.15-7.30 pm.

There should be enough light (in May) and time to admire the Beamsville bench and discuss its significance for the cultivation of grapes.

After dinner, return to Highway 81 (King St) and go west to turn right on Bartlett Avenue and join the QEW and drive back to Toronto.

Appendix 1

Robert Gibson (?-1884) and William Gibson (1849-1914)

In the Grimsby-Lincoln area the pioneer quarryman was Robert Lillie Gibson (?-1884), who emigrated from Scotland with his parents and family in the 1860s. He was in Windsor and St. George before settling in Grimsby in 1866. He was able to open several new quarries and develop a successful business mainly because of the need for stone for use by the railroads, both as rubble to improve the stability of the rail beds, and as building stone to replace the wooden bridges. The line from Hamilton to Niagara had been constructed in 1853, and needed upgrading in the 1860s. After Robert's death the business was taken over by his nephew, William Gibson (1849-1914), who later was elected to Parliament in 1892, and became a Senator in 1902. He supplied stone for the construction of the third Welland canal in the 1890s, and was active in many businesses, besides stone production. In the early 1890s, William constructed a stone mansion in Beamsville, named Inverugie (for the derelict Inverugie Castle in Scotland). He died there in 1914.

The Gibson quarries included property in Lot 10, Concession 2, Township of Grimsby: it supplied the stone, a red and green-grey variegated Grimsby sandstone (Medina) for the former Imperial Bank building at the top of the hill (on the highway at Jordan: ?now demolished), his own house at Grimsby, and the St. John's Presbyterian Church (10 Mountain St. in Grimsby), built by Shaffer Bros using stone donated William Gibson's son Jack Gibson in 1928, and extended using the same stone in 1957. Much of the stone from Gibson's quarry was used by the Great Western Railway. Stone was brought down the mountain on light rails laid down Mountain Street, across Main, along Elizabeth to Victoria Park, and from there along a causeway to the east side of Forty Pond (Rannie, 1987, p.19). From there it was taken by ship to Toronto or St. Catharines. Though the stone could be used as rubble, most was not suitable for building stone.

Robert Gibson opened a second quarry, this time in Lockport dolomite, in Concessions 5 and 6, lots 13 and 14, in Clinton Township in 1884. Robert's nephew Robert Lillie was brought to Canada in 1870 as bookkeeper, and took charge of the new quarry. Most of the building stone came from the quarry on the west side of Quarry Road. After Robert Lillie Gibson's death, however, the Clinton quarry became the property of William Gibson. A sketch of the Clinton quarry is given by Rannie (1987, p.31; see also the description in Miller, 1892, p.97; 1904, p.74; and in Goudge, 1938, p.249). A tramway was constructed in 1884 from the quarry to the Grand Trunk Railway station at Beamsville. In 1891, 160 people were employed, at a cost of $7,500 per month. Miller described two workable beds of grey limestone, 7-8 feet thick, and judged the upper to be better. He remarked that the stone was all cut by hand, and was used by the Grand Trunk Railroad.

(Sources: Rannie's book, *Dictionary of Hamilton Biography*)

Robert (1753-1809) and Alexander (1790-1839) Hamilton

Robert was born in Scotland, and came to Canada to work in the fur trade. In about 1785 he began building a residence and shop in Queenston. He and an associate (Richard Cartwright, in Kingston) became shipping agents for the trade on Lake Ontario. He married the daughter of a partner and they had three sons. Cousins from Scotland emigrated to join the business, and Robert soon controlled the Niagara portage, which moved 30-40% of the trade between Lakes Ontario and Erie. His stone home was destroyed during the War of 1812.

Alexander, son of Robert, was born in Queenston, and his education, begun in Queenston and Niagara was completed in Scotland. He served as a Captain under Major Thomas Merritt in the War of 1812. After the war his business interests did not prosper, but his political career (as a member of the "family compact") did, and by 1833 his personal fortune was large enough that he could construct Willowbank in Queenston. As sheriff, he helped suppress William Lyon Mackenzie's rebellion of 1837, and even hanged one of the leaders himself.

(Sources: *Dictionary of Canadian Biography*)

Thomas Coltrin Keefer (1821-1915)

He was born in Thorold, eighth son of George Keefer who was associated with William Hamilton Merritt and became first President of the Welland Canal Company. He was educated in St Catharines (at Gratham Academy) and apprenticed as an engineer on the Erie Canal, and later worked in the Rideau, St Lawrence and Welland canal systems. He is perhaps best known for his short book on *The Philosophy of Railroads* (1850). He designed waterworks for Montreal (1853) and Hamilton (1857-1859). In 1887 he was founding President of the Canadian Society of Civil Engineers. His brothers Jacob (second son), Samuel, Augustus, and John were all prominent men. Jacob built the Welland Mills in 1845. Samuel was an engineer active in canal and railroads, and he completed the suspension bridge at Niagara in 1869. Augustus was an Ottawa-based lawyer. John was a merchant/farmer and owner of Maplehurst, which was built by his son Hugh. He was a "colourful personality" and gambler. Supposedly Maplehurst mansion has 24 front steps, because that is the number of cards in a deck of Euchre.

(Source: *Dictionary of Canadian Biography;* http://www.keefermansion.com/)

John Latshaw (1806 - 1883)

According to the 1871 census, he was 65 years old, living in Stamford. He had been born in the USA, of German origin, son of John and Christina Latshaw, and was a Wesleyan Methodist. According to information about Ruthven, Latshaw was originally from Pennsylvania. According to a genealogy site (see below) he moved to Niagara Falls about 1826-1828, and died in 1883. On July 6, 1871, he married for the second time to Susan Baxter, 45, widow of Stamford (daughter of David and Nancy Lynch). According to http://genforum.com/latshaw/messages/84.html, his grandson (?) Charles, born July 5, 1866 in Niagara Falls, married Rebecca Wheeler, who died in 1933, was the son of Edward, who changed his name to Ladshaw when he moved from Niagara Falls to South Carolina. Charles was the youngest brother of George Edward Ladshaw, hydraulic engineer of Spartansburg, SC.
His buildings included:

1834 Willowbank mansion, Queenston

1834 Glencairn, Queenston built by Robert Hamilton's son John. A two-storey, large Colonial style clapboard house.

1845-1847 Ruthven Mansion, Cayuga. Neoclassical, built of Devonian limestone imported from Ohio, with some local Bertie dolomite and Oriskany sandstone.

1851 Extension for the courts, added to the St Catharines Town Hall, when it became the Lincoln County Court House

1852 Humberstone Township Hall, Port Colborne. Built of cut stone similar to that used in the second Welland Canal. The oldest part of the building features multi-paned arched windows and Palladian style doors. Doors Open Niagara 2008.

1863c. The Bush House. NY State Senator (31st District, 1848-1849) John T. Bush of Buffalo, hired Latshaw to build an Italian villa on the foundations of the Zimmerman mansion in Clifton (never built because of his death in 1857). It consisted of a great hall 16 feet wide and 90 feet long, and five large rooms and a kitchen on the main floor, a second floor with five large bedrooms, and a third floor with a theatre. Bush lived there for the next 50 years, until his death in c.1915, after which his daughter sold the house in 1928 to Harry Oakes Welland Securities. It was demolished in 1937. There are photos at the Niagara archives (http://www.nflibrary.ca/)

1863 Old Port Robinson School House (Cross Street, Port Robinson, Thorold). A red-brick school house, built at a cost of $1250. Doors Open Niagara 2008.

1873-1874 Stamford Township Hall (built at a cost of c. $8000) Latshaw lived in the village of Drummondville, which is where the Hall is situated (on Lundy's Lane)

1878 The Old Fire Hall, Thorold (built for $2,483, from brick)
(Sources**:** Lundy's Lane historical Museum exhibit, Niagara Falls Public Library)

William Hamilton Merritt (1793-1862) and Thomas Rodman Merritt (1824-1906)

We was born in Westchester County NY, son of Thomas Merritt, who served in the Queens Rangers under Simcoe during the American War of Independence. Thomas settled in St. Catharines and was appointed Sheriff of Lincoln County in 1803. William was sent to school in Ancaster and Niagara, and visited Saint John (NB) and Bermuda. Returning from his travels in 1808 be began to farm on his father's land, but joined the militia in 1812, and fought in the Battle of Queenston Heights, and at Lundy's Lane (see Appendix). After the war, he developed diverse interests as a merchant in St. Catharines, and purchased a mill site there in 1816. He became the principal promoter of the Welland Canal, but the canal was opposed by those whose financial interests lay in the Niagara portage. Nevertheless, his plans were supported by members of the "family compact" and work began in 1824. Two schooners passed through the canal to Lake Erie at the end of November 1829. Its engineering and financial troubles, however, continued and the project was taken over by the government in 1843. Merritt continued to be active in politics and promoted not only the Welland canal but also the Grand River canal, the St Lawrence waterway, the Niagara suspension bridge, and various railroads, as well as many philanthropic projects.

Thomas Rodman Merritt (1824-1906) was William's youngest son. He carried on the family business, and diversified from milling to ship building and banking (he was a founder of the Imperial Bank of Canada). He engaged in local politics, and was elected MP in 1868, serving until 1874. He promoted Bishop Ridley College (established at St Catharines in 1888) and served on its board until his death. He constructed Rodman Hall in 1853.

