MEMOIR 355

PALAEOZOIC GEOLOGY OF THE LAKE SIMCOE AREA, ONTARIO

B. A. Liberty

1969

PALAEOZOIC GEOLOGY OF THE LAKE SIMCOE AREA, ONTARIO

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PLATE I. Precambrian inlier of granite gneiss, showing Bobcaygeon strata overlapping on its eastern flank with 22 degree dip; granite surface is showing at top in middle background. Red Rock, 4½ miles east of Fenelon Falls. P, Precambrian; O, Ordovician.

GEOLOGICAL SURVEY
OF CANADA

MEMOIR 355

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By

B. A. Liberty

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PREFACE

For more than a hundred years the Ordovician rocks of Ontario and adjacent parts of the United States have attracted the interest of stratigraphers and palaeontologists. As a natural consequence the literature has become burdened by a complex stratigraphic terminology, in part due to conflicts between the essentially biostratigraphic approach of some of the earlier workers and the more lithostratigraphic approach required for the modern definition of rock groups and formations.

Surface exposures in the Lake Simcoe area have provided a good basis for the establishment of workable lithostratigraphic subdivisions of the Ordovician strata. The subdivisions presented in this memoir may resolve some complex nomenclatural problems and will assist the interpretation of the subsurface succession in southern Ontario, where Ordovician rocks are important producers of oil and natural gas.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, March 5, 1965

MEMOIR 355 — Paläozoische Geologie des Gebiets vom Lake Simcoe in Ontario

Von B. A. Liberty

Detaillierte Beschreibung der Sedimentschichten des Unteren Paläozoikums am Südrande des Kanadischen Schilds, der darin enthaltenen Fossilien und des Aufbaus, des wirtschaftlichen Potentials und des Ursprungs dieser Schichten. Mit einer neuen Liste von Namen von Gesteinseinheiten zur Ergänzung der älteren biostratigraphischen Gesteinsnamen für diese zum grossen Teil kalkigen Ablagerungen.

МЕМУАР 355 — Геология палеозоя района оз. Симко провинции Онтарио

Б. А. Либерти

В этой работе дается детальное описание нижнепалеозойских осадочных пород южной части Канадского щита, ископаемых, находящихся в них, их структуру, экономический потенциал, а также их происхождение. Она содержит новую терминологию единиц горных пород для дополнения более ранних названий биостратиграфических пород этих в основном известковых осадочных пород.

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PALAEOZOIC GEOLOGY OF THE LAKE SIMCOE AREA, ONTARIO

Abstract

This report describes the flat-lying Lower Palaeozoic shelf carbonates north of Lake Ontario and lying between the Michigan Basin and the Canadian Shield. Investigations have been made in sufficient detail to permit subdivision of the Ordovician strata into two main groups, subdivided as follows:

Nottawasaga Group	Georgian Bay Formation (lower and upper members) Whitby Formation (lower, middle, and upper members)
Simcoe Group	Lindsay Formation Verulam Formation (lower and upper members) Bobcaygeon Formation (lower, middle, and upper members) Gull River Formation (lower, middle, and upper members)

Most of these stratigraphic units have now been traced laterally into both northern Michigan and New York states and into southwestern Ontario, southern Michigan, and Ohio (where some of them are important producers of natural gas and/or oil).

We now have enough stratigraphic knowledge of the Middle Ordovician rocks to resolve the following long-standing stratigraphic problems: 1) the term 'Billings' should be restricted to the Ottawa Valley; 2) the terms Collingwood, Gloucester, and Blue Mountain should be used only in a biostratigraphic sense; 3) the Black River–Trenton and Middle–Upper Ordovician contacts are both time boundaries and must be delimited by fossils; 4) strata of Gloucester age do not extend as far north as Georgian Bay; Blue Mountain strata extend southwards from Georgian Bay to the Toronto area; and 5) the terms Dundas and Meaford should be used only in a biostratigraphic sense. On Manitoulin Island, where Meaford strata constitute a rock unit, the term Meaford is replaced by the upper member of the Georgian Bay Formation, a rock unit present in the Lake Simcoe area.

The Ordovician strata in southern Ontario now have a dual nomenclature, the one biostratigraphic, the other lithostratigraphic. Stratigraphic details have revealed a northwest-trending structure in the Peterborough area (herein called the Peterborough Arch), and a structurally controlled lineament of lakes between Georgian Bay and Belleville (herein called the Kawartha Lineament).

The Lake Simcoe area contains many quarries but only a few are still operating. These produce crushed stone, agricultural lime, and asphalt filler. The proximity of a wide variety of carbonate rocks to a highly industrialized area has prompted the author to include much basic chemical data in the report, in anticipation of future commercial development of these rocks.

Résumé

Le présent rapport a pour objet la description des roches carbonatées du plateau du Paléozoïque inférieur au nord du lac Ontario, entre le bassin du Michigan et le Bouclier canadien. Des recherches suffisamment detailées ont permis la subdivision des couches ordoviciennes en deux groupes principaux, subdivisés comme suite

Groupe de Nottawasaga	Formation de Georgian Bay (Stratifications inférieure et supérieure Formation de Whitby (stratifications inférieure, moyenne, et supérieure
Groupe de Simcoe	Formation de Lindsay Formation de Verulam (stratifications inférieure et supérieure Formation de Bobcaygeon (stratifications inférieure, moyenne, et supérieure Formation de Gull River (stratifications inférieure, moyenne et supérieure

La plupart de ces unités stratigraphiques ont maintenant été repérées latéralement, dans le nord des états du Michigan et de New York, ainsi que dans le sud-ouest de l'Ontario, le sud du Michigan, et l'Ohio (certaines d'entre elles renferment d'importants gisements de gaz naturel et de pétrole).

Nos connaissances de la stratigraphie des roches de l'Ordovicien moyen nous permettent maintenant de résoudre de vieux problèmes stratigraphiques: 1) le terme «Billings» doit être réservé à la vallée d'Ottawa; 2) les termes Collingwood, Gloucester et Blue Mountain ne devraient être utilisés que dans un sens biostratigraphique; 3) les contacts Black River–Trenton et Ordovicien moyen–supérieur sont tous deux des délimitations chronologiques et doivent être identifiés d'après les caractéristiques de leurs fossiles; 4) les couches de Gloucester ne s'étendent pas vers le nord, jusqu'à Georgian Bay; les couches de Blue Mountain s'étendent vers le sud, de Georgian Bay jusqu'aux environs de Toronto; et 5) les termes Dundas et Meaford ne devraient être utilisés que dans un sens biostratigraphique. Dans le cas de l'île Manitoulin, où les couches de Meaford forment une unité rocheuse, le terme Meaford est remplacé par la stratification supérieure de la formation de Georgian Bay, une unité rocheuse présente dans la région du lac Simcoe.

Les couches de l'Ordovicien dans le sud de l'Ontario ont maintenant une double nomenclature, l'une biostratigraphique, l'autre lithostratigraphique. Des détails de stratigraphie révèlent la présence d'une structure d'orientation nord-ouest dans la région de Peterborough (appelée ici l'arche de Peterborough), ainsi que d'un linéament, structuralement identifié, de lacs entre Georgian Bay et Belleville (appelée ici linéament de Kawartha).

Il existe de nombreuses carrières dans la région du Lake Simcoe, dont quelques-unes seulement sont encore en exploitation. Elles fournissent de la pierre concassée, de la chaux agricole et des agrégats d'asphalte. La proximité d'une grande variété de roches carbonatées et d'une région fortement industrialisée, a incité l'auteur à fournir dans son rapport de nombreuses données chimiques essentielles, en prévision d'une éventuelle exploitation commerciale de ces roches.

Chapter I

INTRODUCTION

The Lake Simcoe area is bounded by Georgian Bay on the northwest, the Precambrian rocks of Haliburton county and Muskoka district on the north, the 78°30′ west longitude meridian on the east, Lake Ontario on the south, and the Niagara Escarpment on the west. It includes most of Simcoe, Ontario, Victoria, and Durham counties as well as small parts of York and Peterborough counties, some 3,900 square miles in all. This region is one of the more densely populated areas in Ontario, and includes such cities and towns as: Toronto, Oshawa, Lindsay, Collingwood, Barrie, Orillia, Whitby, Bowmanville, Bobcaygeon, Fenelon Falls, Beaverton, Midland, and Penetangueshene. These communities are linked by a network of paved and gravel roads.

Manufacturing in the cities and agriculture in the rural areas are the most important industries in the map-area. Ranching of beef cattle in the Kirkfield area and fishing in Lake Simcoe, Nottawasaga Bay, and Lake Ontario are other industries, but quarrying of building stone and lumbering, formerly important industries in the map-area, have not been carried on for more than a decade. Other industries include the Uhthoff and Kirkfield[1] quarries for the production of crushed stone, etc., and the recently expanding and lucrative tourist business. The latter is centred about the pleasure resorts of Nottawasaga Bay, the Penetang Peninsula, Lake Simcoe, and the Lindsay–Bobcaygeon area on the Trent Valley Canal.

In 1948 the writer was assigned to investigate the Ordovician stratigraphy of the Lake Simcoe area and to relate the map units in this area to those in several adjoining areas. This project was originally commenced in 1943 by J. F. Caley of the Geological Survey of Canada as part of a program to map the Ordovician rocks from Georgian Bay eastward to the Frontenac axis. The program has since been expanded to include the Ordovician rocks on Bruce Peninsula and Manitoulin Island, on which the writer is preparing final reports.

Detailed stratigraphical and palaeontological investigations were conducted within the map-area, and the results were published in preliminary map form on the scale of an inch to the mile. The multicoloured map accompanying this report is compiled on the scale of 1 inch to 4 miles.

Ms. received 20 December, 1960, with subsequent revisions. The author is now Professor of Geology, Dept. of Geological Sciences, Brock University, St. Catharines, Ontario.

[1] The Kirkfield quarry is presently inactive (1964).

Previous Work

In 1842, Alexander Murray examined the country between Georgian Bay, Lake Erie, and Lake Ontario and provided one of the earliest geological accounts of the present map-area. Murray divided the Palaeozoic rocks of this area into ten lithological divisions and correlated them with the existing divisions in New York state. The Reports of Progress of the Geological Survey of Canada between 1843 and 1863 contain various accounts of the rocks in southwestern Ontario. In 1863, Logan's "Geology of Canada" was published, which summarized the data on the various formations.

About 1900, geologists began to divert their attention from New York state toward eastern and central Ontario. It was at this time that Ami, Cushing, Kindle, and Ells conducted their investigations around the Kingston area. Between 1906 and 1912, Johnston, with Ulrich and Raymond as his advisors, investigated the Lake Simcoe area. Partly as a result of this work, Raymond proposed geographical names for the faunal zones of the Trenton and Utica strata in 1914 and 1916.

In the years between 1913 and 1928, the Upper Ordovician strata near Toronto and Collingwood were investigated by Foerste, Parks, Fritz, Dyer, and Stewart. Similarly, the Middle Ordovician were examined by Parks, Sproule, and Kay between 1928 and 1937. Since 1939, the strata have been further examined by Okulitch, Kay, Sinclair, and Young. Also at this time, contributions were made through the medium of theses by Crombie, Derry, Belding, Miller, Stauft, and Gorrell at the University of Toronto. The most recent work (post-1940) on the Ordovician of the Lake Simcoe district is by Caley in the Toronto–Hamilton and Owen Sound areas, and by the writer in the Lake Simcoe area.

Physical Features

Physical features in the Lake Simcoe area are only briefly described on the following pages. For more complete accounts the reader is referred to the physiographic study of Chapman and Putnam (1951) and to the glacial report of Deane (1950).

The Lake Simcoe area is essentially a lowland plain sloping gently toward the southwest and terminating against the Niagara Escarpment, which rises several hundred feet above the flatter country to the east. Although the slope of the surface and the dip of the underlying Ordovician strata are both generally southwestward, the dip of the strata is steeper than the slope of the surface. Accordingly the strata become progressively more deeply buried towards the south, and drift thicknesses of clay, sand, and gravel increase in this same direction. A narrow outcrop belt is in the northern part of the map-area near the Precambrian rocks; there the drift averages only a few feet in thickness and the physiography is essentially a reflection of the bedrock surface. Extensive flats are common and small northeastward-facing escarpments are numerous, resulting from differential erosion of alternating resistant and non-resistant beds. The influence of glacial Lake Algonquin on the headlands, in the bedrock terraces, and in wavecut bluffs along these small escarpments can be readily seen.

The northernmost part of the map-area comprises granitic rocks of the Canadian Shield, whose glaciated surface is relatively rugged in comparison with the surface of the area underlain by Palaeozoic rocks. The relief on the Precambrian surface ranges from 20 to 100 feet (Wilson, 1903b), and it was on an uneven surface similar to the present one that the Ordovician sediments were deposited. Scattered here and there on this surface (Wilson called it a peneplain) are a few erosional remnants or monadnocks that rise 50 to 150 feet above the surrounding plain. The best examples of monadnocks are the Precambrian inliers at Rohallion, near Bolsover, and along the main road about 4 miles east of Fenelon Falls. This northern part of the map-area contains numerous rock-knob outcrops (*roches moutonnées*) of granite-gneiss that were swept clean by waters of the glacial lakes.

The original surface of the Precambrian rocks has undergone relatively little change in relief and general shape since Precambrian times, as is indicated by the continuation of the peneplain surface beneath the Ordovician rocks. The subsurface continuation of this surface is suggested by local structures in the Black River–Trenton strata, thickness variations in the Shadow Lake Formation, and the surface appearance of the many Precambrian inliers.

The variation in thickness of the Pleistocene deposits in the map-area is in part related to the types of bedrock nearby. As the hard granular Precambrian rocks in the northern part of the map-area were not easily eroded, they yielded little material to the advancing Pleistocene ice, and little drift now covers these rocks. Immediately south of the Precambrian rocks the narrow marginal limestone plains have only a thin drift cover, indicating that the base of the overriding Pleistocene ice was not overloaded. As these narrow plains are underlain by hard, compact, dense Black River strata, they were scoured by the advancing ice, but yielded little debris to it. Only when the advancing ice reached the softer, thinner bedded Trenton limestones and shales, which were easily eroded by plucking and abrasion, did a relatively heavy subglacial load accumulate. Much of this load was subsequently deposited as ground moraine.

Ground moraine overlying the narrow limestone plains near the Canadian Shield contains a high proportion of Precambrian material; that which overlies the Trenton strata contains a high proportion of Black River material. The type of material in the ground moraine has been used with a high degree of success in demarcating the contact between formations in areas where outcrops are scarce or non-existent. This technique was used by Gravenor (1954b) in the Scugog area, and substantiated the writer's extrapolated Cobourg-'Collingwood' contact in this heavily drift-covered area (Liberty, 1953e).

Limestone plains extend as a narrow belt along the southern border of the Canadian Shield. They vary in width from 20 miles, east of Lake Simcoe, to 8 miles, near Orillia, and to about 4 miles, around Coldwater and Waubaushene. They are generally covered with thin lacustrine deposits and drift. Flat-lying limestone outcrops of Black River age are numerous within this narrow belt, and much drift has been removed from the higher areas by Lake Algonquin waters. Georgina and Thorah Islands in Lake Simcoe are isolated remnants of the limestone plains. Northeastward-facing escarpments as much as 40 feet high are common. Most of them are formed of resistant members of the Gull River, Bobcaygeon, Verulam, and Lindsay Formations. These small escarpments continue westward into Penetang Peninsula, where they are generally aligned toward their equivalents on Manitoulin Island to the northwest across Georgian Bay.

The Algonquin Lake plain (Deane, 1950) includes those areas whose characteristic features are flat plains of sand, silt, or clay, deposited from glacial Lake Algonquin. Beach deposits are common at several elevations, marking former shorelines of Lake Algonquin during its various stages. Gravel bay-mouth bars, spits, and beach ridges are best developed along the main Algonquin beach; similar, but fine-grained forms are more common along the lower Algonquin shorelines.

Drumlin fields occur around Cannington, in Mara and Rama townships east of Orillia, and east and south of Lindsay. The drumlins near Lindsay are part of the Peterborough drumlin field. Isolated drumlins are also present elsewhere in the map-area.

The Lake Simcoe till plains include several islands, peninsulas, and headlands of ancient Lake Algonquin, and comprise mainly an undulating ground moraine, the Bass Lake kame moraine, a few drumlins, and ice-contact deposits (Deane, 1950). The material making up the ground moraine in the northern part of the till plains is a sandy till derived mainly from the Precambrian granitic rocks to the north; it becomes increasingly more calcareous in the central and southern parts of the till plains.

A distinctive interlobate moraine, as much as 8 miles wide, extends more than 100 miles from the Niagara Escarpment eastward across the southern part of the map-area, with its general elevation about 1,000 feet above sea-level. It forms the watershed between streams flowing into Lake Ontario and those flowing into Georgian Bay, Lake Simcoe, and Trent River. The north and south slopes of this moraine, together with the adjacent till plains form two regions. The surface of the moraine is generally irregular and the material consists of sand, gravel, and boulder clay.

The Niagara Escarpment, which extends across the map-area from near Milton to Cape Rich on Georgian Bay, is the most distinctive physiographic feature of southern Ontario. It forms the southwesterly limit of surface-exposed Ordovician rocks. The vertical cliffs of this escarpment, or cuesta, mark the edge of the Silurian carbonate and clastic formations, which overlies the less resistant Ordovician Queenston red shales on the lower slopes. There are several mesa-like outliers of Silurian strata east of the escarpment, the largest of which is an area of about 4 square miles near Milton.

Perhaps the most picturesque part of the escarpment is the Blue Mountain section near Collingwood where the Silurian strata are exposed in high cliffs about 1,000 feet above Georgian Bay. The scenic value of the escarpment is also greatly enhanced by deep notches in the rim through which small creeks flow. Westward from the Niagara Escarpment, the Silurian strata dip gently towards Lakes Erie and St. Clair on the southern broad terrace of the Algonquin Arch. Topographic relief is low and rolling, decreasing southward from the top of the arch at Collingwood (1,700 feet above sea-level) to Lake Erie (572 feet above sea-level). Surface deposits include clay moraines and sand and clay plains.

Drainage

The present land configuration masks the bedrock Tertiary drainage pattern, which has been described by Spencer (1907), Grabau (1901), and Coleman (1932).

Surface Drainage

Many lakes and rivers in the map-area are small and occupy depressions in a bedrock drainage system: Pigeon, Sturgeon, and Canal Lakes are particularly good examples of this type. Head, Oak, Beech, Talbot, Johnston, Shadow and Four Mile Lakes are good examples of glint lakes.[1] All the lakes are relatively shallow, although Lake Simcoe has recorded depths of about 140 feet. A system of lakes between Balsam and Stony Lakes, which are known as the Kawartha Lakes, lie in a linear belt between Georgian Bay and the Bay of Quinte. The writer calls this belt the Kawartha Lineament, for it appears to be the southeastern extension of Georgian Bay.

Draining into these lakes are many small rivers. Burnt, Gull, Head, Black, Severn, and Coldwater Rivers and Nogies Creek are generally youthful streams, but meanders indicating more advanced stream maturity are present in Burnt, Beaverton, and Pefferlaw Rivers. The Trent Valley Canal artificially joins several rivers and lakes into a system of waterways that taps the drainage of an extensive tract of land within the map-area. The complete catchment basin for this system extends well beyond the boundaries of the map-area.

Subsurface Drainage

Near Collingwood, the Niagara Escarpment may be subdivided into an upper bench (Silurian) and a lower bench (Ordovician). Eastward it is interesting to follow this escarpment or cuesta into a bifurcation, the upper bench tracing into the Niagara Escarpment proper and the lower into a buried one. For the latter and its limiting valley to the north, the terms Simcoe Escarpment and Simcoe Valley are proposed for convenience because of their location near the lake and in the county bearing that name. The Simcoe Escarpment arises in Mulmur and

[1] A glint lake is one whose basin is excavated in hard rock where a glacier is held in check by an escarpment.

Tosoronto townships and comprises Dundas–Meaford, Blue Mountain, Gloucester and Collingwood strata (Georgian Bay and Whitby Formations) in descending order. This cuesta forms the southern bank of the deep bedrock valley south of Barrie, the relief of the buried cuesta being at least 400 feet. The northern limits of the Simcoe Valley are represented by the low gentle terrace that extends from Orillia to Barrie, whose relief keeps pace with the dip of the bedrock strata at about 12 feet to the mile. In the centre of this valley is the bedrock 'island' south of Barrie that is covered by a thin veneer of drift. This 'island' comprises the Lindsay Formation (Cobourg strata) and has a relief of at least 150 feet above the Simcoe Valley floor.