(Source: *Dictionary of Canadian Biography*)

Kivas Tully (1820-1905)

He was born in Ireland, and educated in the Royal Naval School in London. He then worked for four years with an architect and civil engineer in Ireland. He moved to Toronto in 1844, where his elder brother (also an architect) was already at work. He designed the Bank of Montreal building and the Custom House in Toronto, and submitted many other designs. His career took off after he won commissions for Trinity College, Toronto, the Welland County Court House, and Victoria College in Cobourg. The St Catharines Town Hall was one of his earliest designs. He was one of the founders of the Canadian Institute (1849) and the Canadian Society of Civil Engineers (1887), and was the first President of the Engineers Club in Toronto (1899).

(Source: *Dictionary of Canadian Biography*)

Samuel Zimmerman (1815-1857)

He was born in Pennsylvania of German descent. Though he had little formal education he became involved in the construction of the second Welland Canal. His success in that venture, led to work on the Great Western Railroad, and the Niagara Suspension bridge designed by the American engineer John Augustus Roebling, and completed in 1855. He bought the leading tourist hotel in Niagara Falls, the Clifton House, in 1848, and became a leading developer in part of Clifton (now Niagara Falls, ON). In 1854 he founded the Zimmerman Bank, and in 1855 took over the four mills started by Jacob Keefer in Thorold. He planned on building a large mansion on 52 acres of land overlooking the falls, but the house was never built because Zimmerman was killed in the notorious railway bridge collapse of 1857 in Hamilton. At that time he was reputed to be a bold, if unscrupulous operator, and the richest man in the province. After his death, a house, designed by John Latshaw was built by a rich American businessman on the foundations planned by Zimmerman. The house no longer exists but photographs show it was an imposing building.

(Source: *Dictionary of Canadian Biography*)

Appendix 2: History of Wine in the Niagara Peninsula

1811 The first attempt to market wine commercially was made, using grapes grown in the Credit Valley, by Joseph Schiller, a German mercenary. His property was bought in 1864 by Count de Courtenay, who founded the "Vine Growers Association." His Clair House became the largest winery in Ontario, and the wines were exhibited in Paris in 1867.

1857 Porter Adams is generally credited with being the first to plant vines, near St. Davids, though this was disputed by Rannie (1976). After this many small local wineries were established.

1873 George Barnes started a substantial winery in an old stone building on the left bank of Twelve Mile Creek, near St. Catharines (it survived until 1988).

1874 Thomas Bright started his winery: it became the largest producer of wine in Canada. It was at first located in Toronto, but moved to Niagara Falls in 1890.

1906 In his will, Moses F. Rittenhouse, born in Vinemount in 1846, the son of a Pennsylvania German pioneer settler, left 90 acres of land to the Province of Ontario for "...experimental work on tender fruit." Ritterhouse had made his money in Chicago, but never forgot the place of his birth. The land was used to establish the Vineland Horticultural Station, which later became the modern *Vineland Research and Innovation Centre*, supported by both the Provincial and Federal Governments. The Station developed more than 75 varieties of peaches, apricots, cherries and plums, beside its work in developing and testing new vines for wine. (See http://www.vinelandontario.ca/)

1919-1927 Prohibition was enacted in Ontario, but wines produced in Ontario were exempt. So wineries in Ontario flourished, but quality was poor. In 1927, Prohibition ended and the sale of alcoholic beverages through the Provincial Government (LCBO) stores was established, and wine making and marketing were subject to Government regulation. No new wineries were licensed from 1929 to 1975.

1933 Adhemar de Chaunac, a French chemist who had come to Canada in 1907, was hired by Brights and began to experiment with French hybrids. In 1955, Brights produced the first Chardonnay made from Ontario grapes.

Pre-1974 The leading wineries were *Andres, Brights, Chateau Gai*, and *Jordan and Ste-Michelle*. The best wines were hybrids, such as Seyval Blanc, Marechal Foch, and Baco Noir thought to be the only grapes suitable for the climate. The most popular (and one of the worst) was Baby Duck!

1974 *Inniskillin Wines* was founded by Donald Ziraldo. Inniskillin and Podamer (which made sparkling wine by the *methode champenoise*) were licensed by the LCBO in 1975, the first new wineries licensed since 1929.

1978 *Cave Springs* planted Riesling and Chardonnay; Chateau-des-Charmes planted vinifera vines in Niagara on the Lake.

A guide to LCBO wines published by John Reid listed the following starred wines:

Inniskillin and Brights Chardonnay ($3.45-5.50)
Chateau Gai Gamay ($3.20)
Brights and Inniskillin Seyval Blanc ($3.10-3.90)
Brights Chelois, De Chaunac, Marechal Foch (all red hybrids $2-3 range)
Brights President Burgundy (made from Marechal Foch, $1.95)

Podamer's Brut was recommended but cost $7.95
For comparison, good quality Bordeaux and Burgundies were selling for $5 - 15.

1979-1981 Riesling was also planted at what later became *Vineland Estates* and *Thirty Bench*

1983-1986 The first Rieslings were bottled at *Cave Springs* and *Vineland*

1988 VQA (Vintners Quality Alliance) designation was adopted by 18 wineries, and recognized by the Ontario government in 2000. At least 85% of the grapes used must have been grown in the area of the Appellation (e.g., "Niagara Peninsula") and the remainder must be from Ontario.

1991 *Inniskillin* won the Grand Prize for Icewine in Bordeaux. Canadian wines achieved a measure of international recognition, but in the 2008 edition of Hugh Johnson's Pocket Guide only one page out of 300 is devoted to Canada!

1999 East Dell was founded by Susan O'Dell and Michael East. In 2007 it owned 65 acres, of which 45 acres are planted. 30,000 cases of wine were produced.

2000 Simon Haynes (Brock University) proposed sub appellations of the Niagara Peninsula using "terroirs," based on "variations of landform physiography, soil types, and groundwater flow conditions."

2005 Twelve Sub appellations were recognized in the Niagara region, based largely on microclimate. A map showing the sub appellations may be purchased in many wineries, and a small version can be accessed on the web. See below for a black-and-white version.

Wine production in the Niagara Peninsula

The term *terroir* refers to vineyards (or vines) belonging to a specific area (appellation) sharing the same soil, climate and grapes thereby creating a distinct character to the wine. It can be regarded as defining a unique ‘sense of place’ setting it apart from others. The connections with the geological terms ‘terrane’ and ‘terrain’ are obvious.

The Niagara Peninsula produces three quarters of Canada’s grape output from about 4452 hectares (11,000 acres). The peninsula is Canada’s largest regional wine producing appellation. Within this area the most important regions are the Niagara Escarpment (divided into three sub-appellations (the Short Hills Bench, Twenty Mile Bench and Beamsville Bench) and Niagara-on-the-Lake (including the Niagara River, Niagara Lakeshore, Four Mile Creek and St. Davids Bench sub-appellations). In addition there are the Vinemount Ridge, Creek Shores and Lincoln Lakeshore sub-appellations (See Figure 14). When growing degree days, sunshine hours, mean monthly temperatures, and rain and snow fall are considered, the Niagara Peninsula has been compared with France's Bordeaux and Burgundy regions though the peninsula has the risk of damaging frosts and severe winters.

The conditions for cultivation of grapes in the northern Niagara region depend essentially on the regional climate, which is largely determined by the position of the peninsula between Lakes Erie and Ontario, and upon local topography. The most important topographic feature is the Niagara Escarpment, and the minor Whirlpool sandstone bench at its base. The edge of this bench generally coincides with the Lake Iroquois shoreline. Below the shoreline (roughly 110 feet above Lake Ontario) is the sandy Iroquois plain, some 2-10 km wide that slopes gently down to the Lake Ontario shoreline. The proximity to the lake and the good drainage in the sandy soil helps explain why many vineyards are located on the Iroquois plain (our lunch stop is a good example).

The regional climate is determined by the warming effect of Lakes Erie and Ontario. Lake Erie is shallow and often covered almost completely with ice in the winter, whereas Lake Ontario is deep and rarely has an extensive ice cover (historically about three times during the past 100 years). It warms the Iroquois plain during the winter, and cools it during the summer. The result is that the region has mean summer temperatures in the low 20^{o}s C, precipitation almost uniformly distributed in every month of the year. Warm temperatures (>30^{o} C) in July and August (e.g., as experienced in 1999, 2002, and 2003) are required to develop good cabernets.

Regional winds blow mainly from the south west, so the Niagara escarpment protects its northern slopes from high damaging winds in the winter. The Font Hill Kame protects the Short Hills sub-appellation. Cool air tends to flow off the slopes, and this improves the climate of the "Beamsville bench" and other slopes above the Lake Iroquois plain, and retards budding until damaging frosts have passed in the spring (our dinner stop is a good example).

The main climatic danger to vines results from early warming (e.g., late January thaws) followed by "killer frosts" (temperatures below -2^{o}C). More rarely extremely cold winters can extensively damage *Vinis vinifera* plants. The near certainty of cold temperatures in the winter months explains the excellence of Ontario's ice wines. Topographic lows act as frost hollows and are favourable for growing ice wines, first produced in Ontario in 1984. Stringent regulations require that ice wine grapes must be exposed to cold temperatures of - 8^{o}C or lower. Canada is now the world's largest producer of such wines. For further details see Shaw (2005).