The Simcoe Valley extends eastward to form a re-entrant in Cook Bay at the south end of Lake Simcoe, where it merges with the Laurentian Valley. Southward through the latter, the pre-glacial Laurentian River (Spencer, 1907, p. 387) flowed in this bedrock-walled valley, which extends from Cook Bay to the vicinity of Toronto, on Lake Ontario. This valley is now filled with drift, which is at least 400 feet thick at Richmond Hill and about 600 feet thick near Maple. It is presumably of Tertiary age. The sharply incised drainage pattern on the bedrock of the Balsam Lake–Sturgeon Lake area is probably part of the same drainage system.

These pre-glacial patterns are well presented in A. W. G. Wilson's (1904a) paper: "The Trent River system and the St. Lawrence Outlet". His theory embraced drainage trends and a Precambrian 'peneplain' with river courses trending across its surface. The Kawartha Lineament strikes diagonally across this peneplain between Georgian Bay and the Bay of Quinte; the lakes concerned have no doubt resulted from the river courses and the lineament (*see* Structural Geology in Chapter III).

Regional Drainage

The deep notches in the Niagara Escarpment, which greatly enhance the scenic beauty and through which small creeks now flow, may be of importance in an appreciation of the structure underlying the escarpment face and adjacent to it. Notches similar to the Beaver Valley are sculptured into the face of the cuesta throughout its length and appear to be an integral characteristic of the escarpment wherever it appears throughout the Great Lakes area. The depth and extent of these notches have interested the writer since about 1935, especially the radial pattern they produce relative to the centre of the Michigan Basin. Putnam (1955) regarded these features as of pre-glacial origin and Ehlers (1929, p. 52) considered the pattern as representing a Tertiary radial drainage. The writer suggests that the wrinkling of the peripheral part of the basin may be the result of the moulding of basement Precambrian rocks, and accordingly any overlying strata. Crinkling is suggested by the appearance of certain regular, higher 'radials' that may be structurally controlled, i.e., Owen Sound, Little Current (on Manitoulin Island). The writer considers that the notches resulted from erosion by drainage waters from the central part of the basin; that this drainage followed the structure and accordingly sought out the lows or synclines; and that the present notches indicate the synclinal areas. This theory presupposes a high area in the central part of the Michigan Basin from which rivers would drain radially outward.

The presence of Mesozoic sediments (Jurassic) in the centre of the Michigan Basin indicates that in all probability erosion was initiated in Cretaceous or Early Tertiary time and reached maximum development during the Tertiary. This interpretation is inescapable. A secondary recovery of the basin may well be indicated. A high degree of relief must have been achieved in order that the deep Mackinac Straits channel, the Niagara and Simcoe Escarpments, and the deep Laurentian River could be eroded. Briefly, the deep notches in the Niagara Escarpment are considered to be of pre-glacial origin and to reflect underlying bedrock structure.

Acknowledgments

The writer is indebted to the Geological Survey of Canada for permitting him to use part of the results of his study of the Lake Simcoe area for a doctoral thesis at the University of Toronto. He is also indebted to Dr. J. F. Caley of the Geological Survey of Canada, Dr. M. A. Fritz, Department of Geological Sciences, University of Toronto, the late Dr. A. E. Wilson, formerly of the Geological Survey of Canada, Dr. W. A. Roliff of Imperial Oil Limited, Toronto, the late Dr. C. S. Evans, formerly of Union Gas Limited, Chatham, Dr. L. S. Russell, Royal Ontario Museum, Toronto, and Mr. S. A. Forman, Department of Agriculture, Ottawa, for their kind assistance during the preparation of this report, and to Dr. G. M. Ehlers, formerly of the University of Michigan, and Dr. G. Marshall Kay of Columbia University for continued interest, correspondence, and discussions, and their company during field trips examining Ordovician rocks in both the United States and Canada.

The writer was ably assisted in the field by C. W. Stearn in 1948, A. M. Turner in 1949, and E. W. Best in 1950. Various members of the Geological Survey of Canada have assisted the writer in one way or another during his investigations and their help is herewith gratefully acknowledged.

Chapter II

STRATIGRAPHY

The Lake Simcoe area is underlain by strata of Precambrian, Cambrian, Ordovician, and Silurian ages. The maximum thickness of the Ordovician rocks appears to be about 1,520 feet. They are generally flat lying, but have some local structures that probably resulted when the sediments were deposited upon the uneven Precambrian basement topography. The Ordovician strata have a regional dip averaging about 25 feet to the mile in a southwesterly direction.

The entire map-area has been glaciated. The glacial drift is only a few feet thick in the northern part of the map-area, but is about 430 feet in the pre-glacial valleys south of Barrie and as much as 330 feet in the interlobate moraine north of Oshawa and Bowmanville. Outcrops are most numerous in a 5-mile-wide belt along the Precambrian–Ordovician contact; farther south bedrock strata are generally concealed, as they are too argillaceous to form resistant ridges, their dip too low, and the glacial mantle too thick. The best rock exposures south of the outcrop belt are in a few widely scattered quarries, and in two small northeastward-facing escarpments formed by more resistant strata in the upper part of the Verulam and the lower part of the Lindsay Formations. Additional information on the Ordovician strata in the map-area was obtained from the few petroleum and water wells. The succession in the Lake Simcoe area is shown in the Table of Formations. *See also* Table I for comparison with the nomenclature of other workers.

Precambrian

Precambrian rocks of the Ontario Dome (Grabau, 1913a) occupy the northern part of the map-area. They consist mainly of gneisses, schists, and granitic rocks (Satterly, 1943a, b), but north of Balsam, Sturgeon, and Pigeon Lakes they include granite gneiss, crystalline limestone, dolomite, amphibolite, paragneiss, and pegmatite. In the Toronto area and westward, however, grey crystalline limestone may present considerable difficulty in delimiting the Palaeozoic–Precambrian contact. (*See Frontispiece* and Pls. II and III.)

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PLATE II. Precambrian inlier of granite gneiss, showing lower member of the Bobcaygeon Formation overlapping on western flank; Rohallion, 4 miles northwest of Kirkfield.

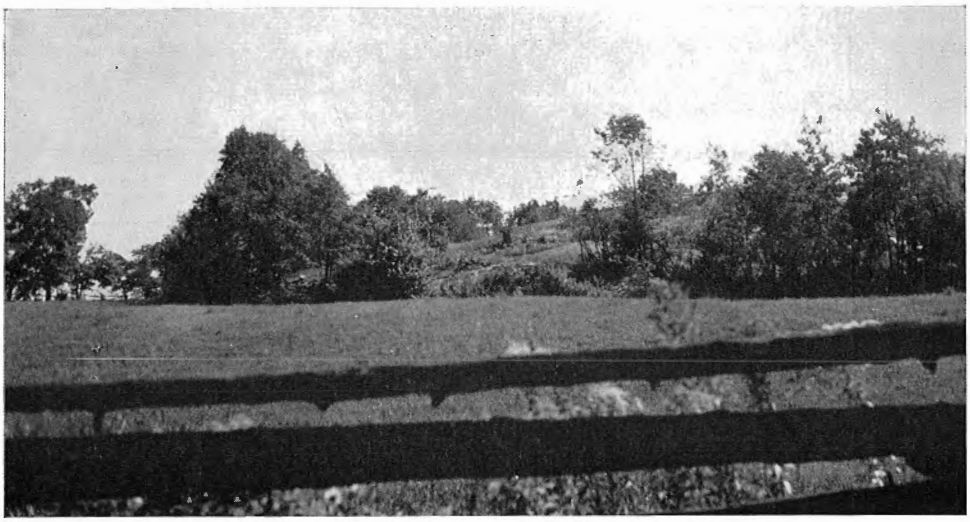

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PLATE III. Precambrian inlier of granite gneiss; 4 miles southeast of Fenelon Falls, in lot 13, con. 2, Verulam tp.

Table of Formations

System	Series	Stage	Substage[1]	Group	Formation	Member	Lithology
ORDOVICIAN	Cincinnatian	Richmondian			QUEENSTON		Red shale
		Maysvillian		NOTTAWASAGA	GEORGIAN BAY	Upper member	Grey limestone
						Lower member	Interbedded shale with limestone
		Edenian			WHITBY	Upper member	Blue shale
			Gloucesterian			Middle member	Brown shale
			Collingwoodian			Lower member	Black shale and limestone
	Mohawkian: Barneveld	Trentonian	Cobourgian	SIMCOE	LINDSAY	(G)	Grey lithographic limestone
			Shermanian: Denmarkian		VERULAM	Upper member (F_2)	Fine-, medium-, coarse-crystalline limestone
			Shermanian: Shorehamian			Lower member (F_1)	Interbedded limestone with shale
	Mohawkian: Wilderness		Kirkfieldian[2]		BOBCAYGEON	Upper member (E)	Calcarenites and sublithographic limestone
			Rocklandian			Middle member (D)	Sublithographic limestone
						Lower member (C)	Argillaceous limestone and calcarenite
		Blackriveran	Chaumontian		GULL RIVER	Upper member (B_3)	Lithographic semicrystalline limestone
			Lowvillian			Middle member ($B_{1,2}$)	Lithographic limestone
			Pamelian			Lower member (A_{1}-$_{4}$)	Dolomitic limestone and lithographic limestone
				BASAL	SHADOW LAKE		Red and green shale, arkose
CAMBRIAN	Croixan				MOUNT SIMON		Fine, even-textured sandstone
					JACOBSVILLE		Red and maroon shales, sandstone
PRECAMBRIAN							

[1]The stage and substage terms here presented are for the most part those of Kay (1960).
[2]The term Kirkfieldian is inserted here for the sake of completeness. See text under "Bobcaygeon Formation" for discussion.

Cambro-Ordovician

Basal Group

The term 'Basal beds' has long been used by investigators in Michigan and Ontario for a group of sandstones and arkoses that lie on the Precambrian rocks, and are in turn overlain by Middle Ordovician limestones. In the Lake Simcoe map-area these beds comprise the following formations, in ascending order: Jacobsville, Mount Simon, and Shadow Lake. Cambrian formations such as the Potsdam and Eau Claire, which lie between the same geological limits in adjacent areas, would also be a part of this basal group.

Of these formations, only the Shadow Lake is known to outcrop within the map-area. It is Middle Ordovician in age. Reference wells in Ontario for these strata include the following: Flesherton well, town of Flesherton, Artemesia tp., Grey co.; W. Nelson No. 1, lot 29, con. VII, Gwillimbury E. tp., York co.: United States Steel Co. Ltd., Diamond Drill Hole No. 1, lot 21, con. I, Charlotteville tp., Norfolk co.; Dow Chemical No. 5, in lot 25, River Road, Sarnia tp., Lambton co.; and the Union-Imperial No. 3, in lot 14, con. XI, Tilbury W. tp., Essex co.

As described by Cohee (1945a, 1948) and Roliff (1954) the component formations of this basal group are rock units. Towards the centre of the Michigan Basin, these rock units and progressively older formations lie on the Precambrian surface. Conversely, towards the map-area from the southwest, progressively younger sandstones lie on the Precambrian surface, the sandstones wedging out owing to overlap and truncation conditions (Fig. 1). A similar condition exists towards the map-area from the northwest. These observations suggest an easterly transgression of Cambrian and Ordovician seas over a higher Precambrian surface of the Ontario Dome in central Ontario (Grabau, 1913a). This suggestion is supported by the presence on the flanks of the Algonquin Arch of material in the basal part of the Shadow Lake Formation that appears to have been derived from the Upper Cambrian formations.

Jacobsville Formation

Name

The name Jacobsville was first proposed by A. C. Lane and A. E. Seaman in 1907 for a red and reddish brown, fine-grained sandstone, with minor shale, conglomerate, and breccia, from Jacobsville, Houghton county, northern Michigan. In this report the term Jacobsville is tentatively applied to strata at the base of the Palaeozoic section in the map-area; these strata may not be true Jacobsville Formation.

Distribution

This formation has been identified only in the Flesherton well in Artemesia township, and probably underlies only a small part of the map-area. Its presence

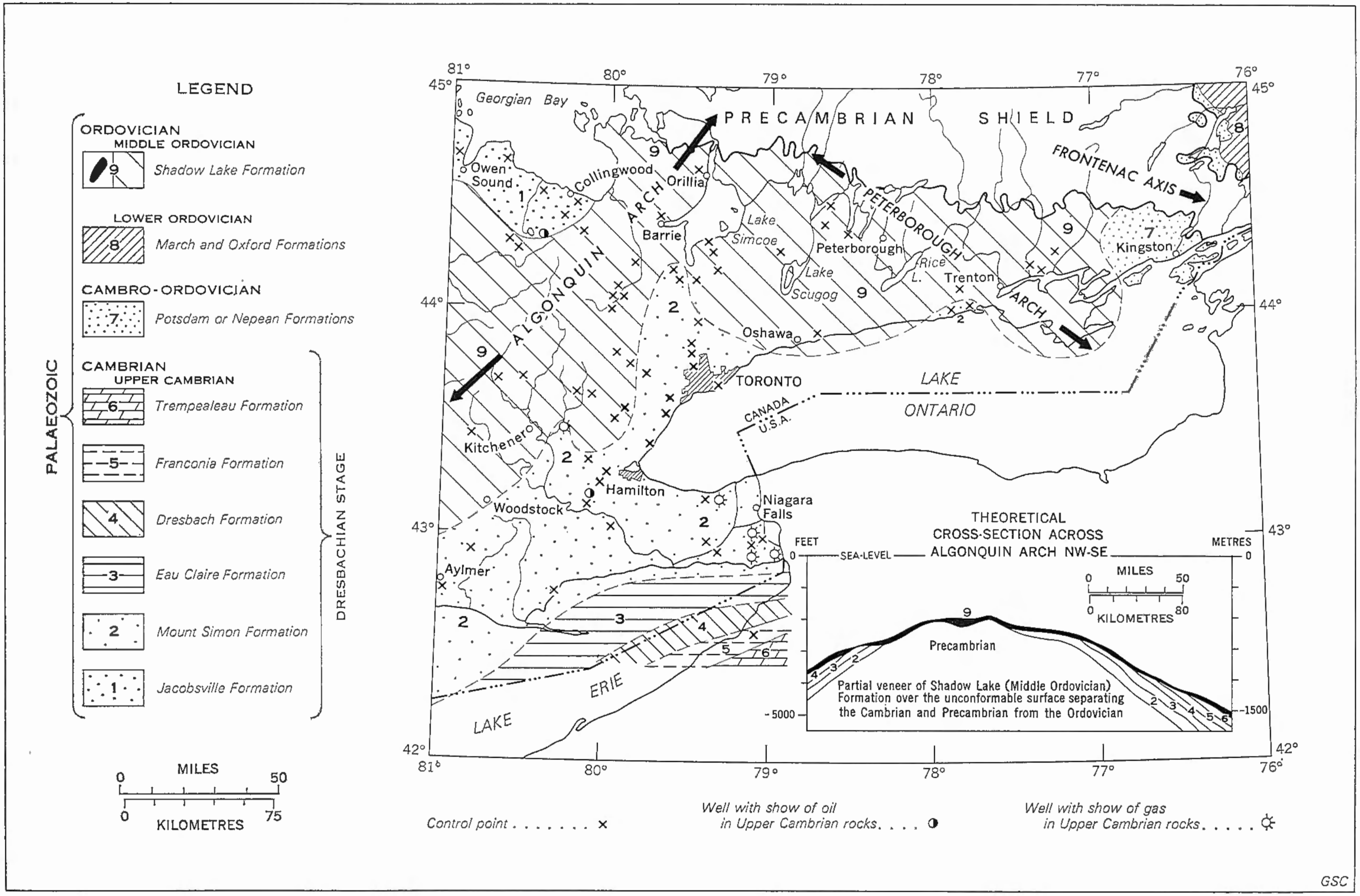

FIGURE 1. Stratigraphic relations of the Basal Group (Jacobsville 2, Mount Simon 3, Potsdam 8, Eau Claire 4, Shadow Lake 9), showing probable distribution of Upper Cambrian formations (after W. A. Roliff, 1954).

or absence in a given locality depends largely on the configuration of the Precambrian surface at the time of deposition and subsequent geological events.

Thickness and Lithology

Well data indicate that the Jacobsville strata in the map-area are only a few feet thick, but near Owen Sound in the adjacent map-area they are as much as 27 feet thick. The formation is red, brown, and purplish fine-grained sandstone and arenaceous shale. Its appearance in well samples is not always distinctive.

Contacts

Contacts of this formation are present only in the subsurface and are not always easily recognized, owing to the relative thinness of the unit. Their positions in the map-area are arbitrarily chosen as the top and bottom of the red to purple clastic sediments.

Stratigraphic Relations

Cohee (1945a) used the term Jacobsville for sediments in southern Michigan that resemble sediments in the type section in northern Michigan. Roliff (1954) then traced this unit into central Ontario. Recently, however, Hamblin (1958) stated that the term Jacobsville is restricted to the Lake Superior area, and cannot extend southwards across the Northern Peninsula (of Michigan) because of a structural barrier, which he claimed was the source area.

Use of the term Jacobsville in the Lake Simcoe area depends upon the following as yet unsolved problems: whether or not 1) rocks that truly belong to the Jacobsville Formation exist south of northern Michigan; 2) the rocks called Jacobsville by Roliff in southern Ontario and south of the Algonquin Arch are the same as the so-called Jacobsville rocks in the Owen Sound area and southern Michigan; 3) sandstones at Sault Ste. Marie (the Sault Ste. Marie sandstone of Logan (1863), St. Mary sandstone of Collins (1925)), which have been traced southeastward to Cockburn Island and possibly to Great Cloche Island (Logan, 1863) in Lake Huron and to the Sarawak well near Owen Sound, are in reality part of the Jacobsville Formation, which they closely resemble. Because of these problems the term Jacobsville cannot yet be used without qualification in the Lake Simcoe area.

Sedimentary Environment

Although the sediments of this unit may appear to be primarily of local provenance, they show a curious consistency of character wherever they are, be it the Lake Simcoe area, Sault Ste. Marie area, or in northern Michigan, which suggests that they are basinal deposits rather than deposits of local and restricted areal origin.

Age

The Jacobsville is a difficult unit to date. It appears to underlie conformably Middle Ordovician rocks south of Sault Ste. Marie (Logan, 1863), to be more closely related to Cambrian rocks west of Sault Ste. Marie, and to be more closely related to the Keweenawan (Precambrian) rocks on Keweenaw Peninsula in northern Michigan. In the Lake Simcoe area the rocks tentatively referred to as Jacobsville Formation are considered to be of Late Cambrian age, but it is not inconceivable that they are time-transgressing, and may be in part Ordovician. In the type area in northern Michigan the formation is Late Cambrian (Dresbachian). The finding of fossils in core and cuttings of this formation would help clarify many of the correlation and age problems.

Mount Simon Formation

Name

C. D. Walcott proposed the name Mount Simon in 1914 for a medium- and coarse-grained sandstone that lies directly on the Precambrian rocks where the Jacobsville Formation is absent in southwestern Wisconsin. G. V. Cohee (1945a, 1948) subsequently traced the formation from the type locality into the Michigan Basin and finally to southwestern Ontario, where Roliff (1954) has studied it. The Ontario reference well for the formation is at Sarnia (United States Steel Company, Diamond Drill Hole No. 1, in lot 21, con. I, Charlotteville tp., Norfolk co.). Core samples from this well are at the Geological Survey of Canada in Ottawa.

Distribution

The Mount Simon Formation underlies a considerable part of Ontario (*see* Fig. 1), where its truncated edge rims the perimeter of the Algonquin Arch from the west side of the Bruce Peninsula to the north shore of Lakes Erie and Ontario. Roliff (1954, Fig. 1) showed that the bedrock band varied in width from about 12 miles on Lake Huron, a fraction of a mile near Sarnia, about 45 miles near Lake Erie, 8 miles at the west end of Lake Ontario, to the 40-mile re-entrant north of Toronto up the pre-glacial Laurentian River valley (Coleman, 1932; Spencer, 1907).