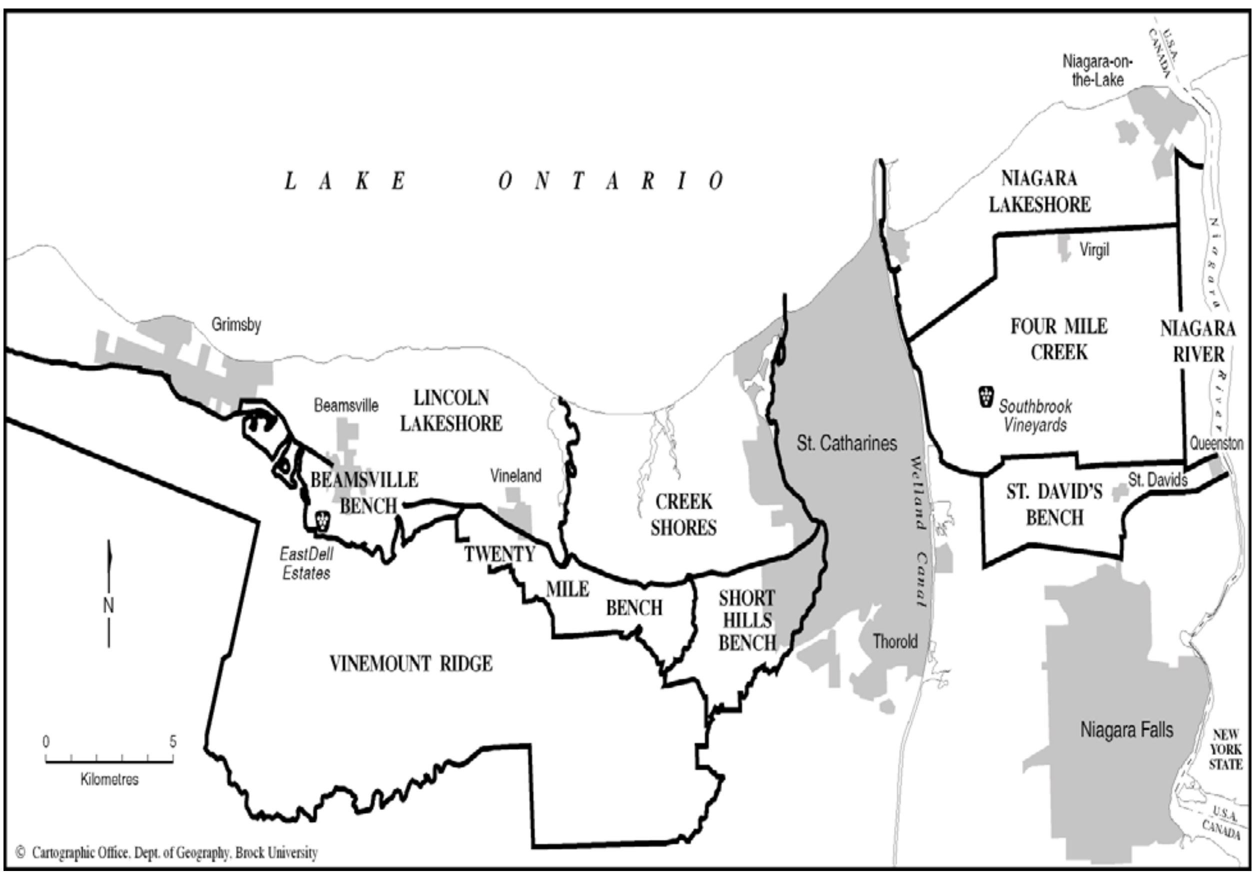


Figure 14 Sub appellations in the Niagara Peninsula (provided by Anthony Shaw and Louis Gasparotto of Brock University).

Appendix 3: War of 1812: Events in Niagara Peninsula

October 13, 1812: The Americans attacked across Niagara River, but were defeated by troops led by Brock at Queenston Heights (Brock died there, hence the monument: for further details see inside the front cover).

April 27, 1813: The Americans attacked York (Toronto), wasted it and burned the Parliament Building. Later in the war the British burned the White House in Washington in retaliation.

May 27, 1813: The Americans took Fort George (Niagara on the Lake). The British retreated, then fought at the Battle of Stoney Creek (June 5; not far from our first stop). This was a significant victory, as later the Americans were not able to penetrate further into Upper Canada. On June 24 another battle was fought at Beaverdams (now Thorold) – and Laura Secord became famous (but only in Canada, eh?) for warning the British of the impending American attack. In the afternoon we will pass close to the battle site in Thorold.

December 13, 1813: The Americans abandoned Fort George and burned Niagara-on-the-Lake.

December 18, 1813: The British took Fort Niagara and later burned Buffalo (then only a village) in retaliation.

July 5, 1814: The Americans, who had taken Fort Erie, defeated the British at the Battle of Chippewa (south of Niagara Falls). This led to the final, climactic battle on land:

July 25, 1814: Lundy's Lane: the Americans retreated to Fort Erie. Lundy's Lane is now in part, called Ferry Street or Highway 20, is almost due west of our stop at Niagara Falls.

The war ended late that year, but the two sides fought on in America until word arrived three months later. Lundy's Lane was the last major battle in the Niagara Peninsula.

Appendix 4: History of Geological Investigation

Bedrock Geology

This document is a brief annotated bibliography of the main papers that describe the bedrock geology of the Niagara region. The items are arranged in chronological order. Basically, two major themes run through many of the works cited: stratigraphic correlation and classification; and environmental interpretation.

The most recent stratigraphic work is that of Brett, Goodman and LoDuca (1990, and in Cheel, 1991). They reinterpreted the Silurian stratigraphy in terms of the seven sequences. The main change from earlier interpretations is that the Lower Clinton is much reduced at Niagara and the Upper Clinton, previously described as consisting of the Reynales, Irondequoit, Rochester, and DeCew, is now considered to be composed of the Merritton (= Reynales of earlier workers), Williamson (absent at Niagara itself), Rockway and Model City (members of the Irondequoit, separated by a sequence boundary!), Rochester and DeCew. Despite the attention given to the palaeontology, there are still difficulties establishing the exact correlation with the European stages.

There have also been some major new interpretations of the Medina, discussed by Duke (in Cheel, 1991). Previously interpreted as a delta, it is now interpreted “as resulting from episodic progradation of a tide-dominated, wave-influenced shoreline into a storm-dominated epicontinental basin." (It might still be interpreted as a type of delta, but not of the conventional fluvial-dominated type.) Not only that but the lower member the Whirlpool Sandstone has been shown by Middleton and co-workers (e.g., Middleton, Rutka and Salas, in Duke, 1987; Cheel and Middleton, 1993) to consist of two parts: a lower fluvial part, separated by a scoured surface from an upper marine part.

Most of the new interpretation has resulted from better understanding of the sedimentary structures, including biogenic structures. For instance, in the earlier literature, the trace fossils were not understood, and were described by both Hall and Grabau as fossil plants (or “fucoids"). A clear distinction between “current” and”wave” ripples was not made until Kindle. The significance of the various types of cross-bedding, especially trough cross-bedding (in the Whirlpool) and hummocky cross-stratification (in the remainder of the Medina) has been understood only recently. Many “mud cracks", previously interpreted as subaerial, are now interpreted as subaqueous “syneresis cracks.”

Nor has the underlying Queenston Formation (Ordovician) escaped some reinterpretation. Brogly, Martini, and Middleton (1999) have reinterpreted the depositional environment as consisting (here) of broad supratidal mudflats (with some depositional gypsum), periodically inundated by storm driven marine floods -- so almost a clastic equivalent of a sabkha. It is interesting to note that Grabau (1913) also interpreted the Queenston as an arid climate deposit.

But let us return to an earlier time. The best secondary sources are the reviews by Schuchert (1914), Fisher (1954), Winder (1961), and papers in Tesmer (1981).

1809 William Maclure (1763-1840) in his *Observations on the Geology of the United States,* interpreted all the Paleozoic rocks of New York State as ``Secondary'' (fide Merrill, 1924, *The First One Hundred Years of American Geology*).

1817-1825 The Erie Canal was constructed: at that time there were no engineering schools in America, but the canal commissioners appointed four New York State residents as principal engineers. By 1818, Wright and Geddes had run level surveys from Rome to Syracuse. Much of the canal was built through virgin forest, and the engineers invented a tree feller and a stump puller to help clear the land and a crane boom to raise excavated rock. By 1823 excavation had reached Lockport, where the engineers met their most difficult challenge, constructing the locks to raise the channel more than 50 feet, followed by excavating a deep channel in the bedrock to the west. Over 1,200 labourers were employed to complete this task, almost all of them being immigrants from Ireland, who were paid $12 per month. In 1824, the engineers who were working on the canal, also helped to found the Rensselaer School (later Polytechnic Institute) in Troy, and Amos Eaton was appointed Professor of chemistry, experimental philosophy (physics) and geology. Six students enrolled in 1825. The canal was completed to Buffalo in 1825, at a total cost of almost $8 million, and was responsible for the rapid growth of most of the communities along its route: not least of which was Buffalo, a village of only a few hundred inhabitants when it was burned by the British in the War of 1812.