Lithology and Thickness

The formation typically consists of light grey to clear, medium- to coarse-grained sandstone, which may be highly glauconitic. It is generally well sorted, but loosely and poorly cemented, with the result that it reduces to a sand during drilling operations. In places it is impure, and contains a few thin beds of light to dark brown, finely crystalline dolomite, and minor amounts of shale. The dolomite content seems to decrease towards the base of the formation (i.e., down section). Roliff (1954) reported some red sandstone and shale in the lower part of the formation near the eastern end of Lake Erie, west of the Lake Simcoe area. Well data indicate a maximum thickness of 45 feet for the formation in the map-area. The formation is 45 feet thick in the reference well on lot 15, con. I, Toronto tp., Peel co.

Contacts

Although the Mount Simon Formation lies stratigraphically above the Jacobsville, well data have not yet revealed a single example of the Mount Simon lying on the Jacobsville in the map-area. Rather, truncation and overlap phenomena show the Mount Simon to lie directly upon the Precambrian gneisses and granite gneisses. Concerning the upper contact, however, most wells in the bedrock belt and farther inland show an admixture of Mount Simon and Shadow Lake lithologies in the lowest samples of the Shadow Lake Formation. These samples show the presence of friable greenish shale and greenish arkose and arkosic sandstone. The formation is stratigraphically overlain by the Eau Claire from which it may be distinguished by the Mount Simon's definitely sandy lithology with dolomite included and the marked decrease in glauconite. The Eau Claire, where present, is darker in colour, more impure, and contains a greater quantity of glauconite.

Stratigraphic Relations and Age

On the basis of its known subsurface distribution, the Mount Simon Formation appears to overlap the Jacobsville Formation. To reason otherwise would have the Mount Simon everywhere underlain by the Jacobsville. The Mount Simon was certainly eroded during the time represented by the hiatus between the Upper Cambrian and Middle Ordovician strata, and this erosion would have progressively limited its former distribution back to its present position on the flanks of the Algonquin Arch. The only basis at present for assigning a Cambrian age to this unit is its consistency from the type locality in Wisconsin across the Michigan Basin into Ontario. The only possibility of a more reliable dating on this eastern side of the basin would be the finding of indicative fossils in core and well samples.

Shadow Lake Formation

Definition

The Shadow Lake Formation, originally named by Okulitch (1939a) is here redefined as the uppermost rock unit of the Basal Group in the map-area. It embraces the basal arkose and red and green shales that lie unconformably on Precambrian and Cambrian strata in Ontario. The formation as redefined is the same as the 'Basal beds' of Johnston (1911). It differs, however, from the formation as defined by Okulitch and as formerly used by the writer (Caley and Liberty, 1952; Liberty, 1952) in that no beds of the limestone sequence (lithographic or dolomitic limestone) are now included. Okulitch included 4 feet of "argillaceous magnesian limestone or dolomite" (similar to the overlying $4\frac{1}{2}$ feet) in the top of his Shadow Lake Formation. The reference section is located in the Shadow Lake road-cut, 4 miles north of Coboconk on the west side of No. 35 highway. The name is taken from Shadow Lake, a quarter mile east of the No. 35 highway road-cut. The Shadow Lake is the only formation in the Basal Group that outcrops in the map-area.

Distribution

Because of the scale of the map (1 inch equals 4 miles), the Shadow Lake Formation is included with the overlying Gull River Formation on Map 1228A, except where specifically noted (unit 2a). On a larger scale map (i.e., 1 inch equals 1 mile), it would appear as a narrow ribbon following the Precambrian–Palaeozoic contact, for the most part, across the map-area from Waubaushene to Bobcaygeon. The formation is best seen at the following places: at Waubaushene; half a mile north of Sebright; on the northwest shore of Head Lake; and 4 miles north of Coboconk on highway No. 35.

The presence or absence of the formation in a given locality is dependent entirely upon the topographic relief of the Precambrian surface at that locality. On the flanks of Precambrian inliers where overlap conditions exist (*see Frontispiece* and Pl. II), the formation is rarely seen; commonly, it is absent from the apices because of truncation phenomena against the flanks of the topographic 'high'. On the other hand, the formation appears to be thickest in depressions on the surface of the Precambrian peneplain. Well records indicate that the formation is generally present beneath the younger strata and that it overlies the Jacobsville Formation, in the Collingwood–Owen Sound area (west of the map-area), and the Mount Simon Formation.

Lithology and Thickness

The Shadow Lake Formation consists of greenish grey, coarse-grained, calcareous arkose overlain by several feet of red and green arenaceous shales. The shales are locally calcareous and commonly contain frosted, rounded to angular quartz grains that are as much as half an inch long. The formation also includes some transitional red-mottled green shale. Where the underlying Cambrian formations are present, the Shadow Lake Formation may include reworked Cambrian sediments, such as the purplish sandstone and shale in the Flesherton well (Artemesia tp., Grey co.). In well cuttings the formation appears to be more arkosic and sandy (with greenish and reddish shale fragments) than it actually is, because the softer shale is washed away by the drilling mud. The thickness of the formation ranges from zero over topographic 'highs' in the Precambrian surface to 40 feet in the depressions in this surface.

Contacts

Where the Shadow Lake Formation overlies Precambrian gneiss, its lower contact can be readily defined. Where it overlies Precambrian crystalline limestone, however, the contact is difficult to define, but the freshness and angularity of fragments, and the lack of quartz sand grains, are indicative of the Precambrian strata. Where the Shadow Lake Formation lies on the Jacobsville and Mount Simon Formations it is generally thin. In these places recognition of the contact depends upon the presence of red and green shale and arkose, the incorporated material being purplish sandstone and shale, and very light grey, well-sorted sandstone. Indeed, the sandstone is so loosely and poorly cemented that it is commonly just a sand. The sand grains of the Mount Simon Formation appear generally rounder, and of more uniform size than those of the Shadow Lake Formation.

The upper contact of the Shadow Lake Formation is defined where the main shale section of the Shadow Lake Formation is overlain by the limestone sequence of the Simcoe Group. The lower member of the Gull River Formation (Simcoe Group) consists of grey and brown, fine- and medium-grained limestone and dolomitic limestone, and grey and brown, dense, sublithographic to lithographic limestone. This upper contact is well exposed in a road-cut on highway No. 35, 4 miles north of Coboconk, where about 24 feet of limestone overlies about 6 feet of the basal red and green shale, which encloses a few beds of impure argillaceous limestone. A thin transition zone is locally present in which limestone strata are interbedded with the shales. The strata in this zone are arbitrarily assigned to the lower member of the Gull River Formation.

Age and Origin

The unfossiliferous strata of the Shadow Lake Formation are dated as Middle Ordovician because they are overlain with apparent conformity by limestones enclosing a Black River fauna, and because subsurface data indicate unconformable relations between the formation and underlying Cambrian strata.

The formation appears to have been deposited as a reasonably widespread, thin, fan-like 'deltaic' mass extending outwards from the Precambrian source area. In wedging out southwards it covers essentially and consistently the Algonquin Arch and a limited area beyond. Its sediments are believed to represent shallow-water deposits.

Before the Cambro-Ordovician hiatus, the Upper Cambrian and possibly Lower Ordovician formations were present in this area, thinning shelfwards against the Algonquin Arch and its extension, and perhaps covering it considerably more than they do at present. During the Cambro-Ordovician hiatus these formations were eroded, truncated, and limited to the degree shown on Figure 1. The Middle Ordovician sea advanced over the erosional surface so produced, reworked parts of the Cambrian sandstones, and utilized the great mass of weathered detritus covering the Canadian Shield in forming the Shadow Lake Formation. The Algonquin Arch evidently did not serve as a source area, for, if it had, the sediments in the Shadow Lake Formation would have a more varied composition. Exceptionally stable conditions must have existed over a long distance, because one cannot distinguish the Black River–Trenton section in the Lake Simcoe area from the same section to the west near Sarnia. The similarity is outstanding, despite the fact that the Gull River Formation thickens considerably towards the southwest.

Ordovician

Simcoe Group

The term 'Simcoe Group' was proposed by Liberty (1955) for the limestone formations that overlie the 'Basal beds' in southwestern and central Ontario and are overlain by the black fissile shale of the Whitby Formation of the Nottawasaga Group. This limestone sequence of Black River and Trenton ages has not been subdivided previously on a strict regional rock-unit basis. Although the beds of the Shadow Lake Formation are dated as Black River within the map-area, they are not included within the Simcoe Group because of their lithology.

The Simcoe Group as so defined is a rock unit and consists from top to bottom of the following four formations: Lindsay, Verulam, Bobcaygeon, and Gull River. These formations in turn can be subdivided into eight members and eight submembers. The Gull River Formation and part of the Bobcaygeon are dated as Black River; the overlying strata in the group are of Trenton age. Use of the group term is justified because the formations within it are all limestones and enclose no significant natural break. Furthermore, use of the group name gets around the nomenclatural conflicts that have arisen through usage of biostratigraphic terms (e.g., Trenton, Black River) in a lithostratigraphic sense. In subsurface studies the group can be divided into seven units (A to G, Table I). Units A to D and E to G provide a useful subgrouping for isopach purposes.

The group is not fully exposed in any one section in the map-area, nor are any of its formations except the Bobcaygeon. Its thickness in that part of the map-area where it is at the surface is estimated to be about 500 feet. South of this, however, samples from wells drilled for oil and natural gas indicate a slight thickening of the group. For example, the H. J. Hird No. 1 well in lot 3, con. IV, Scott tp., Ontario co., near Sandford (the nearest well to the outcrop area) indicates a thickness of 566 feet for the group. On the west side of Lake Simcoe, the A. Breedon No. 1 well in lot 21, con. III, Adjala tp., Simcoe co., shows a thickness of 580 feet. This is the reference well for the group. Nearer Lake Ontario, south of Markham, the H. Coakwell No. 1 well in lot 4, con. IX, Markham tp., York co., indicates a thickness of 575 feet.

The Simcoe Group and its component formations are rock-units, but may be correlated readily with lithostratigraphic and biostratigraphic units in the standard sections in the Ottawa Valley and New York. The group is lithologically correlated directly with the Ottawa Formation; the Gull River Formation with the Pamelia, Lowville, and Leray formations; the Bobcaygeon with the Leray and Rockland; the Verulam with the Sherman Fall and Cobourg; and the Lindsay with the upper part of the Cobourg (*see* Tables II, III, and IV).

Within the map-area, the strata of the Simcoe Group are essentially the product of continuous sedimentation, as no major stratigraphic breaks are recognized. There is, however, evidence of minor stratigraphic breaks (diastems), one in the lower member of the Gull River Formation west of Lake Couchiching, a

TABLE II | *Comparison of Lithostratigraphic and Biostratigraphic Units*

Lithostratigraphic Units		Biostratigraphic Units
Simcoe Group	Lindsay Formation	Cobourg
Simcoe Group	Verulam Formation	Kirkfield–Sherman Fall–Cobourg
Simcoe Group	Bobcaygeon Formation, upper member	Rockland–Kirkfield
Simcoe Group	Bobcaygeon Formation, middle member	Rockland
Simcoe Group	Bobcaygeon Formation, lower member	Chaumont (Leray)–Rockland
Simcoe Group	Gull River Formation	Pamelia–Lowville–(Leray)–Chaumont
	Shadow Lake Formation	Pamelia

second between the Gull River and Bobcaygeon Formations, and a third in the lowest strata of the Lindsay Formation a few miles south of Kirkfield. In addition, the time-line between Black River and Trenton strata, which has been recorded in New York and Michigan is delimited in the Lake Simcoe area within the Bobcaygeon Formation.

In contrast with the sediments of the Shadow Lake Formation, which are interpreted as indicating the transgression of the Middle Ordovician seas, the sediments of the lower member of the Gull River Formation indicate a general deepening of the Middle Ordovician seas and oscillating conditions with the lithographic lagoonal facies. The sediments in the Gull River's middle and upper members are considered to be the extension of the lithographic limestone facies of New York and other eastern Atlantic states; the limestone is probably a lagoonal facies of lime mud. Bobcaygeon sediments indicate a general shallowing of the seas, which led to the deposition of the detritus carried in from local areas where erosion was active. These sediments were probably deposited at the same time as erosion in New York and elsewhere was producing the well-known Black River–Trenton stratigraphic break. The sediments comprising the middle member of the Bobcaygeon Formation are interpreted to indicate deepening conditions in the Middle Ordovician seas, which were carried over into oscillating conditions between the lagoonal, quieter lithographic facies of the middle and upper members of the Gull River Formation, and the calcarenite facies of the upper member of the Bobcaygeon Formation. The sediments of the Verulam and Lindsay Formations are interpreted as indicating very shallow-water deposition under oscillating conditions. The dense, sublithographic limestone of the uppermost part of the

TIME			BIOSTRATIGRAPHY							
			Montreal, Quebec Clark, T.H. 1952		Northern New York Twenhofel, W.H. et al. 1954		Central Ontario		Northern Michigan Stumm, E.C. and Kauffman, E.G. 1958	
ORDOVICIAN	Richmondian					+ Queenston red shale (concealed)	Cincinnatian	+Queenston / Kagawong Meaford	Richmond	Big Hill Beds Stonington Beds Bill's Creek Beds
								Dundas		
	Maysvillian			Lorraine Group		Oswego Sandstone		Dundas		
					Lorraine Group	Pulaski Shale				
	Edenian		Utica Group			Whetstone Gulf Shale	Utica-Edenian	Blue Mountain		
		Gloucester		Lachine	Utica Shale	Atwater Creek Shale		Gloucester	Trenton	Haymeadow Cr
		Collingwood		Lachine		Deer River Shale		Collingwood		Groos Quarry
	Trentonian	Cobourg	Trenton Group	Terrebonne Tetreauville	Trenton Limestone	Cobourg Limestone	Trenton	Cobourg		
		Sherman Fall		Montreal		Sherman Fall Limestone		Sherman Fall		Chandler Falls
		Hull		Mile End		Kirkfield ("Hull") Limestone		Rockland-Hull		Chandler Falls
		Rockland		Mile End		Rockland Limestone		Rockland-Hull		
	Blackriveran	Leray	Black River Group	Leray			Black River	Coboconk		
		Lowville		Lowville	Black R Ls	Chaumont Limestone Lowville Limestone		Moore Hill Lowville	Black River	Bony Falls
		Pamelia		Pamelia		Pamelia Limestone		Pamelia		
CAMBRIAN										

Note: Compiled from published literature. Units are time-rock for most part. There is no general agreement about the Trentonian-Edenian time-line. Most northern U.S. and Canadian workers adopt the interpretation here presented. Others would draw this line at the top of the Collingwood.

+Rock unit

GSC

Table III. Ordovician correlation table.

TIME	TIME-ROCK STANDARD (?) SECTION	ROCK: Ottawa valley	ROCK: Toronto-Georgian Bay			BIOSTRATIGRAPHY: Manitoulin Island	BIOSTRATIGRAPHY: Northern Michigan	
Richmondian	Whitewater-Saluda-Elkhorn	+Queenston		+Queenston		*Kagawong		*Big Hill
	Meaford	Russell	Nottawasaga Group	Georgian Bay Fm	Upper	*Meaford		Ogontz
Maysvillian	Dundas	Carlsbad			Lower	*Wekwemikongsing		*Stonington Bay De Noc
Edenian	Blue Mountain			Whitby Fm	Upper mbr	*Sheguiandah		*Bill's Creek
	*Gloucester	Billings			Middle mbr			Haymeadow Creek
	*Collingwood				Lower mbr	*Collingwood		
Trentonian	Cobourg	Eastview	Simcoe Group	Lindsay Fm		*Cobourg	Trenton	Groos quarry
	Sherman Fall	Ottawa		Verulam Fm		Unnamed beds		Chandler Falls
	Hull			Bobcaygeon Fm	U mbr	Cloche Island		
	Rockland				M mbr			
Blackriveran	Leray				L mbr		Black R	Bony Falls
	Lowville			Gull River Fm		Swift Current		
	Pamelia		Basal Gp	Shadow Lake Fm		Basal bed-Lowville		
Underlying unit		Chazy		Potsdam Formation		?		Upper Cambrian

+Rock unit term

*Time-rock unit term

GSC

Table IV. Interpretative Ordovician table.

Lindsay Formation suggests quieter and deeper water conditions toward the close of its time of deposition. The Lindsay Formation was subsequently actively eroded west of the map-area both around Nottawasaga Bay and on Manitoulin Island.

At the close of deposition of the Simcoe Group, the limestone lithosome was covered by a facies shift of the black shale.

Gull River Formation

The terms Pamelia, Lowville, and Chaumont, which are classical terms in New York state, cannot readily be used as lithostratigraphic terms in central Ontario, where the natural rock units all contain 'Lowville lithologies'. Thus it has been necessary to provide a lithostratigraphic term (Gull River) for these rocks. Lithological correlation of Gull River with Pamelia, Lowville, and Chaumont units is not considered possible.

Definition

The name Gull River was first proposed by Okulitch in 1939 for the limestone strata underlying the Moore Hill Formation and overlying dolomitic limestones included in his Shadow Lake Formation. The formation is here redefined to comprise the strata lying between the top of the red and green shales of the Shadow Lake Formation (as redefined in this report) and the base of the fine- and medium-grained limestone of the Bobcaygeon Formation. As thus defined the formation embraces the strata of Johnston's 'Lowville', and Okulitch's Moore Hill. The latter is now included as the upper member of the Gull River Formation. The formation is divided into three members, the lower conforming to the '*Beatricea* beds', and the middle and upper to the 'Birdseye' limestone of Johnston (1911).

Type sections are: lower member, 4 miles north of Coboconk on No. 35 highway; middle member, Coboconk south road-cut; upper member, Moore Hill road-cut, a mile north of Coboconk on No. 35 highway and in the Coboconk south road-cut. The name Gull River Formation is taken from the river of the same name, which flows south to Coboconk on the east side of No. 35 highway.

Distribution

The Gull River Formation has been mapped from Penetanguishene Peninsula in Georgian Bay, eastward to Bobcaygeon and Pigeon Lake. Throughout this area, the formation appears in long flat exposures, road-cuts, quarries, and stream beds. It forms many of the northeastward-facing escarpments nearest the Precambrian Shield, the most prominent ones being 'held up' by strata of its upper member. It is covered by only a thin veneer of drift. Well records indicate that it underlies the younger formations south of its outcrop area.

The lower member of the formation may best be seen in the Port McNicoll quarry, the Coldwater quarry (Pl. IV), Lake St. George quarry, at the south end of Head Lake, in the road-cut 4 miles north of Coboconk on No. 35 highway,

PLATE IV

Gull River Formation, middle and upper members, showing 'upper lithographic' and Moore Hill beds with veneer of lower member of Bobcaygeon Formation at top of section; Medonte quarry, 2 miles east of Coldwater, Medonte tp., Simcoe co.

B.A.L. 2–3–48

B.A.L. 4–4–49

PLATE V

Gull River Formation, middle and upper members, showing 'upper lithographic' and Moore Hill beds with veneer of lower member of Bobcaygeon Formation at top of section; Bobcaygeon north road-cut, 11 miles north of Bobcaygeon on Kinmount highway.

and the road-cut 10 miles north of Bobcaygeon on the Kinmount road (Pl. V). The middle member may be seen in the Coldwater quarry, Longford quarries, the quarry 2 miles southeast of Burnt River, the road-cut 10 miles north of Bobcaygeon on the Kinmount road, and in an exposure half a mile east of Dongola schoolhouse and also 1,000 feet south of the Monck Road in Somerville township. The upper member is well exposed in the quarries and road-cut in the southern outskirts of the village of Coboconk, in the Moore Hill road-cut 2 miles north of Coboconk, and in the road-cut 10 miles north of Bobcaygeon on the Kinmount road.

Lithology and Thickness

The Gull River Formation is divided into three members within the map-area. The lower member (unit A, Fig. 2) consists of fine-grained limestone, lithographic limestone, and fine-grained dolomitic limestone. The middle member (part of unit B, Fig. 2) is composed almost entirely of lithographic limestone; the upper member (part of unit B, Fig. 2; Fig. 3) consists of lithographic, sub-lithographic, and semi-crystalline limestone. Near Coldwater, Coboconk, and Burnt River, the respective thicknesses of the lower member are 49, 32, and 32 feet; for the middle member they are 28, 18, and 28 feet; and for the upper member, 8, 12, and 12 feet. In general, the thickness of the formation ranges from 70 to 80 feet.

Lower Member (Unit A). Strata of the lower member of the Gull River Formation are best developed in the Coldwater quarry in Medonte township (Pl. IV). They are divided into four units of submember rank, which may vary considerably in texture as they are traced laterally, but are consistent for the most part and are mappable entities. The lithology of a unit may change to such an extent that it cannot be distinguished from the subjacent unit, or one constituent may become dominant and give rise to another complete unit, which is consistently present over a large part of the map-area. In ascending order, these units are: the lower buff (A_1), lower lithographic (A_2), mottled carbonate (A_3), and upper buff (A_4) submembers.

The lower buff (A_1) submember is best seen in a road-cut on No. 35 highway about 4 miles north of Coboconk. There, it consists of about 8 feet of buff-weathered, pale greenish grey, pinkish grey and grey, fine-grained dolomitic limestone in beds ranging in thickness from a few inches to 14 inches. The rock has a conchoidal fracture and contains vugs lined with calcite. Eastward to Burnt River, the unit passes into 13 feet of red and green, mottled and banded, hard, fine-grained dolomitic limestone, in which are scattered quartz grains as much as half an inch in diameter. The colour is predominantly red owing to hematitic staining. Westward to Head Lake and Lake Couchiching, and Coldwater, the unit consists of greenish grey and grey, fine-grained dolomitic limestone and limestone. There, unit A_1 is as much as 24 feet thick, probably because of the topography of the underlying Precambrian surface. Quartz grains are present throughout this unit. Near Fesser-

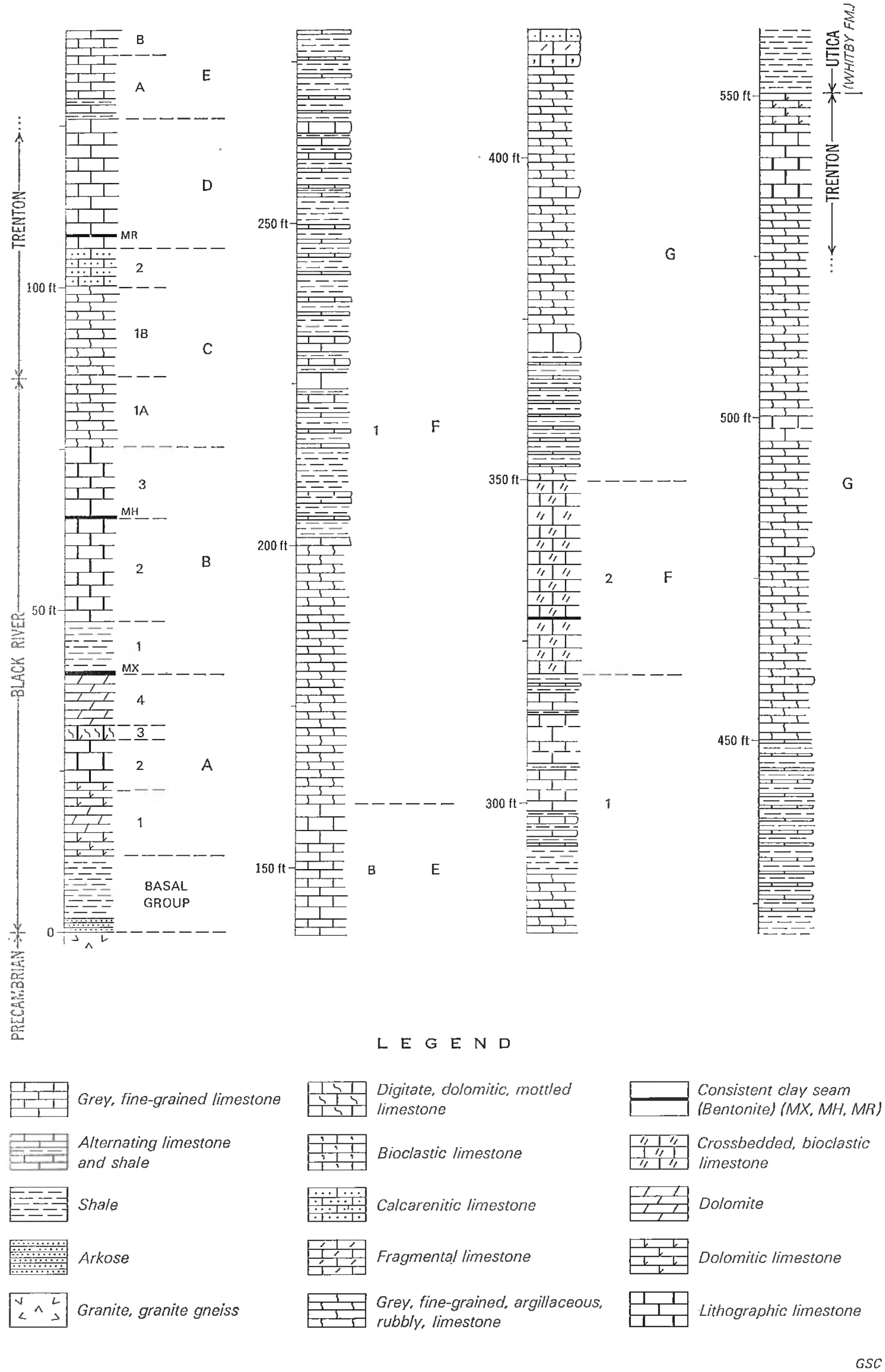

FIGURE 2. Simcoe Group, stratigraphic sequence.

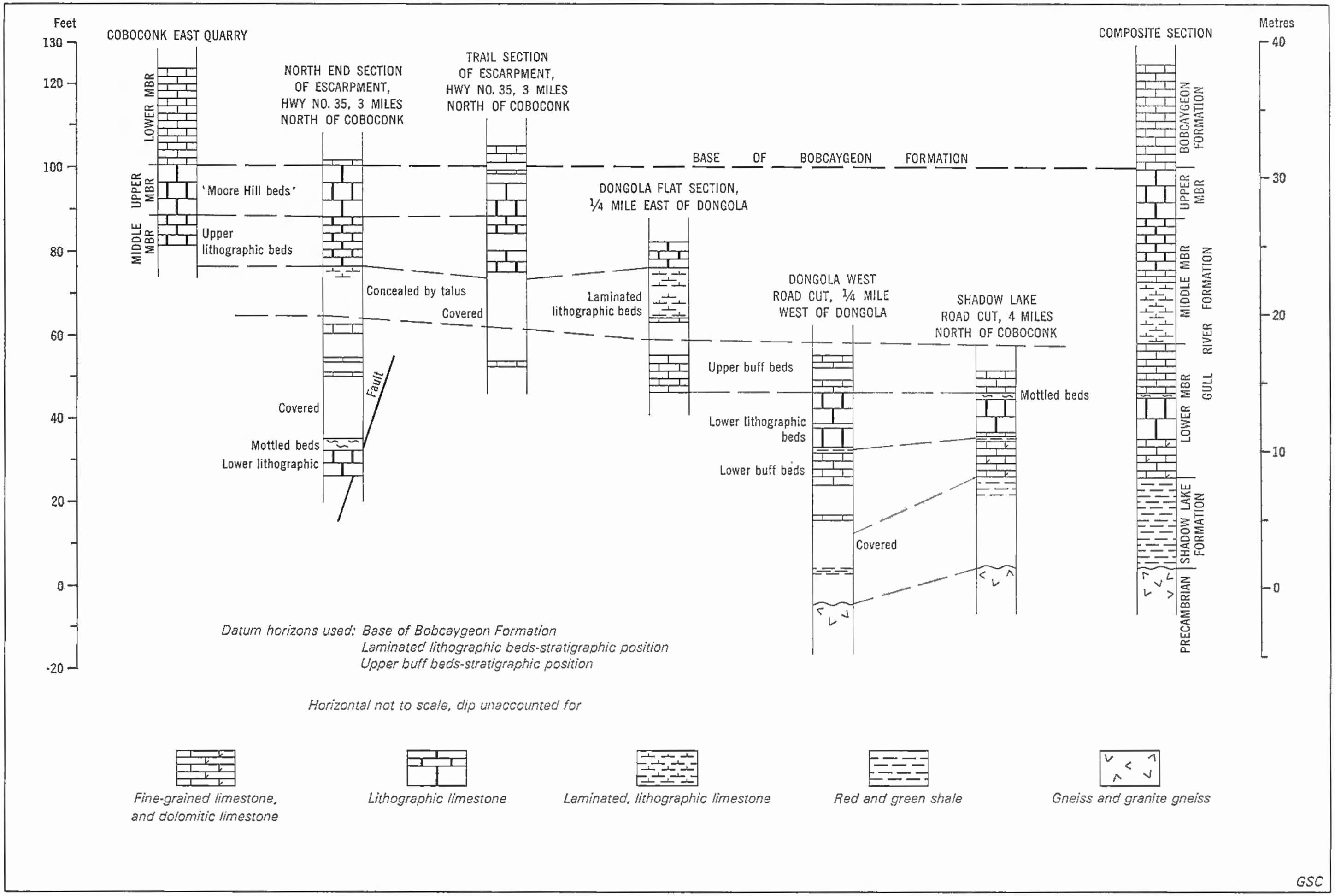

FIGURE 3. Compilation chart for Shadow Lake and Gull River Formations.

ton, northwest of Coldwater, the submember has 'tightened up', the texture changing laterally in this short distance (4 miles) to very fine grained and sublithographic.

The lower lithographic (A_2) submember, like unit A_1, is exposed in the road-cut on No. 35 highway, 4 miles north of Coboconk (Pl. VI), where it consists of about 7 feet of grey-weathered, chocolate-brown and grey, lithographic limestone in beds 8 to 12 inches thick. A few marcasite nodules and calcite crystals occur in these beds. On the weathered quarry face there are faint, light brown horizontal mottlings. To the east, near Burnt River, this submember is a grey lithographic limestone but retains the faint, light brown horizontal mottling on its weathered surface, like that seen on the face in the road-cut near Coboconk. To the west of Coboconk the unit thins because of the thickening of the overlying mottled carbonate beds. The A_2 submember thins to about 4 feet at Lake Couchiching and farther west merges with the overlying mottled carbonate (A_3) submember.

The mottled carbonate (A_3) submember is best seen in the road-cut on No. 35 highway about 4 miles north of Coboconk (Pl. VII) and in the Port McNicoll quarry. In the latter locality, the lower beds consist of 7 feet of grey, fine-grained dolomitic limestone with digitate brown, lithographic limestone (i.e., horizontal and inclined 'fingers' of lithographic material in the fine-grained dolomitic limestone matrix). These are overlain by 3½ feet of brown and grey lithographic limestone with digitate light brown, fine-grained dolomite and dolomitic limestone (the reverse of above). The beds range from an inch to 2 inches in thickness. The lower beds can be traced east from the Port McNicoll area into the Lake Couchiching region, where the fine-grained dolomitic limestone facies has been replaced by the brown lithographic limestone of the A_2 submember, with about the same thickness (i.e., 7 feet). The upper beds (about 3½ feet at Port McNicoll) thin eastward to 14 inches in the Head Lake and Coboconk areas, where they comprise an excellent marker unit. Farther east, they 'fade out' and are not present at Burnt River. The weathered appearance of these upper beds is striking, for the fine-grained dolomitic digitate material weathers out leaving cavities (Pl. VII). West of Lake Couchiching these upper beds only are A_3 and include chert nodules and some conglomerates. Non-pelletoid glauconite characteristically coats the enclosed fossils and pebbles. In that same area, as at Lake St. George quarry, there is evidence of a local diastem or disconformity (Pl. VIII).

The upper buff submember (A_4) of the lower member of the Gull River Formation is best seen in the base of the Coldwater quarry, where it lies below the quarry floor (in a ditch) and consists of 7 feet of buff-weathering, pale green and greenish grey, fine-grained dolomite in beds as much as 18 inches thick. This submember continues eastward to Lake Couchiching, where it was known in the building trade as the 'Rama grey' and 'Rama buff' stone. Eastward from Longford the unit can be divided into lower and upper beds. The lower beds are weathered buff, but consist of 6 feet of brownish grey, fine-grained dolomitic limestone north of Kirkfield (Pl. VII) and 3 feet of light brown to grey, fine-grained dolomitic limestone in the Burnt River region. Similarly, the upper beds consist of

PLATE VI

Gull River Formation, lower lithographic beds of lower member; Shadow Lake road-cut, 4 miles north of Coboconk on No. 35 highway.

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PLATE VII

Gull River Formation, lower member, showing 'lower lithographic' 'mottled', and 'upper buff' beds; Shadow Lake road-cut, 4 miles north of Coboconk on No. 35 highway.

B.A.L.4–4–52

B.A.L. 2–2–50

PLATE VIII. Minor hiatus (at hammer head) within the 'mottled beds' of lower member of Gull River Formation, Lake St. George south quarry; $8\frac{1}{2}$ miles north of Orillia, on west side of No. 11 highway.

5 feet of pale greenish grey, fine-grained dolomite north of Kirkfield. These strata thicken and 'tighten up' (texturally) eastward to Burnt River to become 7 feet of grey and brown sublithographic limestone. There (Pl. IX), the A_4 submember overlies the A_2 submember, as the A_3 is absent. West of Coldwater the A_4 submember thins to 4 feet, the lower beds consisting of $2\frac{1}{2}$ feet of buff to grey, brown weathering, fine-grained limestone, the upper beds comprising $1\frac{1}{2}$ feet of grey lithographic limestone.

A bentonite (or meta-bentonite) clay seam (to which the writer has applied the letters MX for easy reference) is located at the top of the A_4 submember and may be seen at this level in the Coldwater quarry. A thick bed of 'bentonite' that occurs at 930–935 feet in the A. Breedon No. 1 well in lot 21, con. III, Adjala tp., Simcoe co., is probably the MX seam. This 'bentonite' and two others like it, all of which have been traced almost 200 miles into southwestern Ontario, swell a little in water. Forman and Lake (1954) concluded that the Ontario Middle Ordovician samples are predominantly illite and that they should be called neither bentonite nor meta-bentonite but rather "consistent clay seams".

B.A.L. 5–4–49

PLATE IX

Gull River Formation, lower member, showing 'lower buff' and 'lower lithographic' beds; west face of Burnt River west quarry, lot 14, con. 6, Somerville tp., Victoria co.

In the subsurface, the lower member of the Gull River Formation appears as a mixture of dolomitic limestone and lithographic limestone. West of Lake Couchiching, chert and glauconite and the digitate character of the sediments are important marker constituents of the A_3 submember. The lower contact of the member (which is also the base of the formation) is drawn so as to include the gross carbonate lithology in the member. In the Shadow Lake road-cut, only one bed of shale is present in the lower member—at the base of the A_2 submember. The upper contact of the member is defined so as to include the dolomitic upper buff (A_4) submember.

Middle Member (*Unit B*). The middle member of the Gull River Formation is well developed in the Longford quarries, near Longford, 5 miles northeast of Orillia. It consists of two units of submember rank, which retain their lithological identity and position consistently over wide areas. They consist of a laminated lithographic (B_1) unit overlain by a lithographic unit (B_2).

The laminated lithographic (B_1) submember is best exposed in Somerville township, about a mile east of Dongola schoolhouse and 1,000 feet south of the Monck Road, and also in the strata below the quarry in the road-cut about 2 miles southeast of Burnt River. It consists of about 14 feet of thinly laminated, grey, lithographic limestone with thin, green, argillaceous partings between the laminae. About 4 feet of non-laminated, more massive grey lithographic limestone appear in the middle of the unit. The B_1 submember thins westward to about 3 feet in the

Longford, Hampshire Mills (Pl. X), and Coldwater quarries. No exposures of this unit are known between Coboconk and Longford. These strata enclose a large pelecypod, trilobite, and ostracod fauna.

The upper lithographic (B_2) submember is a scarp-forming unit and is well exposed in the road-cut on the southern outskirts of the village of Coboconk. Other exposures are in the Port McNicoll quarry, the Coldwater quarry, a quarry 2 miles southeast of Burnt River, and a road-cut 10 miles north of Bobcaygeon on the Kinmount road (Pl. V). The lowest beds are grey-weathering, grey and cream lithographic limestone with pinkish mottling. The middle beds are made up of grey and brownish grey, lithographic limestone with crystalline calcite 'eye' inclusions. The uppermost beds include buff-weathering, cream, lithographic limestone, at the top of which is a bentonite half an inch thick (Kay, 1942; Young, 1943). This is a clay seam to which the writer has applied the letters MH for easy reference. It is not a true bentonite (*see* Forman and Lake, 1954). It is generally present about the top of the B_2 submember, 10 to 12 feet below the top of the Gull River Formation throughout the map-area. In general, the B_2 submember thickens westward to about 20 feet in the Coldwater quarry and consists of grey-weathering, brown, grey, and cream lithographic limestone in beds that range from a few inches to 24 inches in thickness. This submember was known in the building trade as 'Longford stone'.

In the subsurface, the middle member of the Gull River Formation appears as a lithographic limestone. Lowest strata show argillaceous, green parting material

PLATE X

Gull River Formation, middle and upper members, showing 'laminated lithographic', 'upper lithographic', and Moore Hill beds with veneer of lower member of Bobcaygeon Formation at top of section; Hampshire Mills quarry, lot 12, con. 7, Orillia tp., Simcoe co.

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and lithographic limestone, thus presenting a sharp contrast with the dolomitic limestone of the uppermost strata (A_4) of the lower member. Uppermost strata of the middle member are generally very pure lithographic limestones in contrast with the semi-crystalline, sublithographic and lithographic limestones of the upper member. The MH 'bentonite' is easily recognized in well-cuttings near the top of the middle member.

Green and white calcite 'eyes' impart a 'birdseye' appearance to some of the beds of the middle member. These 'eyes' were originally thought to represent the fossil material and were called *Phytopsis tubulosa*. The writer has observed true *Phytopsis tubulosa* at only one locality in Ontario, near Eldorado, 45 miles east of the map-area. As the *P. tubulosa* there and in New York state are quite different from the structures in the middle member of the Gull River Formation in the Lake Simcoe district, the labelling of these structures ('eyes') by early workers as that species of fossil was not correct. This middle member of the Gull River Formation is the unit to which the term 'Birdseye' has been applied several hundreds of miles away in New York state, and southward. This member is traceable eastward into the rocks called Lowville Formation by G. M. Kay and F. P. Young. Bryozoa and ostracods have been collected from thin shale partings in its lower part and trilobites have been observed in the pure lithographic limestones at the top of this member.

Upper Member (Unit B_3). The upper member of the Gull River Formation comprises 4 to 12 feet of grey, greenish grey, and brownish grey, semi-crystalline, sublithographic and lithographic limestone, with some fine-grained limestone. Individual beds range from 6 to 30 inches in thickness. Commonly the beds are grey-weathering and thin on the sides of quarries and road-cuts that face the prevailing elements. Vertical joints are commonly evident in flat exposures. In the eastern part of the map-area, as at Oak Lake and Beech Lake, nodular black chert layers are common in the uppermost few feet. The member thins westward from Oak Lake to less than 4 feet in the Longford quarry, but thickens farther west in the quarries at Coldwater and Port McNicoll.

In the subsurface the upper member is sometimes difficult to delimit. The MH clay seam is generally located just below its base as the member is traced eastwards. Also, black chert occurs throughout the vertical extent of the member in some sections. The upper member comprises a single rock unit (B_3) within the map-area. It represents: 1) the *Tetradium* beds of older workers, 2) the strata in which Johnston (1911) noted a profusion of the species *Tetradium cellulosum*, and 3) the Moore Hill 'Formation' of Okulitch (1939)[1]. The writer has traced the upper member (B_3) eastward to the Kingston area where it is a submember overlain by additional units of submember rank. Lithologically the B_3 unit belongs in the Gull River Formation as herein defined.

[1] The name Moore Hill was proposed by Okulitch for strata of this unit at Moore Hill road-cut about 2 miles north of Coboconk. However, as there is a faunal connotation to this term (i.e., it defines a biostratigraphic unit) the writer has refrained from using it for his rock unit and uses instead the term upper member.