1824 Amos Eaton (1776-1842) in his *Geological and Agricultural Survey of the Erie Canal, N.Y.,* used the term *Grey Band* for the Thorold, and described, but did not name, the trace fossil *Arthrophycus* – long thought to be a plant but now known to be a trilobite trace.

1829 Lardner Vanuxem (1792-1848) in *American Journal of Science* disputed the Secondary age and claimed that the rocks should be classified by the fossil content, not by their structural state.

1836 The Geological Survey of New York was authorized, and Vanuxem began work on the Fourth District, which included Niagara. At the end of the first season, however, Vanuxem was transferred to another district and James Hall (1811-1898) took over the Fourth District.

1837 Timothy A. Conrad (1803-1877) in *First Annual Report on the Geological Survey* *of the State of New York*, New York Geological Survey Report 1, p. 155-186, described the (undifferentiated) Queenston--Medina strata as the ``Niagara sandstones'' (fide Fisher, 1954). He was also the first person to assign the rocks to the Silurian.

1839 Conrad (*Second annual report on paleontological department of the survey*: New York Geological Survey Annual Report 3, p.57--66) defined the Rochester for the section at Rochester NY. For a detailed review of the Rochester, see Brett (1983). Conrad used the term ``Red and Variegated Sandstone of the Niagara River'' for what we would now call the Medina.

James Hall in the *Third annual report of the fourth geological district of the State of New York*: New York Geological Survey Annual Report, v.3, defined the *Lockport* Formation.

1840 Vanuxem in the *Fourth Annual Report of the Geological Survey of the Third District* introduced the term *Medina* for the red beds below the ``white band'' (the Thorold) – this included not only Silurian but Ordovician (Queenston) strata.

1841-1842 Charles Lyell (1797-1875) visited the United States and Canada twice, and on both trips visited Niagara. On the first trip, with James Hall, he stayed mainly on the American side. On the second trip, accompanied only by his wife Mary, he stayed for six days on the Canadian side at the Clifton House. For details, see the works by Keith Tinkler, listed above, and Leonard Wilson’s book *Lyell in America* (Johns Hopkins, 1998).

1842 Conrad (*Observations on the Silurian and Devonian systems in the United States*: Philadelphia Academy of Natural Sciences Journal, v.8, p.228--235) introduced the term *Clinton*.

Charles Lyell's “A Memoir on the recession of the Falls of Niagara'': *Proceedings of the Geological Society of London*, v.3, pt.2, described the bedrock geology briefly. Lyell acknowledged that this information came from James Hall's publications and by personal communication during his visit in the fall of 1841. The Niagara group fossils were compared to those of the Wenlock limestone, the “Protean group'' included the strata now assigned to the Clinton, and the “Ontario group'' the Medina and upper part of the Queenston. The Niagara (and also Helderberg) escarpment were confidently attributed by Lyell to “the action of the sea'' (i.e., they were sea cliffs).

1843 Hall's report *Geology of New York, pt.IV, Survey of the 4th District*, used the term “New-York System'' to include all the Paleozoic rocks below the Catskill. He recognized that the rocks would be described as Transition, not Secondary, in Werner's scheme, and that the rocks at Niagara were Silurian in the sense of Murchison (*The Silurian System* had appeared in 1839). The part of the New York System outcropping around Niagara was classified into the Medina formation, and the Clinton and Niagara groups. Hall devoted p.32--117 to describing these units, much of it devoted to physical description rather than palaeontology. In the Medina he recognized four units: “Red

marly or shaly sandstone" (Queenston of later authors); “Grey quartzose sandstone" (Whirlpool of later authors); “Red shale and sandstone"; and the Gray Band of Eaton at the top. Strangely, Hall did not observe mud-cracks in the Queenston, and concluded from the fine grain size that it was deposited in deep water (he remarked, on p.37 that “... the absence of fossils renders it a very uninteresting rock to the geological observer"). He described (probably from the Grimsby) oriented *Lingula* shells, with sand shadows behind them, indicating the current direction towards the NNW. Plate II shows a slab which shows not only oriented shells, but also the *heavy mineral shadows* later described from the Whirlpool Sandstone near Georgetown ON by Cheel (1984). The “wave lines" figured by Hall (Fig. 11) are probably not swash marks, but the traces on the bedding of trough cross-bedding, though true swash marks have been found in the Medina: Hall acknowledges Lyell's help in identifying them!
Hall also illustrates (Fig. 13) true swash marks from a modern beach and claims a “most perfect analogy" --- but a comparison between his Figures 11 and 13 shows a distinct lack of similarity. Hall was, nevertheless, a real pioneer in the description of sedimentary structures, and the modern sedimentologist can only agree with the emotions that he described (p.57):

> “In standing upon the exposed surface of the quarry, one can only fancy himself still upon the shore or some quiet bay or arm of the sea, where the waves of the receding tide have left behind these little ridges of sand...How beautiful, how simple, and how grand is this exhibition; and how much does it illuminate the mind as to the mode of production of these older formations which have been considered so obscure...All, for aught we know, was as bright and beautiful as upon our ocean shores of the present day...though man was not there to say, how beautiful! "

1845 Charles Lyell's *Travels in North America* (in two volumes, Wiley and Putnam, reprinted by Arno Press) gave a revised version of Bakewell's panorama of the Niagara gorge and falls, and describes the bedrock geology, based on the revised stratigraphy of Hall. Lyell visited the American side of the Niagara with Hall in1841, and the Canadian side in 1842. While in Niagara, he and his wife Mary stayed in the Clifton House, and took the usual tourist visit beneath the Canadian Falls, and received a tourist diploma in recognition of this achievement.

1852 James Hall’s *Palaeontology of New York, Volume II, Containing descriptions of the organic remains of the lower middle division of the New-York system*: Albany, C. Van Bethuysen, 362 p. + 85 plates, included descriptions of the Medina, Clinton, and Niagara Groups, and is the foundational work on their palaeontology.

1863 The section in William Logan's *Geology of Canada* dealing with the Niagara region was largely based on the work of Alexander Murray. As far as possible, Logan tried to use the same nomenclature as that of New York geologists. He thought the “grey band” (Thorold, but Logan confused it with the Whirlpool) could be traced north to

Owen Sound (which it cannot).

1899 G.K. Gilbert (1843-1918) in “Ripple marks and cross-bedding": *Geological Society of America Bulletin*, v.10, p.135--140, described sedimentary structures from the Medina. Some of these have been interpreted by Duke (1982) to be the earliest descriptions of hummocky cross-stratification (see comments below). Gilbert provided good photographs and localities which show that the “giant ripples" were in the Whirlpool, not the Grimsby, and he wrote that “...there are places...where the strike of a dipping layer can be traced through an elliptical arc, like the end of a spoon, for 150 degrees, the dip swinging with the strike." The photographs and detailed studies in the Niagara gorge by Rutka (in Duke, 1987) make it clear that these structures are large trough cross-beds, with unidirectional paleocurrent, formed by the migration of large subaqueous dunes. Gilbert did not “...regard sand-rippling as a general or even frequent cause of the cross-lamination observed in rocks, except on a small scale," but this was before the studies of Cornish, Kindle, and others showed otherwise.

1901 Amadeus W. Grabau (1870-1946) published “Guide to the geology and palaeontology of Niagara Falls and vicinity": *Buffalo Society of Natural History Bulletin* 7 (also *New York State Museum Bulletin* 45, 284 p. and map). This was designed to be a general review, accessible to the public. In the light of Grabau's later achievements, it is interesting for showing Grabau's very limited understanding of the rocks at that stage. The stratigraphic classification is essentially that of Hall and Gilbert. There is no mention of the Queenston and Grimsby deltas -- indeed; Grabau seems almost inclined to accept the entire section (including the Queenston) as marine. Grabau claimed that one of Gilbert's “giant ripples” was located in the Thorold (perhaps it was, but it seems unlikely). Grabau gave very poor descriptions of cross-bedding in the Grimsby (and none of the outstanding examples in the Whirlpool). His figures are schematic and have no scale! His only explanation is that the structure “indicates diverse currents and wave action in the shallow water in which this rock was forming. While deposition of the strata was essentially horizontal, the minute layers made up of the sand grains were for a time deposited at a high angle, much after the manner of deposition of the layers in a delta.." (The idea that cross-bedding was mainly formed in microdeltas persisted in geological literature for the next 50 years, despite increasing evidence to the contrary.) Grabau's description of the carbonates is also rudimentary -- he was not careful to distinguish limestones from dolomites, and although he later pioneered the classification of clastic textures in carbonates, and did recognize that detrital nature of Clinton and Lockport encrinites, his petrographic descriptions are not very precise. He attributed the source of detritus to reefs, formed possibly by tabulate corals, stromatoporoids and crinoids, but was tentative about identifying any examples.

Herman LeRoy Fairchild (1850-1943) in “Beach structure in the Medina sandstone": *American Geologist*, v.28, p.9--14, disputed Gilbert's interpretation, and returned to Hall's beach interpretation. He interpreted Gilbert's “giant ripples" as beach-ridge structures. Swash marks (the `wavelines' mentioned by Fairchild) are indeed found, and are the only reliable indicators of beaches in the Medina (Grimsby or Thorold) known. Recent workers have not found beaches in the Whirlpool. Fairchild was Professor at University of Rochester from 1888-1920, a founding member of the GSA (President in 1912) and was interested mainly in glacial geology: he left a large archive of great historical value.

John Casper Branner (1850-1922) in an Editorial in the *Journal of Geology,* v.9, p.535--536, suggested that Gilbert's "giant ripples" were beach cusps. Branner was later the first professor appointed at Stamford, and became the second President in 1913.

Clifton James Sarle (1874-1960) described "Reef structures in Clinton and Niagara strata of western New York": *American Geologist*, v.28, p.282--299. Though most of the observations were made near Rochester, there are descriptions reefs in the Niagara gorge at two levels: Irondequoit reefs, surrounded by Rochester shale, and Gasport reefs. Sarle is perhaps best known now for discovering and describing a unique eurypterid fauna at Pittsford, near Rochester in 1903.

1906 John Mason Clarke (1857-1925) in "Report of the state geologist and palaeontologist for 1905": New York State Museum Annual Report 59, p.10--41) defined the *Irondequoit*.

1908 Grabau published a preliminary "Revised classification of the North American Siluric System": *Science*, v.27, p.622--623. This included the new tern *Queenston*, for the red shales below the sandstones of the Medina. Grabau assigned the Queenston to the Ordovician (first suggested in *Science*, v.22, p.529, 1905). This paper revised earlier revisions published briefly in 1905, 1906 and 1907.

1909 Grabau published "A revised classification of the North America Lower Paleozoic": *Science*, v.29, p.351--356, a more complete statement of his views and also excluded the Queenston from the Medina..

Grabau in "Physical and faunal evolution of North America during Ordovicic, Siluric and Early Devonic time": *Journal of Geology*, v.17, p.209--252, proposed the name *Whirlpool* for the sandstone at the base of the Medina.. He claimed that the red Medina sandstones had "aeolian cross-bedding" (so were terrestrial) whereas the Whirlpool sandstone exhibited beach features (citing Fairchild), though he agreed with a suggestion by A.W.G. Wilson that the sand was probably originally aeolian, reworked during the transgression (in fact, it is fluvial, with only to top part reworked during the transgression).

1913 Grabau published his great paper "Early Paleozoic delta deposits of North America": *Geological Society of America Bulletin*, v.24, p. 399--528. He described the Queenston and
Medina deltas, and named the Cabot Head Formation (the spelling was changed by Williams, 1914). He also defined the *Thorold* as a member of the Medina. He described "complex bedding" (trough cross-bedding) as typical of aeolian sandstones,

citing observations by Johannes Walther, stating "...it is difficult to conceive how it can be formed on a large scale except by the method of migrating dunes." In this, he was ahead of Gilbert, but like most geologists of the time, he did not know about large subaqueous dunes. He accepted Fairchild's interpretation of the intersection between troughs as indicating beach structures in the Whirlpool, and thought the Whirlpool was composed of aeolian sands reworked during the marine transgression.

E.M. Kindle (1869-1940) and F.B. Taylor (1860-1938) published "Geological Atlas of the United States, Niagara Falls folio": *U.S. Geological Survey Folio 190*. They regarded the Medina Group as including both the Queenston and what we would now call the Medina, which they defined as the *Albion* Formation, with the Thorold member at the top, the Whirlpool member at the base, and an unnamed unit between the two. They noted that their work was based partly on Gilbert's field work which had begun in 1897, and that they had access to Gilbert's field notes (p.9). They also remarked that Gilbert's observations of "giant ripples" were made mainly along the New York Central Railroad (which used to run along the top of the Whirlpool outcrop, inside the gorge, south of what is now ArtPark) and in quarries north of Lockport (the outcrops there no longer exist, but there is a fine new railway cut): the "giant ripples" were therefore in the Whirlpool. They provided photographs of these structures, additional to the two published by Gilbert, but were reserved about their origin, citing both Gilbert's and Fairchild's theories, but tending to favour a marine "drift sand zone" origin in shallow water not far from the shore. They also included a fine photograph of a sand-filled scour from what is now called the Grimsby in the gorge section south of ArtPark, and conclude it " It may have been caused by marine channelling or scour." They described and figured reef structures in the Irondequoit. They defined the *Gasport* member of the Lockport, and noted the change from crinoidal limestone near Lockport, to the dolomitized equivalent at the Gorge. They noted the reefs in the Gasport later described in detail by Crowley (1973).

1913, 1914 Charles Schuchert (1858-1942) published "The Cataract: a new formation at the base of the Siluric in Ontario and New York": *Geological Society of America Bulletin*, v.24, p.107; and "Medina and Cataract formations of Siluric of New York and Ontario": *Geological Society of America Bulletin*, 25, p.277--320. He introduced the term *Cataract*, for the Whirlpool and grey beds or limestones above it, up to the base of the (sandy) Medina. He provided a careful historical review of earlier work and detailed measured sections for the Niagara Gorge and many other localities in New York and Ontario.

1914 E.M. Kindle ("What does the Medina sandstone of the Niagara section include": *Science*, v.39, p.915--918.) differed from Schuchert, and used Medina for the lower (non-red, shaly) part of the section.

M.Y. Williams (1883-1974) proposed a revised stratigraphy ("Stratigraphy of the Niagara escarpment of Southwestern Ontario": *Geological Survey of Canada Summary Report for 1913*, p.178--188. This included the new term *Grimsby* for the red beds above the Cabot Head, and *DeCew* for a bed of fine grained dolomite below the Gasport. (It shows spectacular convolute lamination in the Niagara region.)

1923 E.O. Ulrich and R.S. Bassler "American Silurian formations of North America": Maryland Geological Survey, Silurian volume, p.233--270. This was the first proposal that the Thorold should be separated from the Medina and included in the Clinton.

1929 R.B. Harkness ("The oil and gas fields of Ontario": *Ontario Department of Mines, 27th Annual Report*, pt.V, p.51--77) presented isopach maps for the Grimsby and Whirlpool members in Ontario.

1933 J.T. Sanford published an abstract, "Clinton in western New York": *Geological Society of America Bulletin*, v.44, p.194, in which he defined the *Neahga* Formation, a thin shale above the Thorold in the Niagara region.

1936 Harold L. Alling (1888-1960) in "Petrology of the Niagara Gorge sediments": *Proceedings of the Rochester Academy of Sciences*, v.7, p.189--207) published the first petrographic study of the Medina sandstones. Alling's work was mainly in hard-rock petrology, but he was also a pioneer sedimentary petrologist in America.

1939 J.T. Sanford published "Sedimentary rocks of the Niagara Gorge": *Journal of Sedimentary Petrology*, v.9, p.77--85. Considerable attention was devoted to size analysis of the sandstones, and composition of the soluble part of the carbonates.

1947 B.F. Howell and J.T. Sanford described "Trilobites from the Silurian Orchard Park member of the Lockport formation of New York": *Wagner Free Institute of Science Bulletin*, v.22, p.33--40. They also defined the *Goat Island* member of the Lockport.

T. Gillette "The Clinton of western and central New York": *New York State Museum Bulletin* 341.

1953 Thomas Elwood Bolton (1924-1997) published "Silurian formations of the Niagara escarpment in Ontario": Geological Survey of Canada Paper 53-23. He revised the stratigraphy and proposed the name *Power Glen* for the grey shales (and other lithologies) between the Whirlpool and the red Grimsby.

Donald William Fisher published "Additions to the stratigraphy and palaeontology of the lower Clinton of western New York"; *Buffalo Society of Natural Sciences Bulletin*, v.21, p.26--36.

1954 Fisher presented an authoritative review of the Medina (``Stratigraphy of the Medinan Group, New York and Ontario'': *American Association of Petroleum Geologists Bulletin*, v.38, p.1979--1996). He argued that, if the Clinton is considered a Group, then the Medina should be one too. He proposed the name ``Fish Creek'' for the shales in the Gorge between the Whirlpool and a dolomite that he thought was correlative with the Manitoulin. Most subsequent writers agree that the Manitoulin formation is not present in the Niagara region, so the term Fish Creek is not used. He recognized that macrofossils, and wave formed (``oscillation'' and ``interference'') ripples in the Whirlpool are restricted to the upper part, and thought the Whirlpool resulted from reworking of an aeolian sand during the marine transgression (``probably from the southwest'') over the subaerially exposed, mud-cracked Queenston surface.

1957 Bolton's memoir was published ("Silurian Stratigraphy and Paleontology of the Niagara Escarpment in Ontario": *Geological Survey of Canada Memoir* 289).

1961 C. Gordon Winder published ``Lexicon of Paleozoic Names of Southern Ontario'': University of Toronto Press, 121 p.

1963 W.J. Kilgour ("Lower Clinton (Silurian) relationships in western New York and Ontario": *Geological Society of America Bulletin*, v. 74, p.1127--1141) revised the stratigraphy and defined the *Merritton* Formation for a type locality near St. Catharines.

1965 Donald H. Zenger published his monograph "Stratigraphy of the Lockport Formation (Middle Silurian) in New York State": *New York State Museum and Science Service, Bulletin* 404.

1969 David N. Lumsden and Bernard R. Pelletier describe the "Petrology of the Grimsby Sandstone (Lower Silurian) of Ontario and New York": *Journal of Sedimentary Petrology*, v.39, p.521--530. This was based on theses written in 1953 (Pelletier) and 1960 (Lumsden). Size analyses of the sandstones were measured in thin section, and the coarsest sediment was found where the sandstones were thickest.