The upper member contains:

Tetradium cellulosum
T. fibratum
T. cf. *syringoporoides*
T. halysitoides
T. clarki
T. racemosum
Foerstephyllum halli
Rafinesquina trentonensis
Öpikina clara
Ö. minnesotensis
Zygospira recurvirostris
Rhinidictya sp.
Hormotoma gracilis
'Orthoceras' cf. *multicameratum*
Isotelus gigas
Bumastus sp.
Eoleperditia fabulites

Contacts

The lower contact of the Gull River Formation is defined where the limestone and dolomitic limestone overlie the red and green shales of the Shadow Lake Formation. The upper contact is defined as the top of the highest development of lithographic limestone, below the grey and brownish grey, fine- and medium-grained limestone and argillaceous limestone of the Bobcaygeon Formation. On gross lithology, the Gull River is lithographic limestone; the Bobcaygeon is grey, fine-grained, argillaceous limestone. The contact is drawn with the intent of retaining such gross lithological differences. In a few localities, there is evidence of a disconformity, for the Bobcaygeon Formation overlies a solution-pitted upper surface of the Gull River Formation. (This is actually a corrosion surface.) The same contacts can be recognized readily in outliers of the two formations northward within the Precambrian Shield, despite thinning and admixture of submember lithologies.

Stratigraphic Relations

As Dr. A. E. Wilson (1946a) has noted in the Ottawa Formation, the palaeontological limits of the Black River and Trenton times are quite indefinite. Very few fossil species have restricted ranges; most of them can be traced through several successive zones. In addition, with increasing knowledge of these strata, the number of wide-ranging species increases, whereas the number of restricted range species diminishes. Such a trend, however, is to be expected, especially in an area where essentially continuous sedimentation has taken place. A situation similar to the one in the Ottawa area exists in the Lake Simcoe district.

Stratigraphically, the writer's rock-unit classification of the Black River–Trenton strata is essentially the same as that established by Johnston in 1911. We now know that, lithologically, the writer's lower member of the Gull River Formation is the equivalent of the Pamelia Formation of New York state. The middle member correlates with the Lowville Formation in that state. The upper member also belongs to the Lowville; its fauna correlates palaeontologically with the Chaumont of New York state; however the Chaumont unit is not traceable this far west. The writer believes the term Leray (of Ontario) to be biostratigraphic and to include the Chaumont and Moore Hill units (also biostratigraphic units) and the lower C_{1A} beds of the overlying Coboconk (i.e., part of the lithostratigraphic Bobcaygeon Formation). It is evident then that each one of these units (Chaumont, Moore Hill, Coboconk) can have a Leray fauna and yet Leray cannot be one of them restrictedly. It should be pointed out that in contrast with Ontario usage, i.e., Pamelia, Lowville, Leray, Rockland, etc. (in which Leray has been supposedly synonymous with '*Columnaria* beds' and Coboconk), in New York state, Leray was the lowest 'member' of Kay's Chaumont (i.e., Leray, Glenburnie, Watertown, in ascending order), and was much lower in the section.

Correlation

On the basis of the fauna they enclose, the lower member and the lowest submember of the middle member of the Gull River Formation are correlated with the Pamelia, and the upper submember of the middle member with the Lowville of New York state and the Ottawa Valley. The upper member is correlated with the Chaumont Formation of New York state. The Gull River Formation is the lithological equivalent of the Swift Current beds (exclusive of the Basal beds; Foerste, 1912) of Manitoulin Island, of the Pamelia and Lowville Formations of New York state and the Ottawa Valley, and of lowest Bony Falls strata in northern Michigan.

Sedimentary Environment

The nature of the sediments of the lower member indicates general deepening conditions. Quiet lagoonal conditions are postulated for the lithographic limestone. The fine-grained carbonates were deposited in shallower waters, as indicated by the presence of mudcracks and related shallow water features. The lithographic limestone is considered to have been formed from precipitated lime-muds. In the instance of the A_3 submember the digitate material is considered to be primary dolomite, which separated from the precipitated lime-mud that forms the matrix. Similarly, where the lithographic limestone is in digitate form within the dolomite, the two components are intimately intermixed, the dolomite being more abundant. The lithographic texture of the middle member is also believed to be indicative of lagoonal lime-mud precipitation. This member is the westward extension of the similar unit in New York state. The sediments of the upper member are believed to signify a return to shallow conditions that prevailed during the deposition of the Bobcaygeon sediments. They are less aphanitic and contain some clastic and fragmental material in addition to the abundant fauna. The facies pattern within the Gull River Formation (Fig. 4), which is especially pronounced near Coboconk, is interpreted as indicating the influence of the Peterborough Arch on sedimentation in this area during Pamelia and Lowville time.

Bobcaygeon Formation

The terms Coboconk, Kirkfield, Leray, Rockland, and Hull have long been used in the Lake Simcoe area for units now interpreted to be biostratigraphic. The strata to which these five terms have been applied are now grouped into a single

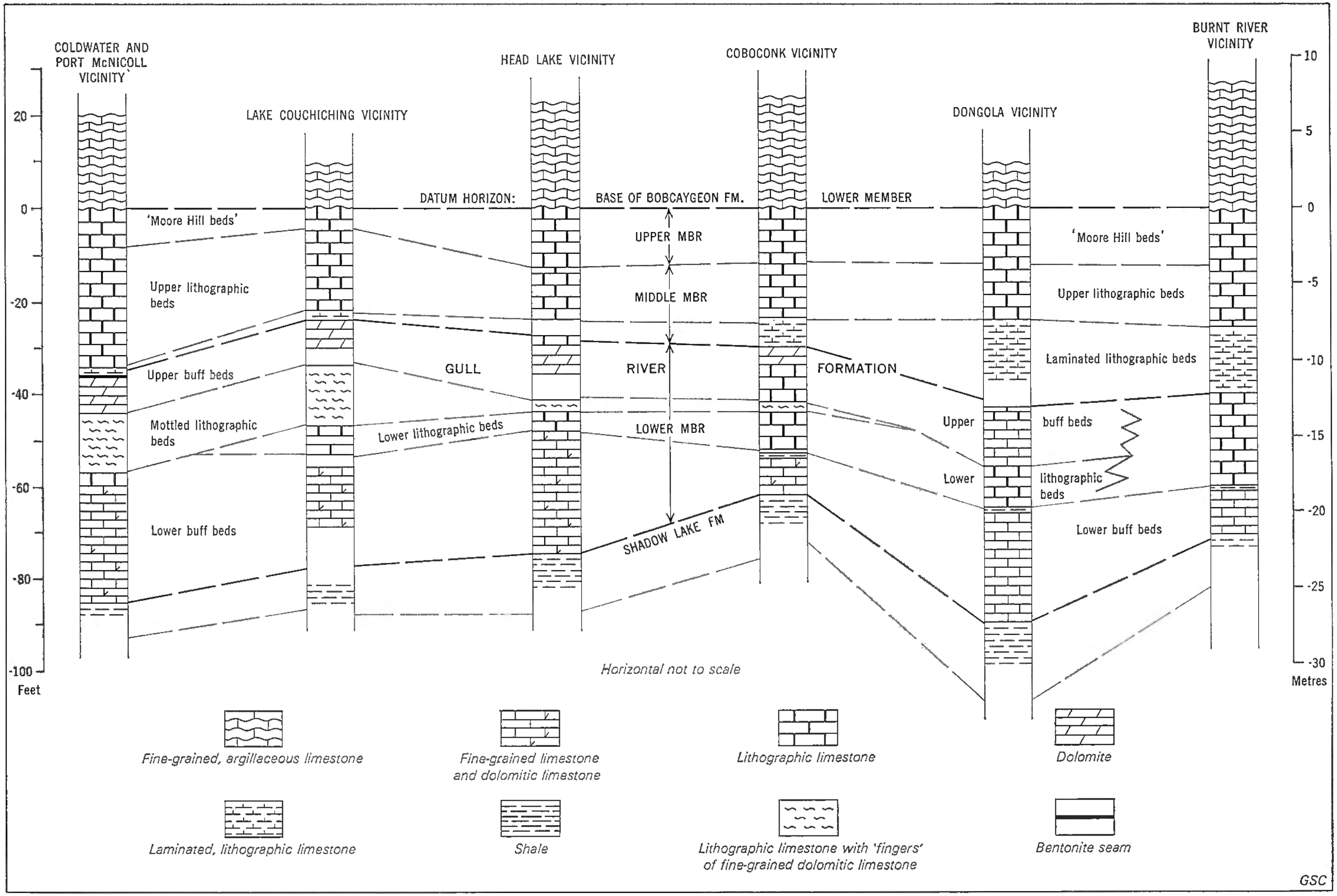

FIGURE 4. Regional facies chart of Gull River Formation. Based on local composite sections.

formation (Bobcaygeon) on lithical grounds. These strata have at various times been referred to as Black River or Trenton. The terms Black River and Trenton have now been elevated to stage status, however (Kay, 1960), and their boundary is therefore a time-line and should be delimited faunally. This boundary is considered to lie within the lower member of the Bobcaygeon Formation.

Definition

The term Bobcaygeon Formation is herewith proposed for the strata lying above the lithographic sediments of the Gull River Formation and below the interbedded limestone and shale of the Verulam Formation. As so defined, the formation embraces the lithogenetic unit (and problem strata) between the '*Tetradium* beds' of Johnston (uppermost part of the Gull River Formation, which is also Okulitch's Moore Hill Formation) and the '*Prasopora* beds'. These are the same strata that lie between the top of Kay's Chaumont Formation and the base of Kay's Sherman Fall Formation.

Rather than redefine essentially biostratigraphic terms to lithostratigraphic units, the writer has introduced a new term. The formation, as now defined, comprises three members: 1) a lower, grey, fine-grained limestone; 2) a middle sublithographic limestone; and 3) an upper alternating grey sublithographic limestone and grey, medium-granular calcarenitic limestone.

The strata of the formation can be seen in their true sequence (although not in their entirety) at only two localities: 1) at the Kirkfield liftlock, where the Gull River Formation is in the base of the liftlock well and the Verulam strata overlie this section at the Ontario Hydro transformer half a mile to the east; and 2) near Bobcaygeon, where a composite section can be made up from the Nogies Creek road-cut, the Little Bob quarry, and No. 36 highway road-cut south of town. The name is taken from the town of Bobcaygeon. Type sections include: lower member C_1, Coboconk east quarry; C_2 Silver Lake section north of Bobcaygeon; Middle member, Little Bob quarry, south of Bobcaygeon; upper member, Kirkfield quarry.

Distribution

The Bobcaygeon Formation has been mapped from east of Pigeon Lake to Christian Island in Georgian Bay. The lower member commonly is the cap rock for the northeastward-facing escarpments formed by the underlying Gull River Formation. The middle and upper members, however, are softer and are rarely found in escarpments. The formation does not outcrop in the drift area between Nottawasaga Bay and Lake Simcoe. The levelling of topography by ice-movement and erosion in areas underlain by the formation together with the formation's average dip of some 20 feet to the mile, has left a wide area underlain by the Bobcaygeon Formation, most of which is obscured by a mantle of glacial material. Drift thicknesses appear greater in areas underlain by the middle and upper members than in areas underlain by the lower. Thickness of the formation ranges from 30 feet in the outcrop belt north of Lake Simcoe to 300 feet farther south. Well records indicate that the formation is present beneath younger strata throughout the map-area.

The lower member is best seen at the following localities: in lot 10, con. 11, Orillia tp., Simcoe co., Longford quarry near Orillia; the quarries in the village of Coboconk (Pl. XI); a quarry 2 miles southeast of Burnt River; the road-cut 10 miles north of Bobcaygeon on the Kinmount road; and the Silver Lake road-cut, 9½ miles north of Bobcaygeon. The middle member is best observed at the Kirkfield liftlock above water level in the side of the canal (Pl. XII), and in the Little Bob quarry, south of Bobcaygeon (Pl. XIII). The upper member is best seen in the Kirkfield quarry (+2 to 36 feet), (Pl. XIV) in the quarry at Corson Siding, and at Fenelon Falls below the locks (between water level and the Verulam Formation at the top of the section).

Thickness and Lithology (Units C, D, E)

The Bobcaygeon Formation is divided into three members (units C, D, and E, Table I; Fig. 5) within the map-area. Essentially the lower member (C) consists of grey, fine-grained limestone, but encloses calcarenite in its uppermost few

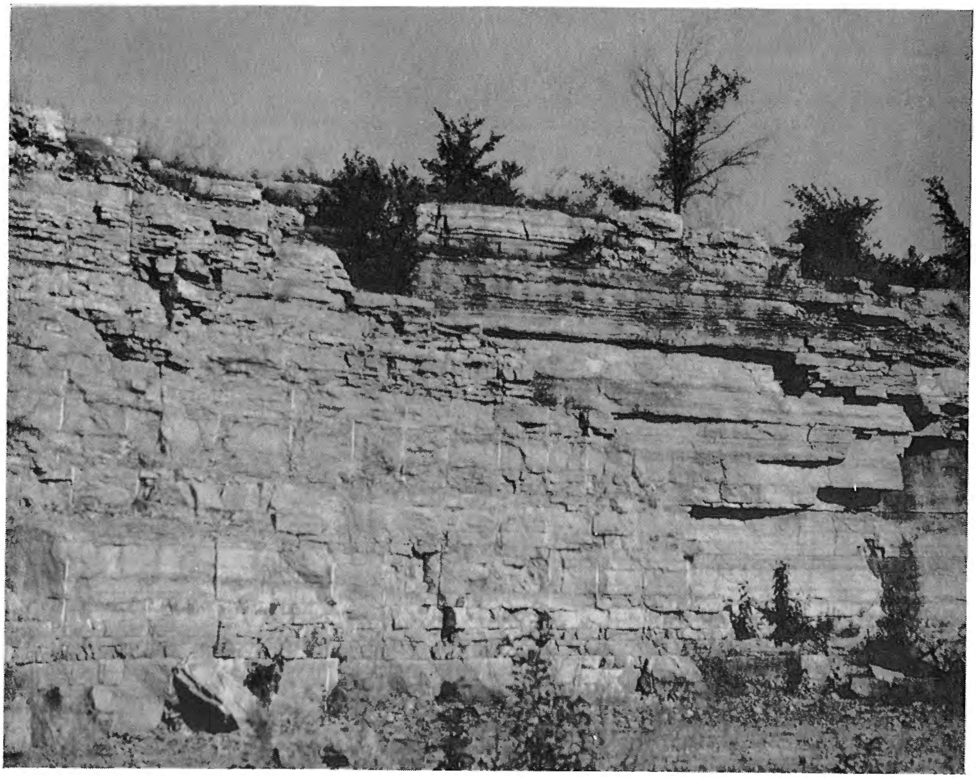

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PLATE XI. Bobcaygeon Formation, lower member, overlying uppermost beds of upper member (Moore Hill) of Gull River Formation; east face of Arena quarry (Coboconk east quarry), Coboconk.

B.A.L. 10–5–50

PLATE XII. Bobcaygeon Formation, lower and middle members, north bank of Trent Valley Canal at west end of Kirkfield Liftlock, $7\frac{1}{2}$ miles north of Kirkfield.

B.A.L. 14–2–50

PLATE XIII. Bobcaygeon Formation, middle member, collecting locality B, Little Bob quarry, a mile southeast of Bobcaygeon.

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PLATE XIV. Bobcaygeon Formation, upper member, overlying 6 feet of lower member in base, and overlain by 6 feet of Verulam Formation at the top; collecting locality K, northwest corner of Kirkfield Quarry, 7 miles northeast of Kirkfield.

feet. The middle member (D) consists of sublithographic limestone. The upper member (E) alternates between sublithographic and medium calcarenitic limestone, but also includes some brown lithographic limestone and bluish fine-grained limestone in minor thicknesses. In general the formation is about 80 feet thick in the outcrop area north of Lake Simcoe. This thickness is fairly constant, but the formation may thin southwards.

Lower Member (*Unit C*). The lower member of the Bobcaygeon Formation comprises 20 to 25 feet of grey and brownish grey, fine- and medium-grained limestone, and some grey crystalline crinoidal limestone (C_1) (Pl. XI). Rarely seen are thin beds of grey, finely clastic limestone (calcarenite) (C_2). The main beds (C_1) are generally more than 12 inches thick, but commonly weather thin ($1\frac{1}{2}$ to 2 inches thick) or to a rubble because of argillaceous content in the rock. On flat outcrops, beds exhibit vertical jointing and weather grey and bluish grey. Irregular nodules of chert are present in the uppermost few feet of this member and form a consistent stratigraphic marker throughout the map-area. Also within

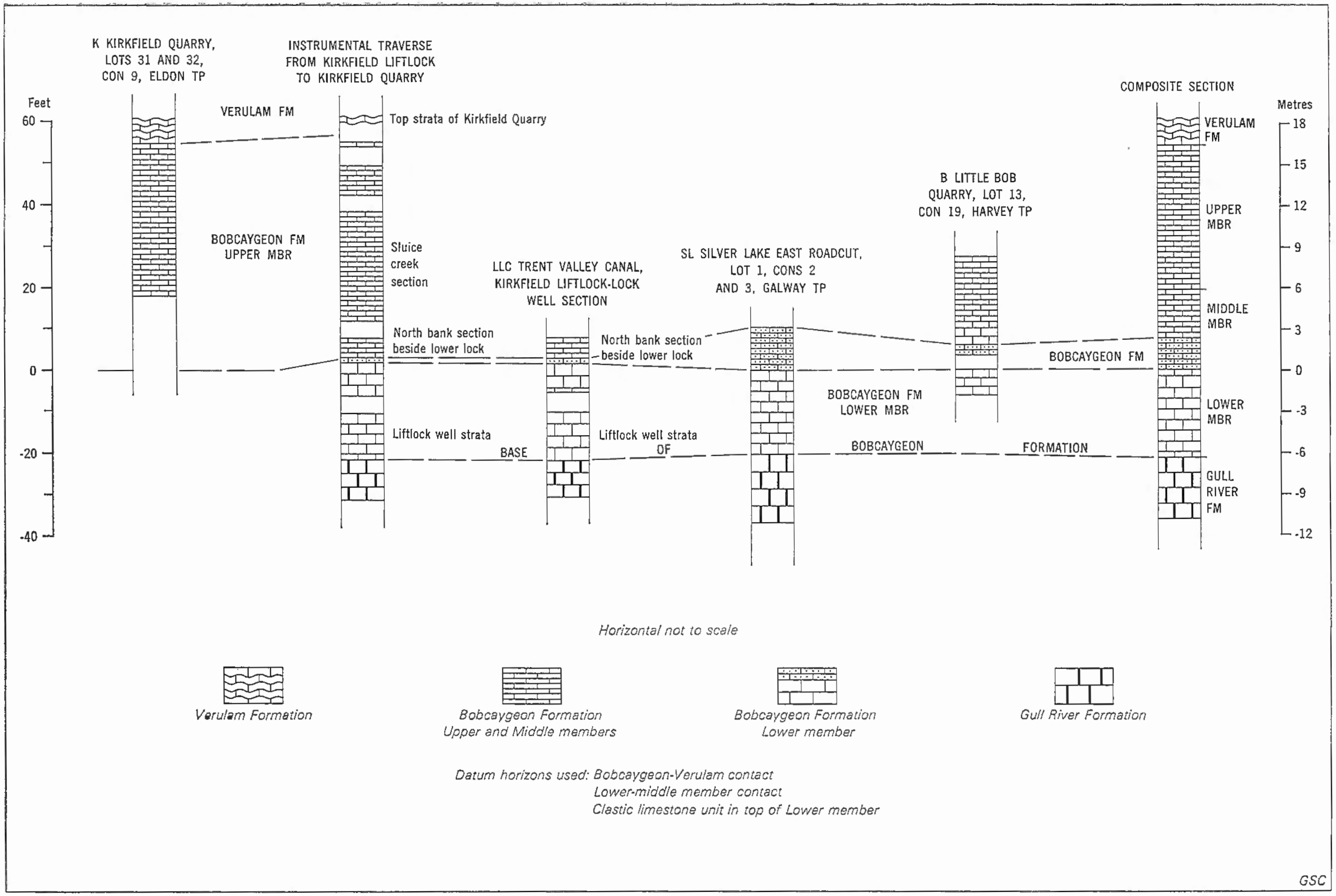


FIGURE 5. Compilation chart for the Bobcaygeon Formation, Balsam Lake–Sturgeon Lake area.

these uppermost strata (C_1) there are two anomalous lenses of chert produced by siliceous springs. One of these is about 10 miles north of Kirkfield near Duck Lake.