1971 J. Gray and A.J. Boucot described "Early Silurian spore tetrads from New York: earliest New World evidence for vascular plants?" *Science* v.173, p.918--921. The earliest, probably terrestrial, spores are found in the lower part of the Whirlpool sandstone, and were described before it was realized that this is in fact a fluvial unit.

Peter I. Martini published his doctoral work on the Medina ("Regional analysis of sedimentology of Medina Formation (Silurian), Ontario and New York": *American Association of Petroleum Geologists Bulletin*, v.55, p.1249--1261.) This first modern sedimentological study interpreted the Grimsby as a fluvial delta with a strong tidal influence.

1973 D.J. Crowley ("Middle Silurian patch reefs in the Gasport Member (Lockport Formation), New York": *American Association of Petroleum Geologists Bulletin*, v.57, p.283--300.)

1981 Irving H. Tesmer edited *Colossal Cataract: The Geological History of Niagara Falls*: Albany, State University of New York Press, 219 p. Like Grabau's work, this was designed to be a general review, accessible to the public. It is useful particularly for details on the engineering aspects of the Falls and Gorge.

1982 William L. Duke ("The `type locality' of hummocky cross-stratification: the storm-dominated Silurian Medina Formation in the Niagara Gorge, New York and Ontario": *Ontario Petroleum Institute Proceedings*, v.21, p.2.1--2.31) claimed that G.K. Gilbert first described HCS, from Niagara. There is certainly HCS in Medina sandstones, as first described in Duke's paper, but Gilbert's giant ripples were actually exposed surfaces of trough cross-bedding (this was conceded by Duke et al.,1992). Most of Duke's paper is devoted to comparing the Medina to the Cardium of western Canada, and developing a wave-dominated shoreline model that was substantially modified in his later publications.

M. Miller and L.E. Eames described "Palynomorphs from the Silurian Medina Group (Lower Llandovery) of the Niagara Gorge, Lewiston, New York": *Palynology*, v.6, p.221--254.

Peter Martini, in *Guidebook to Field Excursion 17A* "Sedimentary Facies: Products of Sedimentary Environments in a Cross-section of the Classic Appalachian Mountains and Adjoining Appalachian Basin in New York and Ontario" (International Association of Sedimentologists Congress, Hamilton, Ontario) gave detailed sections and interpretations of the Medina in the Niagara area (Section M of the Guidebook). The overall interpretation was that of a fluvial delta, with a tidal influence. The Whirlpool was interpreted as deposited in a high-energy, marine longshore bar.

1983 Carleton Brett published the results of his doctoral study of the Rochester shale in two papers ("Stratigraphy and facies relationships of the Silurian Rochester Shale (Wenlockian, Clinton Group) along the Niagara Gorge": *Proceedings of the Rochester Academy of Science*, v.15, p.118--141; and "Sedimentology, facies relations, and depositional environments of the Rochester Shale": *Journal of Sedimentary Petrology*, v.53, p.947--972). Brett studied several sections along the gorge, and established that there were several facies belts in the Rochester, trending roughly E-W (therefore parallel to the escarpment).

1984 Richard J. Cheel "Heavy mineral shadows, a new sedimentary structure formed under upper flow-regime conditions: its directional and hydraulic significance": *Journal of Sedimentary Petrology*, v.54, p.1175--1182 (described from the Whirlpool of the Georgetown area: but they can also be seen in Grimsby sandstones).

1987 William L. Duke edited the Eastern SEPM Guidebook in which revised interpretations of the Medina were first presented at length: *Sedimentology, Stratigraphy, and Ichnology of the Lower Silurian Medina Formation in New York and Ontario*, 185 p.

Carleton E. Brett and Parker E. Calkin described the ``Niagara Falls and Gorge, New York--Ontario": *Geological Society of America Centennial Field Guide---Northeastern Section*, p.97--105.

1989 Irving H. Tesmer published "History of Geology of Westernmost New York State: Niagara, Erie, Chatauqua, and Cattaraugus Counties, 1604-1899". Buffalo, I.H. Tesmer, 214 p.

1990 Carleton E. Brett, W.H. Goodman, and S.T. LoDuca, "Sequences, cycles, and basin dynamics in the Silurian of the Appalachian foreland basin": *Sedimentary Geology*, v.191--244.

1991 R.J. Cheel edited a Guidebook "Sedimentology and Depositional Environments of Silurian Strata of the Niagara Escarpment, Ontario and New York": *Geological Association of Canada Guidebook B-4, Toronto Annual Meeting*, 99 p. This includes papers on the sequence stratigraphy by Brett et al. and Duke et al.

William L. Duke, Peter J. Fawcett, and William C. Brusse described "Prograding shoreline deposits in the Lower Silurian Medina Group in outcrop, Ontario and New York: storm- and tide-influenced sedimentation in a shallow epicontinental sea, and the origin of enigmatic shore-normal channels encapsulated by open shallow marine deposits": in Swift et al. eds., 1990 *Shelf Sand and Sandstone Bodies*, International Association of Sedimentologists Special Publication 12, p.339--375. This was a study based on many detailed sections, including 15 within the Gorge itself.

1993 R.J. Cheel and G.V. Middleton described "Scours in a marine surface of transgression, Whirlpool Sandstone (Silurian, Ontario)": *Journal of Sedimentary Petrology*, v.62, p.392--397. These scours are best seen in plan view in quarries near Georgetown, but can be seen in section in the Niagara Gorge. Paleocurrents in the lower part of the Whirlpool indicate a consistent paleoslope to the northwest, but the scours and wave rippled surfaces at the base of the upper marine part of the Whirlpool indicate that the transgression progressed from the east to the west, i.e., it was not simply due to eustatic flooding up the old fluvial plain, but was due to tectonic tilting resulting from tectonic loading (a late stage of the Taconic orogeny) to the east. Note that, following computer models, the spreading of fluvial sediments far to the west, is interpreted as a hiatus in the Taconic thrusting, accompanied by continued isostatic rise and erosion, not a new phase of orogeny.

1998 P.J. Brogly, I.P. Martini, and G.V. Middleton, "The Queenston Formation: Shale-dominated, mixed terrigenous-carbonate deposits of Late Ordovician, semiarid, muddy shores in Ontario, Canada": *Canadian Journal of Earth Sciences* 35, p.702-719.

Bibliography

Barnett, P. 1992. Quaternary Geology. In: Thurston, P. (Ed.). Geology of Ontario, Special Volume 4, Part 2, pp. 1011-1090.

Birks, J. and Eyles, C.H. 1997. Leachate and landfills along the Niagara Escarpment. In: Eyles, N., Ed, Environmental Geology of Urban Areas: Geological Association of Canada, Geotext No. 3, pp. 347-364.

Boileau, Marc, 2006. *Towers of Time: Ontario*. St. Catharines, Looking Back Press, 128 p.

Bolton, T. E. 1976. Paleozoic Geology of Niagara. Ontario Division of Mines Map 2344.
Coleman, A.P. 1936. Lake Iroquois. Ontario Dept. of Mines 45th Annual Report, v. XLV Part VII, pp. 1-36.

Brett, C.E. and P.D. Calkin, 1987. Niagara Falls and Gorge, New York – Ontario. pp.97-105, in David C. Roy, Ed., *Northeastern Section of the Geological Society of America*, Centennial Field Guide Volume 5.

Brett, C.E., D.H. Tepper, W.M. Goodman, S.T. LoDuca and B-Y. Eckert, 1995. Revised stratigraphy and correlations of the Niagaran Provincial Series (Medina, Clinton, and Lockport Groups) in the type area of westerner New York. USGS Bulletin 2086, 66 pp.

Brett, C.E., D. Tretreault, W. Goodman and S. LoDuca, 2004. Silurian-Early Devonian Sequence Stratigraphy, Events, and Paleoenvironments of the Niagara Peninsula area of New York and Adjacent Ontario, Canada. Geological Association of Canada – Mineralogical Association of Canada Field Trip Guidbook, Brock University, St. Catharines, Ontario, no pagination.

Chapple, N., 2006. *A Heritage of Stone: Buildings of the Niagara Peninsula, Fergus and Elora, Guelph, Region of Waterloo, Cambridge, Paris, Ancaster-Dundas-Flamborough, Hamilton and St. Mary's*. James Lorimer, 128 pp.

Collins, Gilbert, 1998. *Guidebook to the Historic Sites of the War of 1812.* Toronto, Dundurn, 327 p.

Duke, W.L., P.J. Fawcett, and W.C. Brusse, 1991. Prograding shoreline deposits in the Lower Silurian Medina Group. Ontario and New York — storm- and tide-influenced sedimentation in a shallow epicontinental sea, and the origin of enigmatic shore-normal channels encapsulated by open shallow shallow-marine deposits. International Association of Sedimentologists Special Publication 14, p.339-375.

Duquemin, C. K., 2004. *The Driver's Guide to the Historic Welland Canal*. St. Catharines, Norman Enterprises, 51 p.

Dyke, A.S., 2004. An outline of North American deglaciation with emphasis on central and northern Canada. In: Ehlers, J. and Gibbard, P.L. (Eds.), Quaternary Glaciations – Extent and Chronology, Part II. Elsevier, Amsterdam, pp. 373-424.

Eyles, N, 1997. Environmental geology of a Canadian supercity; the Greater Toronto Area. In: Eyles, N., (Ed.,) Environmental Geology of Urban Areas: Geological Association of Canada, Geotext No. 3, pp. 7-80.

Eyles, N. and J. A. Westgate. J.A. 1987. Restricted regional extent of the Laurentide Ice Sheet in the Great Lakes Basins during early Wisconsin glaciation. Geology 15, 537-540.

Eyles, N., Boyce, J.I. and Mohajer, A. 1993. Bedrock topography in the western Lake Ontario region: Evidence of reactivated basement structures? Geographie physique et Quaternaire 47, 269-283.

Eyles, N., Scheidegger, A.E., Arnaud, E. and Eyles, C.H. 1997. The influence of bedrock jointing on the geomorphology of southwestern Ontario: an example of tectonic predesign. Geomorphology 19, 17-34.

Eyles, N., Eyles, C.H., Woodsworth-Lynas, C. and Randall, T. 2005. The sedimentary record of drifting ice (early Wisconsin Sunnybrook deposit) in an ancestral ice-dammed Lake Ontario. Quaternary Research 63, 171-181.

Eyles, N. and Miall, A.D. 2007. *Canada Rocks: The Geologic Journey*. Fitzhenry and Whiteside, Markham ON. 512pp.

Feenstra, B.H. 1972. Quaternary Geology: Welland area. Ontario Division of Mines. Preliminary Map P.796.

Feenstra, B.H. 1975 Quaternary Geology: Grimsby area. Ontario Division of Mines. Preliminary Map P.993.

Feenstra, B.H. 1981. Quaternary geology and industrial minerals of the Niagara-Welland area. Ontario Geological Survey Open File Report 5361, 260 pp.

Flint, J.E. and Lolcama, J. 1985. Buried ancestral drainage between lakes Erie and Ontario. Geological Society of America Bulletin 97, 75-84.

Gayler, H. J., Ed., 1994. *Niagara's Changing Landscapes*. Carleton University Press, 368 pp.

Goudge, M.F., 1938. *Limestones of Canada, Part IV, Ontario*. Canada Department of Mines and Resources, Mines Branch Report 781, 362 pp.

Graves, D.E., 1997. *Where Right and Glory Lead! The Battle of Lundy's Lane, 1814*. Toronto, Robin Brass, Second edition, 332 p.

Haynes, S. J., 2000. Geology and wine 2. A geological foundation for *terroirs* and potential *sub-appellations* of the Niagara Peninsula wines, Ontario, Canada. *Geoscience Canada* 27, p.67-87.

Hewitt, D.F., 1960. *The Limestone Industries of Ontario*. Ontario Department of Mines, Industrial Mineral Circular 5, 177 pp.

Hobson, G.D. and Terasmae, J. 1969. Pleistocene geology of the buried St.Davids Gorge, Niagara Falls, Ontario: Geophysical and Palynological Studies. Geological Survey of Canada Paper 68-67, 16 pp.

Jackman, Rev. E., 1997. *A Brief History of the Diocese of St. Catharines*. Second edition. (Also at http://www.romancatholic.niagara.on.ca/historyb.htm)

Jackson, J. N., 1976. *St. Catharines, Ontario: Its Early Years*. Belleville, ON, Mika Publishing Co., 416 pp.

Jackson, J. N., 1988. *The Four Welland Canals: A Journey of Discovery in St. Catharines and Thorold.* St. Catharines, Vanwell Publishers, 75 pp.

Jackson, J. N., 1997. *The Welland Canals and Their Communities: Engineering, Industrial, and Urban Transformation*. University of Toronto Press, 535 p.

Jackson, L.J., Ellis, C., Morgan, A.V. and McAndrews, J.H. 2000. Glacial lake levels and eastern Great Lakes Paleo-Indians. Geoarcheology 15, 415-440.

Jay, E. B. and J. H. Long, 1981. *Historic Buildings of Niagara Falls*. No pagination or publisher listed.

Johnson, M.D. Armstrong, D.K., Sanford, B.V. Telford, P.G. and Rutka, M.A. 1992. Paleozoic and Mesozoic. In: R.C. Thurston, H.R. Williams, R,H. Sutcliffe (Eds). Geology of Ontario. Ontario Geological Survey Special Volume 4, Pt.2, pp. 907=1010.

Karrow, P.F.,1963. Pleistocene Geology of the Hamilton-Galt area. Ontario Department of Mines Report 16, 68 pp.

Kilbourn, W.,1960. *The Elements Combined: A History of the Steel Company of Canada*. Toronto, Clarke, Irwin & Company, 335 pp.

Latimer, J., 2007. *1812: War with America*. Harvard University Press.

Legget, R., 1972. *Rideau Waterway*. University of Toronto Press, 249 pp.

Legget, R., 1988. *Ottawa River Canals, and the Defence of British North America*. University of Toronto Press, 308 pp.

MacRae, M. and Adamson, A. 1975. *Hallowed Walls: Church Architecture of Upper Canada*. Toronto, Clarke, Irwin, 304 pp.

MacRae, M. and Adamson, A. 1983. *Cornerstones of Order: Courthouses and Town Halls of Ontario, 1784-1914.* Toronto, Clarke, Irwin, 283 pp.

Malcomson, R., 2003. *A Very Brilliant Affair: the Battle of Queenston Heights, 1812*. Toronto, Robin Brass.

Miller, Willet G., 1892. *First Report of the Ontario Bureau of Mines, 1891*. Structural Materials, pp.95-101.

Morden, James C., 1932. *Historic Niagara Falls*. Niagara Falls, Lindsay Press for the Lundy's Lane Historical Society, 117pp.

Parks, W. A., 1912. *Report on the Building and Ornamental Stones of Canada*, Volume 1, Canada Department of Mines, 376 pp.

Rannie, W. F., 1987. *Stone from the Mountain: Stories of Grimsby and Lincoln*. Grimsby Historical Society, 148 pp.

Rannie, W. F., 1976. Wines of Ontario: An Industry Comes of Age. Lincoln, ON, W.F. Rannie, 171 p.

Seibel, G. A., 1991. *The Niagara Portage Road: a History of the Portage on the West Bank of the Niagara River*. City of Niagara Falls.

Seibel, G. A. and others, 1967. *Niagara Falls, Canada: A History of the City and the World Famous Beauty Spot. An Anthology.* Niagara Falls, ON, Kiwanis Club of Stamford, 432 p.

Seibel, G. A., 1990. *The Niagara Portage Road: a History of the Portage on the West Bank of the Niagara River*. City of Niagara Falls.

Shaw, A. B., 2005. The Niagara peninsula viticultural area: a climatic analysis of

Canada’s largest wine region. Journal of Wine Research, 16, p.85-103.

Shipley, R., 1987. *St. Catharines: Garden on the Canal – An Illustrated History*. Burlington ON, Windsor Publications, 176 pp.

Straw. A. 1968. Late Pleistocene glacial erosion along the Niagara Escarpment of Southern Ontario. Geological Society of America Bulletin 79, 885-910.

Styran, R. M. and R. R. Taylor, 1988. *The Welland Canal: The Growth of Mr. Merritt’s Ditch*. Erin ON, Boston Mills Press, 168 pp.

Tammemagi, H. and Allyson, P. 2007. *Exploring Niagara*. Fitzhenry and Whiteside, Markham, ON revised edition, 218 pp.

Taylor, R. R., 1992. *Discovering St. Catharines’ Heritage*. St. Catharines, Vanwell Publishing, 59 p.

Tinkler, K. J., 1993. *Field Guide to Niagara Peninsula and Niagara Gorge*. Third International Conference in Geomorphology, McMaster University, 24 pp.