An upper subdivision, C_2, of the lower member is recognizable eastward from the longitude of Coboconk (Pl. XII). This unit, which ranges from 0 to 11 feet in thickness, comprises the calcarenite submember that the writer formerly placed in the base of the lower member of the Kirkfield Formation (Liberty, 1955), which lower member is presently the middle member of the Bobcaygeon Formation. This C_2 submember consists of grey, fine to medium, granular and fragmental clastic limestone (calcarenite). It is consistently present in the eastern part of the map-area, where it ranges from 1½ to 11 feet in thickness, in beds from 3 to 6 inches thick. A conglomerate in the calcarenite contains pebbles of rocks from the Gull River Formation and from the C_1 submember. Many of the fossils in the calcarenite are fragmental and covered by beekite, a variety of chalcedony. The C_2 submember is best seen in the base of the Little Bob quarry south of Bobcaygeon and in the Silver Lake road-cut in lot 1, cons. II and III, Galway tp. The distribution of the lower member on Map 1228A is slightly smaller (and narrower) than its actual areal extent, because the upper (C_2) submember was originally mapped by the writer as part of what is now designated the middle member of the Bobcaygeon Formation (shown as lower member, Kirkfield Formation, in Liberty, 1955).

In the subsurface, member C appears mainly as a grey, fine-grained limestone. Fragments of chert are common near the top of submember C_1, but the presence of beekite as granules generally indicates the overlying C_2 submember. The latter unit appears as a medium granular clastic limestone, but insoluble residue studies indicate that it contains a considerable proportion of siliceous and argillaceous material. It also contains a few algal pisolites. The contact of the lower member (C) with the overlying middle member (D) is drawn at the base of the sublithographic limestone of the latter unit. As the C_2 submember is absent in many places west of Coboconk, the sublithographic limestone of the middle (D) member then lies directly on the fine-grained, argillaceous limestone of the C_1 submember.

In the subsurface in southwestern Ontario the C_2 submember becomes very important for the recognition of both thickening phenomena and oil and gas accumulations. Some workers have incorrectly considered it to constitute the Coboconk Formation.

Middle Member (*Unit D*). This unit comprises about 20 feet of grey and brown, very fine grained to sublithographic, sparsely fossiliferous limestone, with some fine-grained limestone in the upper part. The strata weather into grey beds, 2 to 10 inches thick, which are generally more massive than those of the lower and upper members. The member is best seen in the Little Bob quarry south of Bobcaygeon (Pl. XIII). In subsurface cuttings, the member is a grey and brown, very fine grained to sublithographic limestone. A consistent clay seam ('bentonite'), to which the writer has applied the letters MR (this is the CR seam reported in Forman and Lake, 1954), has been found in well samples at the base of this member, but to date has not been found in surface exposures. Large and small algal pisolites are very common in this member and can be seen in the cuttings.

The contact of the middle member with the overlying upper member is drawn at the base of the lowest calcarenite development (in the upper member), leaving the middle as non-calcarenitic and essentially sublithographic limestone. As thus defined, the lowest 6 feet of the Kirkfield quarry, as exposed in 1960, is assigned to the middle member (in a ditch in the quarry floor, i.e., —4 to +2 feet with respect to the quarry floor).

Upper Member (Unit E). The upper member of the Bobcaygeon Formation comprises about 34 feet of grey, fine- and medium-grained limestone alternating with fine and medium granular calcarenitic limestone, and weathering grey. Some brown lithographic limestone is present between 23 and 24 feet above its base and a hard, bluish grey, fine- and medium-grained, in part crystalline, limestone occurs between 28 and 34 feet above its base. The latter 6 feet of limestone weathers light blue, into beds from 3 to 8 inches thick. It is this unit that imparts the characteristic blue colour to the road-metal produced by the Kirkfield quarry. The remaining 27 feet of limestone in the upper member weathers grey, alternating smooth and rough surfaced, and into beds from 2 to 10 inches thick. Some beds are not consistently thick even within the quarry, one calcarenite thinning from 14 to 8 inches. The upper member also contains black shale partings (as much as three-quarters of an inch thick), which contain fucoidal material and echinoderms along the bedding planes. Shale is notably lacking. The member is best seen in the Kirkfield quarry between 2 and 36 feet above the quarry floor (Pl. XIV).

The lowest 10 feet of the member contains a great profusion of the genus *Dalmanella* and are the '*Dalmanella* beds' of W. A. Johnston (1911, and subsequent publications) and other early workers such as P. E. Raymond. The overlying 18 feet contains a large echinoderm fauna (at 2 levels: 19.5 and 25.5 feet), which was found by these same workers and named the 'Crinoid beds'. The remaining 6 feet of the member contains a non-diagnostic fauna, but underlies the '*Prasopora* beds' (of the Verulam Formation) in the top of the Kirkfield quarry. Accordingly the uppermost 6 feet of the upper member are included by the writer with the underlying 'Crinoid beds'. In subsurface samples, the upper member appears mainly as a grey calcarenitic limestone with fine-grained limestone and a minor amount of lithographic limestone. It is typically a calcarenite and is the lithological equivalent of the Kirkfield Formation as defined by Kay (1956).

Contacts

The lower contact of the Bobcaygeon Formation is defined where the typical grey, fine- and medium-grained limestone overlies the highest development of the lithographic and sublithographic limestone of the Gull River Formation. This contact in many places is marked by a disconformity, which is interpreted as of very local occurrence and short duration. In a few places where the disconformity is not apparent a thin transitional facies can be observed. Such strata are assigned arbitrarily to the Bobcaygeon Formation, thus leaving the main development of lithographic limestone as the Gull River Formation. The base of the Bobcaygeon Formation is where Kay (1937) drew his Black River–Trenton contact.

The upper contact of the formation is defined where the fine- and medium-grained and calcarenitic limestone is overlain by the very argillaceous unit in the base of the Verulam Formation (an alternation of rusty weathering, grey and brownish grey, fine- and medium-grained argillaceous limestone and greenish grey shale). This unit also encloses a great profusion of fossils: *Dalmanella, Platystrophia,* and *Prasopora* and crinoids.

Fauna

The lower member of the Bobcaygeon Formation contains two zonal subdivisions, C_{1A} and C_{1B}, within its lower submember C_1. The more characteristic species in the C_{1A} zone are:

Solenopora 'compacta'
Foerstephyllum halli
Stromatocerium rugosum
Lambeophyllum profundum
Lichenaria carterensis
Öpikina minnesotensis
Ö. clara
Strophomena filitexta
Hesperorthis tricenaria
Maclurites logani
Lophospira perangulata
Actinoceras bigsbyi
Hormoceras tenuifilum
Isotelus gigas
Ceraurus pleurexanthemus

The C_{1B} zone includes the species *Maclurites logani, Receptaculites occidentalis, Hesperorthis tricenaria, Calapoecia canadensis,* and *Ottawacrinus typus.*

The calcarenite (C_2) submember includes the following species:

Paucicrura rogata
Sowerbyella sericea
S. cf. *curdsvillensis*
Triplecia cuspidata
Parastrophina hemiplicata
Camerella panderi
Rhynchotrema increbescens
Hesperorthis tricenaria
Lichenaria coboconkensis
Receptaculites occidentalis
Trochonema cf. *umbilicatum*
Phragmolites compressus

The middle member (D) of the formation includes the following species:

Receptaculites occidentalis
Foerstephyllum halli
Skenidioides? merope
Resserella resupinata
Cyclonema cf. *cushingi*
Bathyurus cf. *trispinosus*
Achatella sp.
Gonioceras sp.
Hormotoma trentonensis

In the upper member (E) of the formation, the 2- to 10-foot interval represents the '*Dalmanella* beds' (E_A zonal subdivision), the 10- to 34-foot interval represents the 'Crinoid beds' (E_B zonal subdivision).

The lower beds (E_A) include:

Resserella whittakeri	*Dinorthis pectinella*
Hesperorthis tricenaria	*D. pectinella sweeneyi*
Sowerbyella subovalis	*Flexicalymene senaria*

The upper beds (E_B) include:

Hybocystites sp.	*Platystrophia uxoris*
Cleiocrinus sp.	*P. trentonensis*
Cupulocrinus humilis	*Trematis* cf. *ottawaensis*
Glyptocrinus grandis	*Rafinesquina praecursor*
Hemicystites billingsi	*Eccyliomphalus* sp.
	Chasmops bebryx

The echinoderm faunas are found 19.5–20.5 and 25.5–26.0 feet above the Kirkfield quarry floor. A third echinoderm level in this quarry lies in the uppermost 6 feet of the quarry in the Verulam Formation.

Correlation

Strata in the lower C_{1A} (6′ 10″) zonal subdivision contain a Chaumont fauna, i.e., Black River, precisely the same fauna as that found in the upper member of the Gull River Formation. In the upper C_{1B} (13′ 6″) zone, irrefutable Trenton species are present and are believed to correlate with the Rockland's Napanee beds. The upper submember (C_2) contains *Triplecia cuspidata,* whose presence in uppermost Coboconk strata only was used by Kay (1937) to date the whole of the Coboconk. This unit also is correlated with the Rockland's Napanee beds. The middle member of the Bobcaygeon Formation is also correlated with the Rockland's Napanee beds.

The upper member (E) is the Kirkfield (Kay, 1943), which the writer believes to be Rockland. This is based on the following four items. The '*Dalmanella* beds' were Rockland by Raymond's original definition (1914); they are located in the 2- to 10-foot interval, E_A zone of the Kirkfield (quarry), of the upper member. Secondly, the 10- to 36-foot interval, E_B zone of the Kirkfield (quarry), comprises the 'Crinoid beds'; these were Hull by Raymond's (1914) original definition. The non-echinoderm fauna of this interval is Rockland (Sinclair, 1954) and the writer has corroborated this. Thirdly, in 1937, Kay redefined Hull to include the '*Dalmanella* beds' (E_A zone), and subsequently, this redefined Hull was replaced by the term Kirkfield (Kay, 1943). Thus Kay's Kirkfield enclosed Raymond's Rockland (E_A zone) in its base and Raymond's Hull (E_B zone) above it. Finally the writer has mapped and traced Kay's Kirkfield (= the writer's upper member of the Bobcaygeon Formation) from the Kirkfield quarry type section into Kay's Napanee beds at their type section on Selby Creek near Napanee, Ontario[1]. With this in mind and with the faunas the same, the writer has no alternative but to correlate the upper member of the Bobcaygeon Formation with the Rockland Formation's Napanee beds. Thus, the Kirkfield in the

[1] *See* Liberty, 1963, footnote re sedimentary environment, Bobcaygeon Formation.

Kirkfield quarry must correlate with the Napanee. The Bobcaygeon Formation's upper member therefore contains a Rockland fauna and must be Rocklandian in age.

Westward, the Bobcaygeon Formation's member lithologies coalesce and the formation is traced into the Cloche Island beds (Foerste, 1912) on Manitoulin Island, and is correlated with them. The formation is traceable into southwestern Ontario in the subsurface. There, a pronounced colour change within the formation is used as a lithological contact; it is attributed to the greater carbonaceous content of the younger Bobcaygeon beds[1]. The writer does not believe that this colour change is the Black River–Trenton contact referred to by Cohee (1945b, 1947). Personal discussions with Cohee have led the writer to consider Cohee's 'Black River–Trenton contact' to be the writer's Bobcaygeon–Verulam contact. Cohee's (1947) reference to Kay indicates that Kay believed the Black River–Trenton contact should have been defined much lower; indeed Kay defines this contact at the writer's Gull River–Bobcaygeon formational boundary.

It thus becomes evident that in present subsurface usage the terms Black River and Trenton are being applied to lithical units; as no fossils are used the term 'correlation' should not be used. In lieu of microfossils, subsurface units must be traced to the outcrop area for their biostratigraphic and age relationships.

Stratigraphic Nomenclature and Related Problems

Table I (*in pocket*) shows the evolution of the Middle and Upper Ordovician stratigraphic nomenclature in central Ontario. A detailed discussion of this table and pertinent problems has been deferred at this time, but can be found in large part in the writer's unpublished Ph.D. thesis (Liberty, 1953h). The classification used in the present report, with the exception of the term Bobcaygeon, was published by the author in 1955, and has proved to be a reliable guide in field work for the past 16 years.

The term Bobcaygeon Formation has now been substituted for the combined strata previously termed Coboconk and Kirkfield. The need for this change was necessitated by the following factors: (1) the varying definitions of 'Coboconk and Kirkfield' between authors; (2) the attendant Black River–Trenton boundary strata; and (3) the presence of unsuspected strata (middle member) between the Coboconk and Kirkfield units. The term Bobcaygeon Formation is a lithogenetic unit of calcarenites and interbedded lithographic and argillaceous limestone. Its subdivision into three members clarifies the stratigraphic confusion that has centred around these rocks in the Kirkfield–Coboconk area for many years.

Within this formation may be found: the arbitrary Black River–Trenton faunal delimitation, and a continuous stratigraphic sequence from '*Columnaria* beds' to the '*Dalmanella* beds' to the 'Crinoid beds' inclusive. Under such conditions of continuous sedimentation, the writer believes that certain forerunners of the Trenton fauna would be expected to appear above the Chaumont fauna in the top of the underlying Gull River Formation. The Chaumont fauna is present

[1] This refers to the lighter coloured underlying Gull River Formation.

in the lower beds (C_{1A}) of the Bobcaygeon Formation's lower member. Trenton species are introduced in C_{1B} beds, and they become the dominant species in the C_2 submember. For this reason the writer places the 'Black River–Trenton time boundary' within the lower submember (C_1) of the Bobcaygeon Formation's lower member (C), thus corroborating the work of Okulitch (1939). The writer concurs with Okulitch's (1939, p. 357) statement: "Our subdivision of this continuous record will necessarily have to be, to some extent, arbitrary and depend on statistical evaluation of large fossil collections rather than one or 2 'index fossils' ". Accordingly the Blackriveran–Trentonian time boundary is drawn 6′ 10″ above the base of the Bobcaygeon Formation. In contrast it should be noted that the base of the Trenton varies with the worker: Cooper[1]—at the base of the Sherman Fall's Shoreham (= base of the writer's Verulam Formation); Kay—at the base of the Coboconk (= base of the writer's Bobcaygeon Formation); Winder —at the base of the Bobcaygeon Formation's upper member; and Sanford—at the top of the Coboconk (= at the top of the Bobcaygeon's lower member). Some of these workers' contacts are drawn on faunal grounds, some on a lithical basis.

In recent years the writer has been impressed increasingly as to the faunal connotation attached to the terms 'Black River' and 'Trenton' by most workers. This is in direct contrast with known lithological use of the terms 'Black River Group' and 'Trenton Group' by subsurface workers and New York state investigators. As regards the Trenton, it must be admitted that the rock unit and biostratigraphic unit can coincide at and near the type sections in northern New York state. Farther afield, however (e.g., in Ontario), such is not the case. With the terms Rockland (lowest Trenton Group, Kay, 1937) and Chaumont (highest Black River Group, Young, 1943) being defined by faunal attributes, and with these secondary terms becoming Trentonian and Blackriveran stages (Kay, 1960), the evolution of terms Black River and Trenton into the biostratigraphic status is complete.

Through Marshall Kay's continued interest on a regional scale and the lack of interest on the part of most other investigators not only in the local area, Kay's biostratigraphic terminology has become deeply entrenched in the literature and is known worldwide. The writer contends that outside the New York state type area and with, or without, the 'ian' suffixes, the terms Black River and Trenton are biostratigraphic terms. Thus a line of delimitation between the two units must be a timeline and definable solely by palaeontological evidence.

In areas such as southern Ontario, however, the stratigrapher may be faced with transgression of time lines by his rock units[2]; then he must turn to other terms for his regional surface mapping and subsurface tracing. Table II compares the lithostratigraphic units now used by the writer with Kay's biostratigraphic

[1]G. A. Cooper (1956) used the term 'Wilderness' rather than Black River. 'Wilderness' incorporates strata heretofore called Black River in Ontario. This is a biostratigraphic term, as is the term 'Barneveld' with which D. W. Fisher replaced the term Trenton, in his paper published since this memoir was submitted for publication. (Fisher, D. W.: Correlation of the Ordovician rocks in New York State; *Geol. Surv.*, Map and Chart series, No. 3, 1962.)

[2]This problem is discussed briefly in the following report, published since this memoir was submitted for publication: Liberty, B. A., 1963: Geology of Tweed, Kaladar and Bannockburn map-areas, Ontario; *Geol. Surv. Can.*, Paper 63-14, p. 8.

units. Both sets of terms are necessary in areas such as southern Ontario, but the rock units are more easily recognized by lithostratigraphers, hence have a more practical application than the older biostratigraphic terms.

Sedimentary Environment

The sediments of the lower member of the Bobcaygeon Formation are indicative of shallowing conditions in this shelf area of the Middle Ordovician sea. Continuous sedimentation is postulated from Black River into Trenton time, culminating with the deposition of clastic, fragmental limestones (calcarenite) in the top of the C_2 submember (in early Trenton time). This clastic material probably came from a more positive feature or area and includes material eroded subaqueously from the Gull River Formation and the lower member of the Bobcaygeon. Such a local source area would provide sediments that could mask, at least in part, any sediments coming from another source area. This clastic material was transported and deposited within the map-area in the course of continuous sedimentation. Normal marine conditions are considered to have existed, as the general ecology (i.e. sediment, depth, turbulence) appears to have been more conducive to life and preservation than the limy mud precipitates of the underlying Gull River Formation. Local minor current action is suggested, however, by small scale cross-laminations (micro-crossbedding), and small 'cusps', a foot to 2 feet in diameter, in the clastic, crinoidal, and fragmental material.

Deepening waters and quieter conditions of sedimentation are postulated for the period of time during which the sparsely fossiliferous middle member was deposited. The fine-grained limestones, lithographic limestones, and calcarenites of the upper member of the formation were probably deposited under shallow water and oscillatory conditions. Sinclair (1951, p. 178) described the conditions thus: "... shallow water, with a sufficient dearth of clastic material to allow induration and wear of one surface before a new influx of sediment". The strata of this member show many alternations of this sort.

The sediments in the Bobcaygeon Formation reflect a type of sedimentation that somewhat resembles reefal accumulations reported by other authors, notably Hadding (1941) on the Silurian strata in Sweden. Despite similarities to other known reefal complexes with which the writer is acquainted (Ordovician, Silurian, and Devonian of the Michigan Basin and the Carboniferous in Great Britain), there are important dissimilarities. The lithographic 'lagoonal' limestone facies in the Bobcaygeon Formation is present over vast areas, but biohermal or reefoid masses are almost lacking. The largest seen by the writer comprises accumulations of *'Columnaria'* coralla and are about 8 feet in height and about 40 square feet in areal extent. The formation is not known to contain the structureless, unfossiliferous, biohermal masses that are so common in Lower Ordovician, Silurian, and Devonian strata, but rather thin layers are covered by algal mats and coralline and mollusc faunas.

On the basis of his studies of the formation throughout Ontario, the writer considers the entire Bobcaygeon Formation as a biostromal complex, similar to the Upper Ordovician biostromes in the Georgian Bay region. The C_1 portion of the lower member is a biostrome. Associated with it are the clastic carbonates and fragmental fossil remains of the C_2 submember, together with the marked algal and coralline fossil assemblage. The overlying sublithographic limestones of the middle member and finally the calcarenitic upper member are logical associated sediments, the whole Bobcaygeon Formation being a lithogenetic unit. At certain localities the calcarenitic C_2 may be excessively thick or anomalously thin, but these variations would be expected within a biostromal complex. That the biostrome is widespread is indicated by the persistent nature of the lower and upper members across central Ontario. The faunal assemblage includes: *Foerstephyllum (Columnaria) halli, Stromatocerium rugosum, Lambeophyllum (Streptelasma) profundum, L. corniculum,* Michelenoceroid and Orthoceroid nautiloids, and *Solenopora 'compacta'* abundant in C_{1A}); *Receptaculites occidentalis, Calapoecia canadensis, Maclurites logani, Solenopora 'compacta',* and *Hesperorthis tricenaria* (abundant in C_{1B} and C_2); *Triplecia cuspidata* and *Parastrophina hemiplicata* (in C_2 anc D).

Verulam Formation

The terms Sherman Fall and Cobourg have long been used in central Ontario for units now interpreted to be biostratigraphic. The strata to which these two names have been given contain two very distinctive lithical units, the boundary of which lies within the lower part of the Cobourg (Hallowell). The lower of these two lithical units is herein named the Verulam Formation; the upper unit is the Lindsay.

Definition

The name Verulam (pronounced Faroo'lum) Formation was proposed by the writer (Liberty, 1955) for the grey, fine- and medium-grained and crystalline limestone that lies between the top of the Bobcaygeon Formation and the base of the Lindsay in central Ontario (unit F, Table I). The name is taken from Verulam township where the formation is well exposed, south from Sturgeon Lake. The formation comprises essentially the '*Prasopora* beds' of Johnston (1910, 1911), but as here defined is a rock unit. It is divided into two members: a lower unit of alternating limestone and shale, and an upper one of crystalline limestone. Type sections are: lower member—sections S2, S8, and S9 (*see* Fig. 6) on south shore of Sturgeon Lake, in Verulam township; upper member—road-cut in lot 21, con. 7, Eldon tp., Victoria co.

Distribution

The Verulam Formation has been mapped from Nottawasaga Bay eastward to Pigeon Lake. Like the underlying upper member of the Bobcaygeon Formation, the Verulam is not resistant to erosion and its bedrock surface weathers to a plain. However, low northeastward-facing escarpments do exist, the upper member generally forming the crest (Pl. XV). Between Nottawasaga Bay and Lake Simcoe the formation is covered by a thick mantle of glacial drift and does not outcrop. Its distribution in this area has been established from well records.

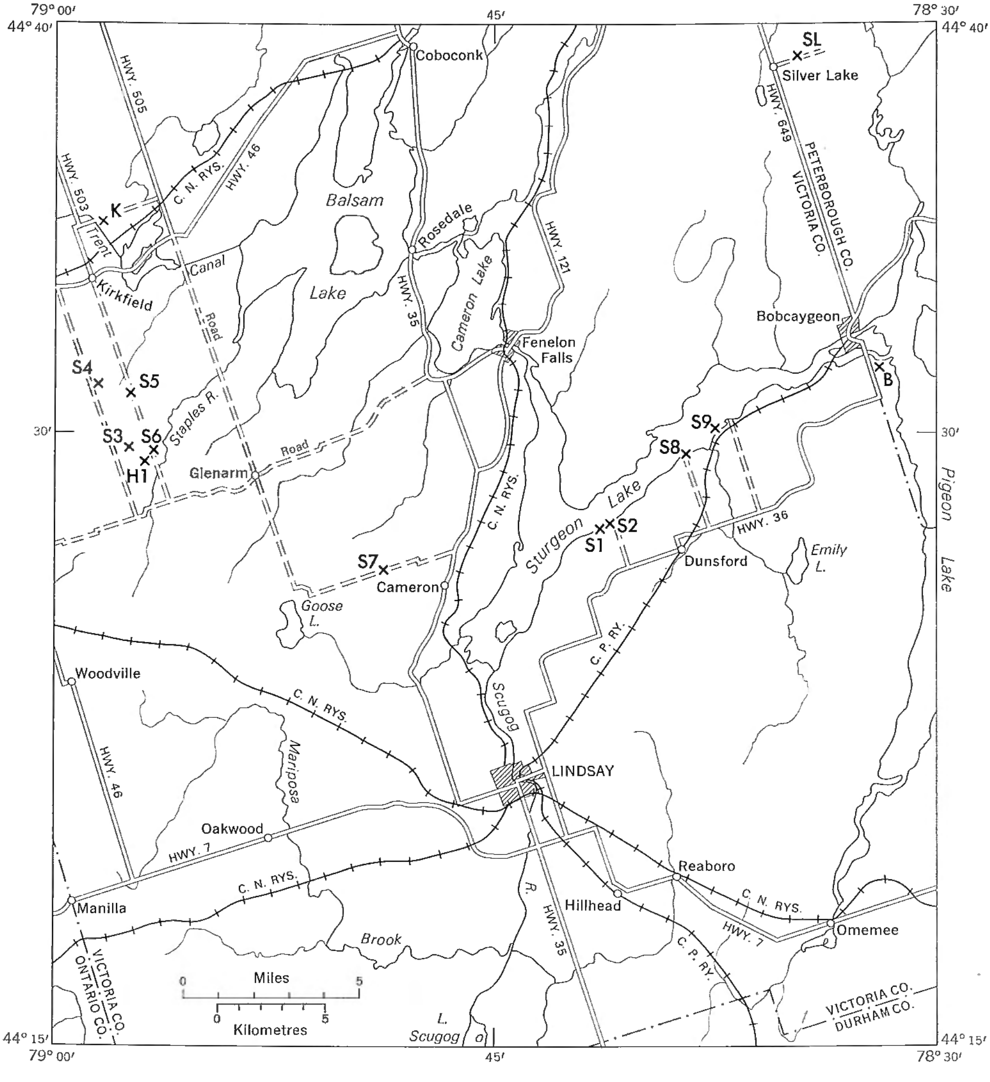


FIGURE 6. Location of key collecting localities.

These records indicate that the formation continues southwards beneath younger strata throughout the map-area.

Strata of the lower member are well exposed: in the quarry and railway-cut at Gamebridge; in the uppermost 7 feet of the Kirkfield quarry; and in several sections on the south shore of Sturgeon Lake, northwest of Dunsford (Pls. XVI and XVII). The upper member can be seen at several localities within 3 miles southwest of Kirkfield (Pl. XVIII); just west of Eldon Station; about 2 miles west of Cameron; a mile north of Zion; and about 2½ miles southwest of Dunsford on No. 36 highway.

B.A.L. 2–3–52

PLATE XV. Escarpment formed by upper member of Verulam Formation; lots 1 and 2, con. 4, Verulam tp., Victoria co.

B.A.L. 12–3–50

PLATE XVI. Verulam Formation, lower member, showing typical lower strata; collecting locality S-1; in lot 9, con. 11, Verulam tp., Victoria co.

B.A.L. 13–3–50

PLATE XVII. Verulam Formation, lower member, showing typical heavier beds higher in the lower member; collecting locality S-2; in lot 9, con. 11, Verulam tp., Victoria co.

B.A.L. 9–5–50

PLATE XVIII. Verulam Formation, upper member, showing upper beds of bioclastic limestone, abandoned railway-cut in lot 15, con. 8, Eldon tp., Victoria co.

Thickness and Lithology

The Verulam Formation comprises about 200 feet. It is known to thicken southwards to 230 feet. A composite section is shown on Figure 7.

The *lower member* (unit F_1) consists of 170 feet of grey and brownish grey, fine- and medium-grained, argillaceous and sublithographic limestone; and higher in the formation, 8- to 10-inch beds of grey, medium-crystalline, crinoidal limestone alternating with 2- to 3-foot beds of greenish grey shale. Most of the strata weather to thin, 1- to 2-inch beds and to a buff and rusty colour. The lowermost 10 to 30 feet are non-resistant and consist of an alternation of grey and brownish grey, fine-grained, argillaceous limestone and thin, 1-inch greenish shale partings (Pl. XVI). This unit contains a profusion of fossil material, notably *Resserella* (=*Dalmanella*), *Platystrophia,* and *Prasopora.* In the uppermost 40 feet of this member crystalline limestone constitutes a greater proportion of the section (Pl. XVII).

In subsurface samples, this member (F_1) consists essentially of light grey to buff to dark brown, fine-grained, fine-crystalline, argillaceous limestone, fine- to medium-crystalline fossiliferous limestone, and some clastic limestone. Numerous fossil fragments are intermixed with soft greenish grey to light brownish grey, calcareous shale. Core indicates that the member consists of an alternation of thin-bedded, fine- to medium- to coarse-crystalline limestone with thin shale sections and a considerable amount of sublithographic limestone.

The *upper member* (Unit F_2) of the Verulam Formation has a total thickness of about 27 feet, but is known to be as thin as 10 feet. It consists of brownish grey and grey, fine- to coarse-crystalline, bioclastic, crinoidal limestone in beds an inch to 3 inches thick, together with minor amounts of argillaceous limestone and granular fragmental limestone. The strata locally weather grey and brown into beds 8 to 10 inches thick. A peculiar weathering phenomenon, involving a thin, regular, discoidal sheeting effect, oblique to individual beds, and cutting across them, is characteristic and is considered to be crossbedding (Pls. XIX, XX). On the uppermost surface and visible at only two localities within the map-area, are large ripple-like structures, as much as 30 inches in wave length and 6 inches in amplitude. They are considered to be para-ripples modified by glacial scour action. These can be seen near Eldon Station and 2 miles west of Cameron in lot 8, con. III, Fenelon tp. In subsurface samples, this member (F_2) appears as a 'sugary' crystalline limestone, the medium and coarse crystals having been pulverized. It is chiefly a fine- to coarse-crystalline limestone, but encloses a consistent clay seam ('bentonite') a few feet above its base.

Contacts

The lower contact of the formation is defined where a very argillaceous (and richly fossiliferous) unit overlies the grey to bluish grey, fine- to medium-grained calcarenite of the upper member of the Bobcaygeon Formation. A profusion of bryozoa occurs a few feet above the contact. The contact between the lower (F_1) and upper members (F_2) of the formation is placed where the crystalline limestone of the upper member overlies the fine- to medium-grained

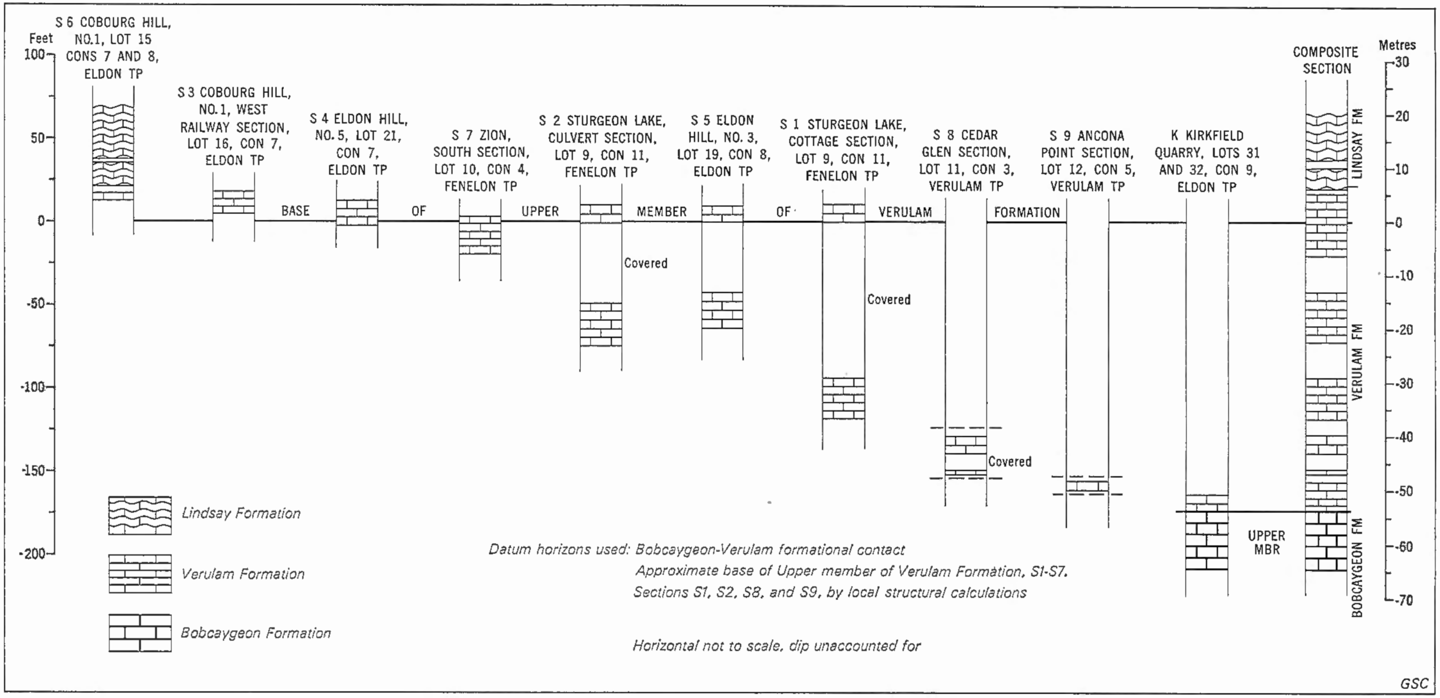
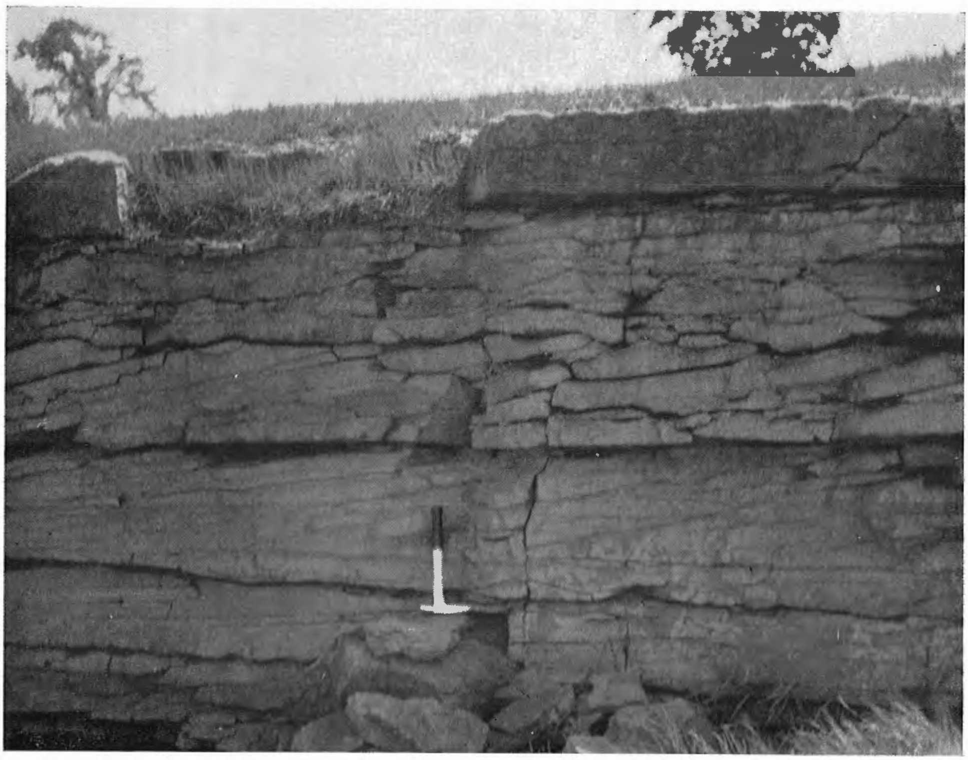


FIGURE 7. Compilation chart for the Verulam Formation, Balsam Lake–Sturgeon Lake area.

B.A.L. 2–2–52

PLATE XIX. Verulam Formation, upper member, showing weathering of crossbedded bioclastic limestone; north side of road-cut in lot 9, con. 14, Emily tp., Victoria co.



B.A.L. 1–2–50

PLATE XX. Crossbedding in bioclastic limestone, upper member of Verulam Formation; lot 16, con. 7, Eldon tp. Victoria co.

limestone and shale interbeds of the lower. This contact has been observed at three localities: 2 miles south-southeast of Zion, in lots 10 and 11, con. IV, Fenelon tp.; 5.9 miles north-northeast of Woodville, lot 16, con. IV, Eldon tp.; and 2.1 miles south-southeast of Kirkfield, lot 20, con. VIII, Eldon tp. (Pl. XXI).

The upper contact of the Verulam Formation is defined where the crystalline limestone is overlain by grey, fine-grained argillaceous limestone or by blue, very fine grained to sublithographic limestone of the Lindsay Formation. This contact may be seen in lot 10, con. IV, Fenelon tp., and is very nearly exposed in the railway- and road-cuts in lot 15, cons. VII and VIII, Eldon tp., Victoria co.

Stratigraphic Relations

Johnston (between 1909 and 1912) mapped the rocks now called Verulam Formation by the writer, but did not publish his detailed descriptions, sections, or maps. From his unpublished maps it can be seen that the top of his '*Prasopora* beds' was the top of the writer's Verulam Formation. In addition, Johnston (1914) stated that the '*Prasopora* beds' were overlain by the '*Hormotoma* and *Fusispira* beds' and the '*Rafinesquina deltoidea* beds'. The '*Hormotoma* and *Fusispira* beds' and the '*Rafinesquina deltoidea* beds' now belong to the biostratigraphic Cobourg

B.A.L. 11–4–50

PLATE XXI. Contact (at hammer head) between lower and upper members of Verulam Formation; lot 16, con. 6 Eldon tp., Victoria co.

unit, by definition, and are located within the writer's Lindsay Formation. The "upper member (unknown)" of Johnston's Kirkfield Group must be Johnston's upper Trenton '*Hormotoma* and *Fusispira* beds' and the '*Rafinesquina deltoidea*' beds (which would be the Lindsay Formation). Also the writer does not consider the upper member (of the Verulam Formation) to be the resistant strata forming the top of Kay's Hallowell member of the Cobourg (Kay, 1937). The top of the upper member of the Verulam Formation is about 100 feet below the top of the Hallowell (which is in the middle of the Lindsay Formation). The base of Kay's Cobourg (biostratigraphic) unit is located in the middle of the writer's lower member of the Verulam Formation.

The upper member is placed in the Verulam Formation because of its lithology. It is very similar in character to the crystalline limestone interbeds of the lower member (uppermost strata) and quite dissimilar to typical sediments of the Lindsay Formation.

Fauna

The formation is exceptionally rich in brachiopods, bryozoa, and gastropods, but no fossils are diagnostic. The fauna includes the following species:

Ischadites sp.
Streptelasma corniculum
Pholidops trentonensis
Trematis ottawaensis
Dinorthis cf. *calderi*
Lingula cf. *briseis*
Rafinesquina deltoidea
Strophomena billingsi
Fusispira subfusiformis
Hormotoma simplex
H. trentonensis
H. bellicincta
Helicotoma planulata
Fusispira angusta
Calliops narrawayi
cf. *Sphaerocorphe* sp.

Hemiarges paulianus
Bumastus billingsi

There is a large bryozoa fauna also. A full faunal list for the formation is given in Appendix D.

Correlation

The Verulam Formation is correlated palaeontologically with the Sherman Fall and the lower part of the Hallowell member of the Cobourg (Kay, 1937) of New York state, and with the Sherman Fall beds of the Ottawa Formation in the Ottawa Valley. The Verulam Formation is the lithological equivalent of the 'unnamed beds' (Liberty, 1954) that overlie the Cloche Island beds on Manitoulin Island, and of the Chandler Falls Formation in Northern Michigan. The term Sherman Fall (Kay, 1937) corresponds to the 'Trenton (restricted)' of Raymond (1912).

Sedimentary Environment

Oscillatory conditions between the limestone and shale lithosomes appear to characterize Verulam sedimentation, i.e., the increase in shale content over that in the Bobcaygeon Formation. According to Kay (1937, p. 293): "The maximum of lower Trenton submergence seems to have been reached in the earlier part of the Sherman Fall stage." While this was taking place the sediments of the Verulam Formation were being deposited in deeper water where conditions were exceptionally conducive to the survival of life. That these sediments were not deposited in really deep water is indicated by crossbedding, para-ripples (in both members), and by slumping and channelling phenomena. That transgression took place is indicated by overlap on Precambrian inliers, incorporating medium-sized, angular, gneissic fragments. An example of this phenomenon may be seen on the western flank of the Red Rock monadnock, 4 miles east of Fenelon Falls.

Lindsay Formation

Definition

The name Lindsay Formation is here proposed for the limestone unit (G on Table I) that overlies the crystalline bioclastic limestone of the upper member of the Verulam Formation and is overlain by black shale of the Whitby Formation. The formation is named for the town of Lindsay, near which it is well exposed. Reference section is that referred to by Raymond at Cobourg (Raymond, 1921), on the north shore of Lake Ontario. The type section is located 4 miles northwest of Lindsay on No. 35 highway, and a reference section in the railway ditch and shore sections near Craigleith station, on Georgian Bay. The name is taken from the town of Lindsay. The formation, as herein defined, is a rock unit and includes the '*Rafinesquina deltoidea* beds' and the '*Hormotoma* and *Fusispira* beds' of Johnston (1910, 1911).