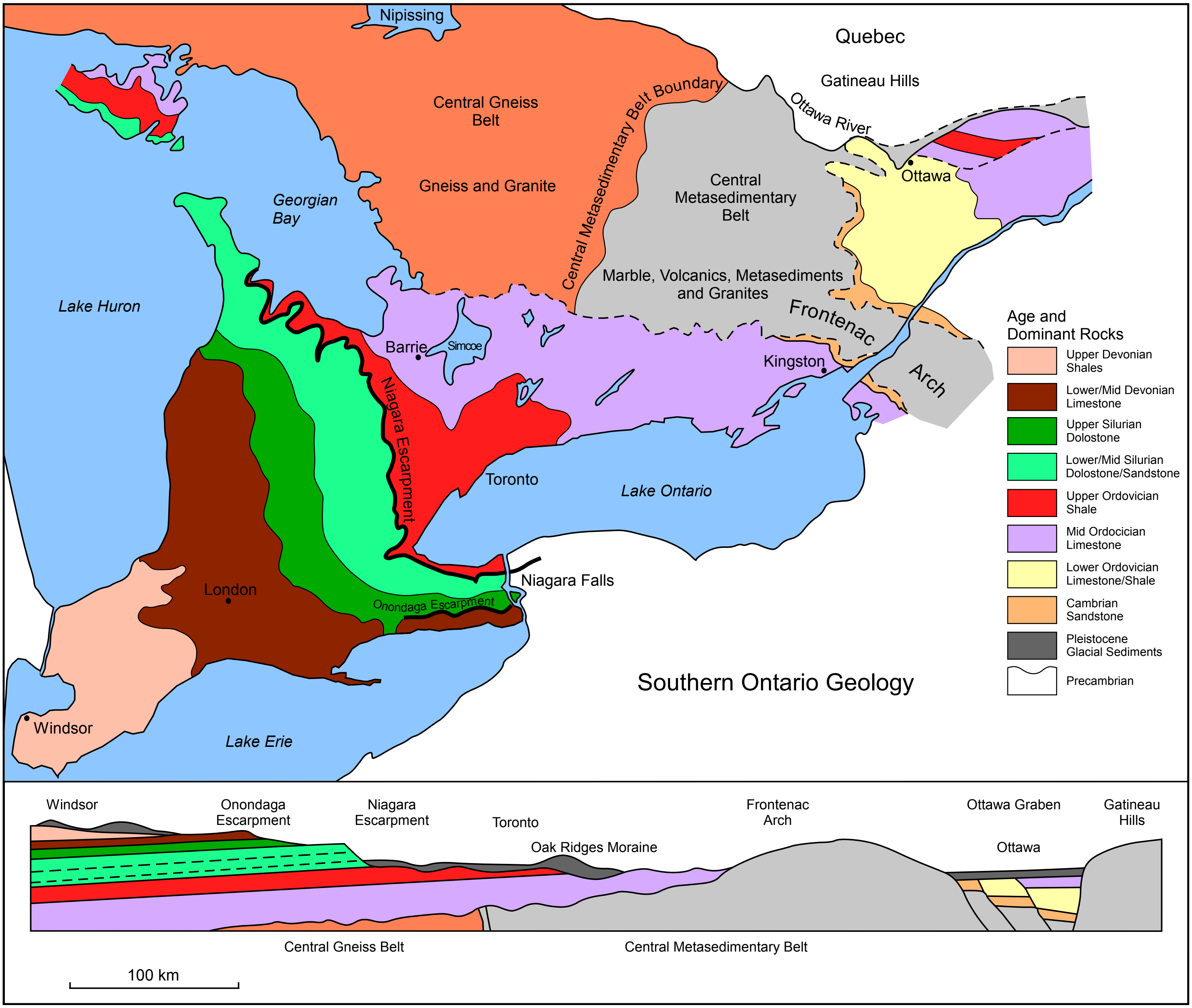
Tinkler, K. J., 1998. *History of Geology Field Trip to Niagara Falls*. GAC/GSA Field Trip Guidebook 9. (also see his contribution in Gaylor,1994).

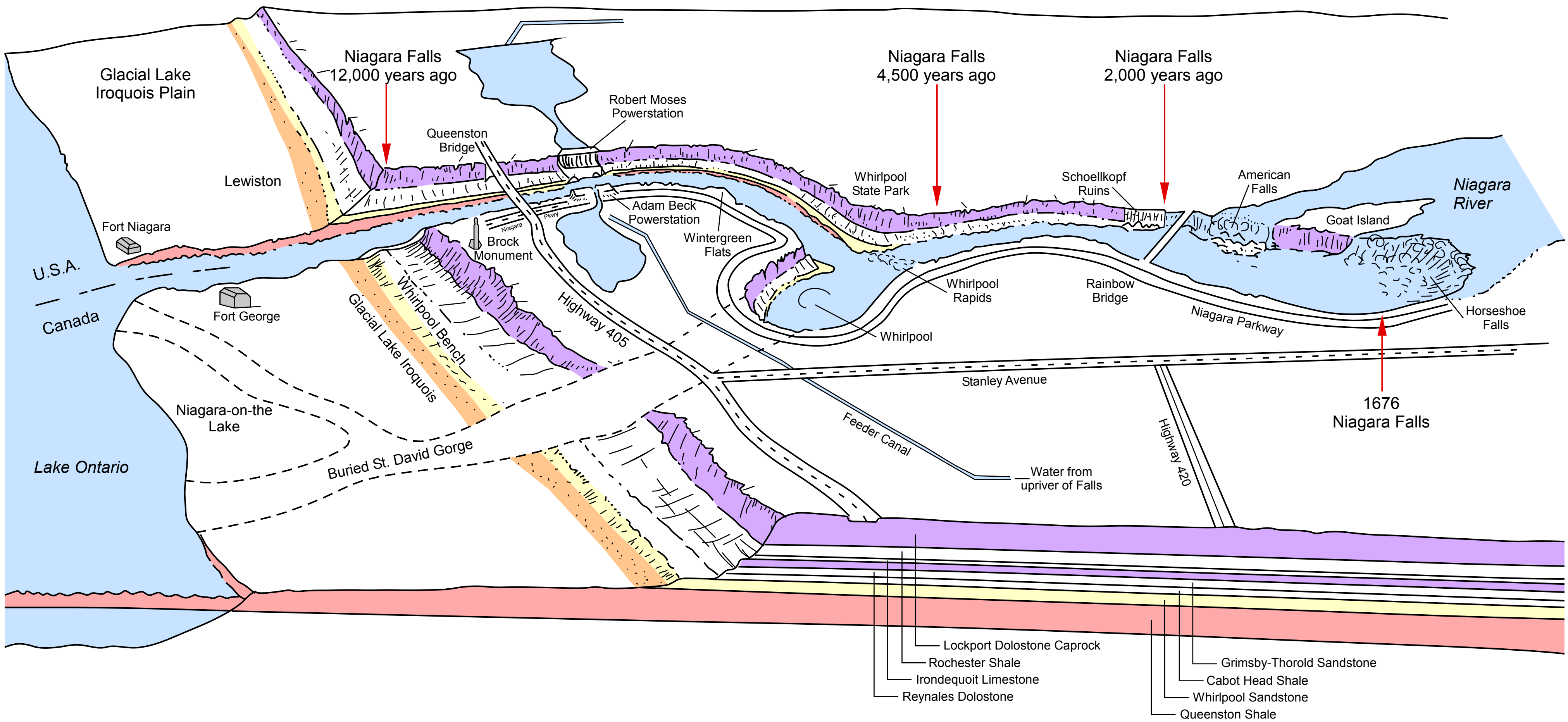
Tiplin, A.H.,with additional material by George A. Seibel, 1988. *Our Romantic Niagara: A Geological History of the River and Its Falls*. Niagara Falls Heritage Foundation, 216 p. This book reprints Tiplin’s articles, originally published in the *Niagara Falls Evening Review*, some of which appeared 50 years earlier. Seibel contributed sections on history. The geology and geomorphology remained badly out-of-date but the book contains many valuable historical photographs.

Tovell, W.M. 1992. Guide to the Geology of the Niagara Escarpment. Niagara Escarpment Commission. Ashton-Potter Ltd., Concord. ON 176pp.

Turcotte, D., 1995. *People and Places from Grimsby’s Past*. Grimsby Historical Society, 2006.

Zuehlke, M., 2006. *For Honour’s Sake: the War of 1812 and the Brokering of an Uneasy Peace*. Alfred A. Knopf, 443 pp.


Nipissing
Quebec
Gatineau Hills
Central Gneiss Belt
Central Metasedimentary Belt Boundary
Ottawa River
Gneiss and Granite
Ottawa
Georgian Bay
Central Metasedimentary Belt
Marble, Volcanics, Metasediments and Granites
Lake Huron
Frontenac
Barrie
Simcoe
Kingston
Arch
Niagara Escarpment
Toronto
Lake Ontario
Niagara Falls
London
Onondaga Escarpment
Windsor
Lake Erie
Southern Ontario Geology
Age and Dominant Rocks
Upper Devonian Shales
Lower/Mid Devonian Limestone
Upper Silurian Dolostone
Lower/Mid Silurian Dolostone/Sandstone
Upper Ordovician Shale
Mid Ordocician Limestone
Lower Ordovician Limestone/Shale
Cambrian Sandstone
Pleistocene Glacial Sediments
Precambrian
Windsor
Onondaga Escarpment
Niagara Escarpment
Toronto
Frontenac Arch
Ottawa Graben
Gatineau Hills
Oak Ridges Moraine
Ottawa
Central Gneiss Belt
Central Metasedimentary Belt
100 km



Glacial Lake
Iroquois Plain
Niagara Falls
12,000 years ago
Niagara Falls
4,500 years ago
Niagara Falls
2,000 years ago
Robert Moses
Powerstation
Queenston
Bridge
Lewiston
Fort Niagara
U.S.A.
Canada
Fort George
Brock
Monument
Niagara
Pkwy
Adam Beck
Powerstation
Wintergreen
Flats
Whirlpool
State Park
Schoellkopf
Ruins
American
Falls
Niagara
River
Goat Island
Whirlpool
Rapids
Rainbow
Bridge
Whirlpool
Niagara Parkway
Horseshoe
Falls
Highway 405
Glacial Lake Iroquois
Whirlpool Bench
Niagara-on-the
Lake
Buried St. David Gorge
Lake Ontario
Stanley Avenue
Feeder Canal
Water from
upriver of Falls
Highway 420
1676
Niagara Falls
Lockport Dolostone Caprock
Rochester Shale
Irondequoit Limestone
Reynales Dolostone
Grimsby-Thorold Sandstone
Cabot Head Shale
Whirlpool Sandstone
Queenston Shale