Distribution

The Lindsay Formation has been mapped from Craigleith station, on Nottawasaga Bay, to Newcastle on Lake Ontario. It does not outcrop between Lake Simcoe and Nottawasaga Bay or between Lindsay and Newcastle. It is covered by a mantle of glacial drift, which increases from a few feet to a maximum of 330 feet in the Oak Ridge Interlobate Moraine area a few miles north of Lake Ontario, and to 430 feet in the area south of Barrie and north of the buried Simcoe Escarpment (the eastward bifurcation of the Niagara Escarpment). This Simcoe Escarpment limits the southern bedrock extent of the formation in the area southwest of Lake Simcoe. Boring records indicate that the formation underlies the younger formations throughout the southern part of the map-area.

Between Lake Simcoe and Lindsay, where the formation outcrops, the lowermost 40 feet nearly always appears in northeastward-facing escarpments (Plate XXII) that overlook the flat terrain formed by the upper member of the Verulam Formation. The Lindsay Formation is well exposed at the following localities: outcrops on the south shore of Nottawasaga Bay at Craigleith, Collingwood, and east to the Batteaux River; in the quarries at Collingwood; 2 miles west of Collingwood on the south side of No. 26 highway; 2½ miles east of Collingwood on the north side of No. 26 highway; the north shore of Georgina and Thorah Islands in Lake Simcoe; in the creek at Pefferlaw; 2 miles west of Cameron; the road-cut 4 miles northwest of Lindsay on No. 35 highway; and the road-cut 2½ miles north of Downeyville east of Lindsay. Formerly it could also be seen in the quarry at Bowmanville, but the quarry is now abandoned and flooded.

Thickness

Near Collingwood, the Lindsay Formation has been calculated by the writer to be about 200 feet thick (Fig. 8). This corroborates Sproule's (1936) estimate for the thickness of the Cobourg. East of Lake Simcoe the thickness is estimated to be about 185 feet. South of its outcrop area, the formation probably thickens, similar to associated Ordovician units.

Lithology

The formation consists generally of grey to greenish grey, fine-grained, argillaceous limestone in beds from an inch to 2 feet thick. It also includes shale partings, as much as 2 inches thick, along most bedding planes. Interbedded are a few beds 8 to 12 inches thick, of medium-crystalline, crinoidal limestone and calcarenite, the latter commonly enclosing lenses of fine to coarse conglomerate and breccia. In most localities the formation is very fossiliferous. In general, it weathers to a thin, rubbly, irregularly bedded limestone in road-cuts and quarries and to a loose, greenish grey rubble on flat surfaces.

The formation can be divided into at least four units in a few places, but insufficient field exposures permit neither a satisfactory check on the areal extent of these units nor an accurate idea of their relative thicknesses. Consequently

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PLATE XXII. Escarpment formed by low Lindsay strata, lots 14 and 15, con. 6, Eldon tp., Victoria co.

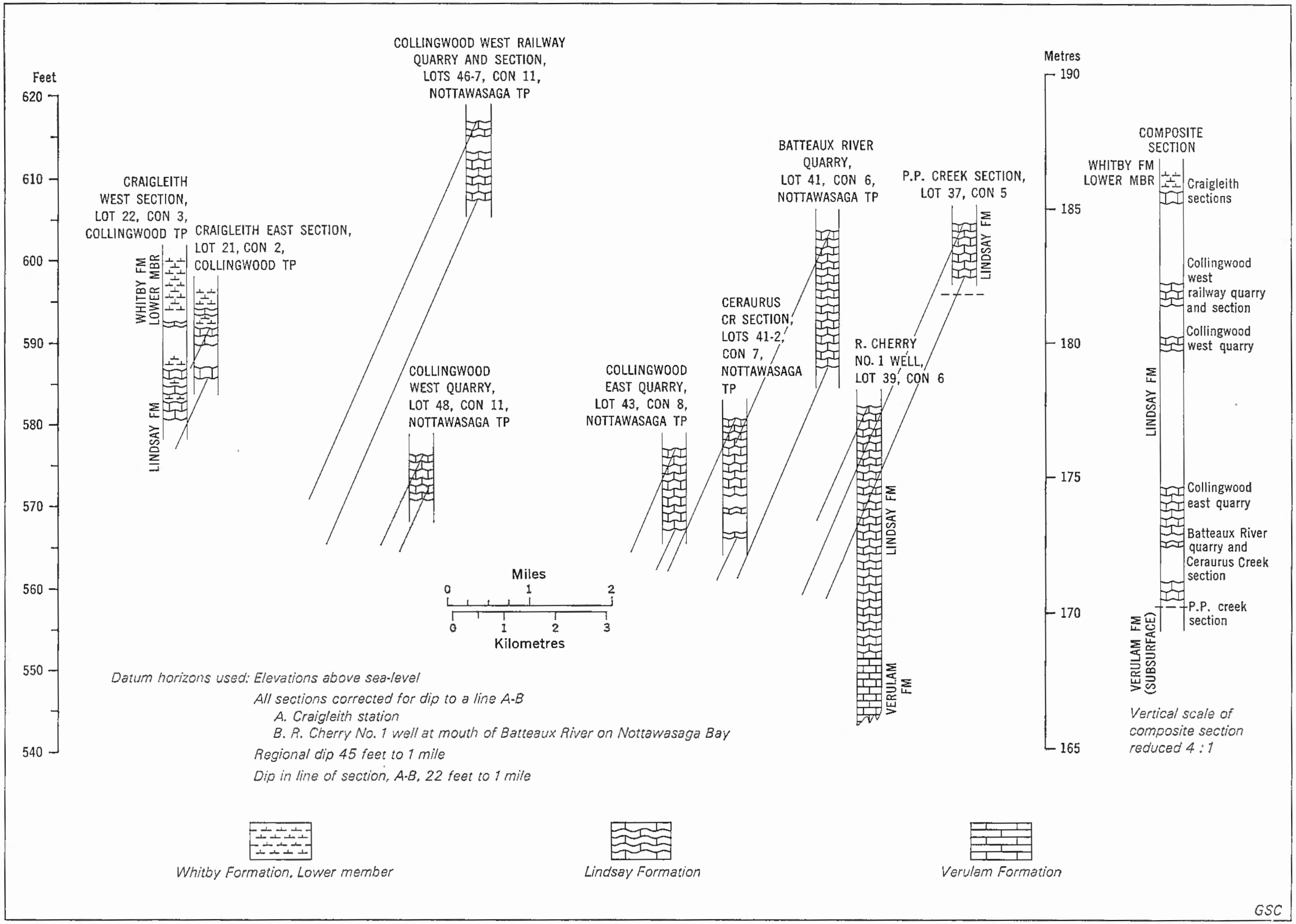
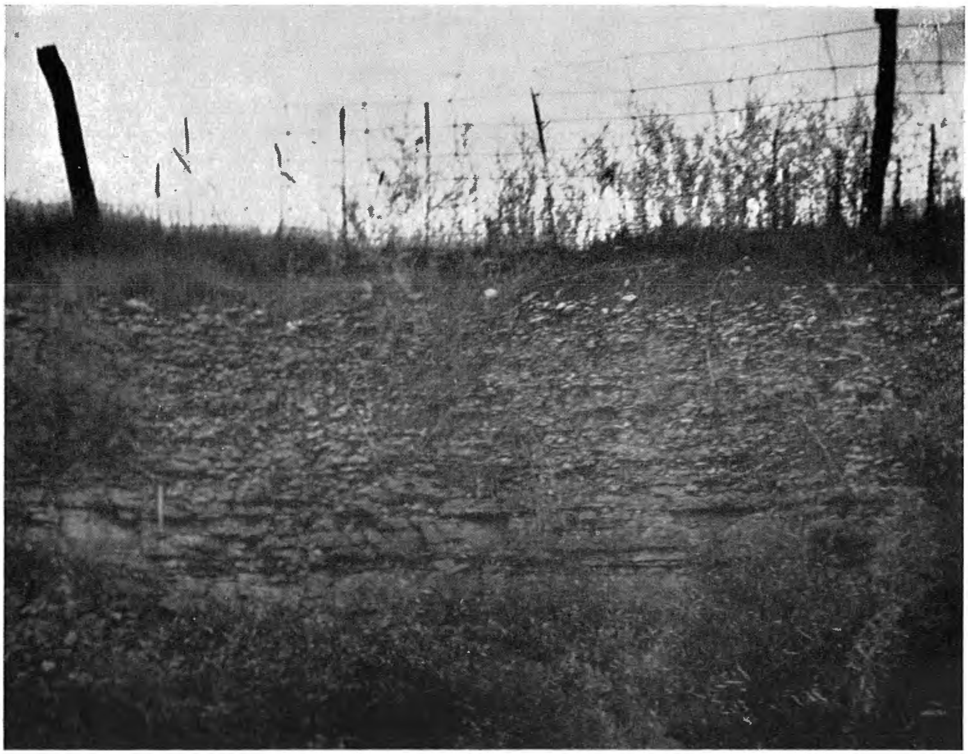


FIGURE 8. Compilation chart for the Lindsay Formation, Collingwood area.

they have not been given member status. The lowest unit consists of blue, sublithographic limestone with thin interbeds of shale, commonly with only shale partings. It can be seen to advantage south of Kirkfield and west of Lindsay. This unit is overlain by a thin-bedded (1 inch), grey to bluish grey, fine-crystalline to sublithographic limestone, which reduces to a fragmentary pseudo-rubble on weathered exposures, and may include coarse conglomerates and calcarenites; it is well exposed south of Kirkfield and west of Lindsay (Pl. XXIII). The third unit comprises alternating limestone and shale in which the limestone varies from fine crystalline to fine grained; it is well exposed on Thorah Island and north of Lindsay. The fourth unit comprises the uppermost strata in many places and consists of grey, bluish grey and brown, very fine grained to sublithographic limestone with thin, wispy shale partings. It may be seen to advantage at Bowmanville (loose slabs), Craigleith, and Collingwood. Yet another (fifth) unit, consisting of porous dolomite, may be present at the top of the Lindsay Formation, at Collingwood (subsurface), and also at Sheguiandah on Manitoulin Island (surface), northwest of the map-area. This unit is of local development only and may be related to the disconformity at the top of the formation. The brown, fine-grained, commonly sulphide-bearing dolomite at the top of the Lindsay, on Manitoulin Island, is definitely related to the unconformity. This fifth unit may



B.A.L. 15–5–50

PLATE XXIII. Lindsay Formation, upper road-cut in lot 7, con. 12, Emily tp., Victoria co.

therefore be present elsewhere where local conditions are similar to those at Sheguiandah and Collingwood.

These four (or five) units are detected only with difficulty in well cuttings, owing mainly to the 'washing out' of the shale content during drilling. In the cuttings, the formation appears as a brown and grey, fine- and medium-grained limestone with minor amounts of medium-crystalline limestone and traces of dark grey and brown shale. Cores indicate that much of the formation consists of an alternation of the rock types described above with 1-inch to 6-inch shale sections, corresponding to the third unit. The dolomite unit, in which some 'petroleum shows' have been found, is known only in the subsurface in the map-area, where it is at the top of the formation, corresponding to unit 5, as mentioned above. Consistent clay seams ('bentonites', metabentonites) have been recorded in this formation, but as yet little stratigraphic use has been made of them. Also, in the abandoned railway-cut in lot 16, con. VII, Eldon tp., truncated bedding and a minor conglomerate are believed to signify a minor hiatus in this unit.

Contacts

The lower contact of the Lindsay Formation is defined where its fine-grained, argillaceous limestone or blue, very fine grained limestone and shale overlie(s) the fine- to coarse-crystalline limestone of the upper member of the Verulam Formation. This base of the Lindsay Formation corresponds to the base of the '*Rafinesquina deltoidea* beds' and '*Hormotoma* and *Fusispira* beds' of Johnston (1911), as can be seen from an examination of Johnston's unpublished maps (on file, Geological Survey of Canada). The upper contact is commonly marked both by a disconformity (Pl. XXIV) and by a change from grey, very fine

PLATE XXIV

Erosional contact between Lindsay and Whitby Formations; east of Craigleith station on shore of Nottawasaga Bay, in creek.

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grained to sublithographic limestone (Lindsay Formation) to black, fissile, petroliferous, and calcareous shale (Whitby Formation). The actual contact is defined where the black shale first appears. Transitional beds are arbitrarily assigned to the overlying Whitby Formation. This contact is the Cobourg–Collingwood contact commonly mentioned in the literature and in terms borrowed from the palaeontologists and biostratigraphers. It is also the Middle-Upper Ordovician contact of most North American workers, e.g., Cohee (1945b) in the Michigan Basin.

Stratigraphic Relations

The name Lindsay is used in this report as a rock-unit term in place of the term Cobourg because of confusion in the literature over the meaning of the term Cobourg. No one has previously defined a rock unit at this level in the stratigraphic succession of southwestern Ontario. In addition, the lower contact of the Cobourg was neither described nor accurately defined, as Sproule (1936) and Kay (1937) placed it on the basis of faunal evidence. On the other hand, the Lindsay Formation includes the '*Rafinesquina deltoidea* beds' and the '*Hormotoma* and *Fusispira* beds' well within its contacts, and therefore conforms exactly to Johnston's "upper member (unknown)" (1912) and closely to Sproule's (1936) Cobourg, but is very different from Kay's (1937) defined Cobourg. Kay's lower limit lies in the middle of the writer's underlying Verulam Formation, i.e., the Denmark–Hallowell contact was placed in the lower member of the Verulam Formation. The term Cobourg as used by Kay (1937), therefore, does not apply to exactly the same strata called Cobourg by Sproule (1936), Caley and Liberty (1950), and Liberty (1952, and subsequent publications), nor the Lindsay of Liberty (as used in this report). As defined by Raymond (1921) and Kay (1937) the term Cobourg is biostratigraphic in status. Raymond (1914) had earlier proposed the term Picton for the strata (the '*Rafinesquina deltoidea* beds' and the '*Hormotoma* and *Fusispira* beds') between the '*Prasopora* beds' and the overlying black shale. As that term had been preoccupied, Raymond (1921) later proposed the name Cobourg.

The Lindsay Formation is considered by the writer to be the uppermost formation of the Middle Ordovician in Ontario. This interpretation agrees with that of Sproule (1936), most Canadian stratigraphers, and most workers in northeastern United States. It does not agree with the interpretation of Kay (1937), however, who included the Collingwood and Gloucester strata in the Trenton.

Fauna

The formation is richly fossiliferous: bryozoa, brachiopods, gastropods, and trilobites. The fauna includes the following species:

Cyclospira bisulcata
Rafinesquina deltoidea
Fusispira subfusiformis
Hormotoma trentonensis
Probillingsites primus
Pseudogygites canadensis

Correlation

The Lindsay Formation is correlated palaeontologically with the lower 'Utica' shales, and the Cobourg limestone of New York state, with Kay's Cobourg in eastern Ontario, and with the Cobourg beds of the Ottawa Formation in the Ottawa Valley. It is the lithical equivalent of the uppermost Trenton unit of Manitoulin Island (Cobourg of Caley 1935, and Sproule, 1936), of the strata in the Groos quarry in northern Michigan, and of the Cobourg beds in the Ottawa Valley.

Sedimentary Environment

Kay (1937, p. 294) considered that the "... Cobourg (Stewartville) sea seems to have been the most widespread of all Trenton submergences". Although this statement was applied to the entire continental interior, it seems particularly applicable to central Ontario where the conditions were quite stable and consistent. The increase in calcareous material in the Lindsay sediments over that in the underlying Verulam Formation suggests slightly deeper and more stable conditions. That there were fluctuating conditions between the two is indicated by thin rubbly sediments, the thick shale partings and thin shale sections, the lenses of calcarenite, breccia, and conglomerate. One of the writer's specimens of breccia includes fragments of feldspar, granite gneiss, Gull River and Bobcaygeon lithologies, all enclosed in a matrix of magnetite and carbonate. Evidence would suggest shallow water sedimentation and active erosion of Precambrian and lower Simcoe Group strata. Subsurface data indicate little in the way of facies change in the Lindsay across the Lake Simcoe area such as is found in the underlying Bobcaygeon and Gull River Formations. This suggests that the Peterborough Arch was inactive during the deposition of the Lindsay Formation.

Concerning the previously described (Sproule, 1936) disconformable relations with the overlying Whitby Formation, at Collingwood, the relief and size of the limestone blocks in the black shale would suggest that erosive forces were not as insignificant as previously considered by the author. Subsequent oscillatory conditions between the limestone and black shale lithosomes would suffice to produce the interbeds of limestone in lowest Whitby strata.

Nottawasaga Group

As herein redefined, the Nottawasaga Group comprises the Ordovician shale and limestone sequence that overlies limestones of the Lindsay Formation (Simcoe Group) and is overlain by shales of the Queenston Formation. In 1955, the writer had defined the group as overlying black and brown shales (Whitby Formation) that it now includes in its base. Within the map-area, the group constitutes about the same stratigraphic level as that of the following biostratigraphic units: Collingwood, Gloucester, Blue Mountain, Dundas, and Meaford. The group as redefined also includes the carbonate sequence below the base of the Silurian Manitoulin Formation on Manitoulin Island, for northward from Lake Simcoe map-area and the Bruce Peninsula the shale of the Queenston Formation is replaced by the carbonate lithosome (its facies equivalent). On Manitoulin Island, therefore, this group includes the strata of the Collingwood, Sheguiandah, Wekwemikongsing, Meaford, and Kagawong biostratigraphic units. The group is named after Nottawasaga Bay in Georgian Bay, along which it is well exposed.

The term Nottawasaga Group is a rock unit comprising two rock-unit formations: the Whitby Formation with three members and the overlying Georgian Bay with two members. At no one locality can the group be seen in its entirety. In the Nottawasaga Bay area, however, the lower and upper members of the Whitby Formation are exposed near Craigleith and Camperdown, respectively, and the lower and upper members of the Georgian Bay Formation can be seen on East Meaford Creek. Near Lake Ontario, lower, middle, and upper members of the Whitby Formation can be seen at Oshawa and Rouge River, and the Georgian Bay Formation is exposed in the Don Valley brickyard in Toronto and on Credit River near Streetsville. The thickness of the group varies from about 570 feet in the Georgian Bay area to about 900 feet in the Toronto area. Reference sections are in the aforementioned localities; the reference well is located in the town of Flesherton (Artemesia tp., Grey co.) about 600 feet southwest of the main intersection, on the Ceylon road, and behind the Co-op store on the north side of this road (about 44°15′42″N lat. and 83°30′4″W long.).

Except for evidence of an hiatus during which the middle member of the Whitby Formation was eroded from the Nottawasaga Bay area, the whole Nottawasaga Group succession is considered to be the result of continuous sedimentation. No other stratigraphic breaks have been observed or suspected. On faunal evidence the Whitby Formation is dated as Collingwood–Gloucester–Blue Mountain (Pictonian–Edenian), the Georgian Bay as Maysvillian–Richmondian.

The sediments of the group were initiated by the incursion of the shale lithosome (the 'Utica' dark shales) that took place subsequent to a subaqueous erosional interval, whose presence is indicated by the disconformity at the top of the Lindsay Formation. After this interval, in central Ontario at least, the Appalachian source area was rejuvenated and the basin and shelf areas underwent changes that permitted the widespread invasion from the east of the resultant muddy facies. Subsequently there was the transition from black shale to brown and blue shales (all within the Whitby Formation), which was followed by the interbedded carbonate and shale strata of the lower member of the Georgian Bay Formation. This facies change is interpreted as indicating the intertonguing and encroachment of a carbonate lithosome from the north (Manitoulin Island and Bruce Peninsula areas). The carbonate content of the Georgian Bay Formation increases upward in the section as the interbedded carbonates and shales of the lower member give way to the limestone and dolomite of the upper member. These calcareous deposits suggest deepening marine conditions shortly after the start of Richmond time in the Ontario area. Only in the Manitoulin Island area, however, did this carbonate lithosome remain dominant, for the shale lithosome in the form of the Queenston Formation returned to dominate the Nottawasaga Bay–Toronto area.

Whitby Formation

The terms Collingwood, Gloucester, and Blue Mountain have frequently been used for rocks in the lower part of the Upper Ordovician in central Ontario. These terms are now regarded by most workers as biostratigraphic. The lithical unit embracing these three biostratigraphic units is the Whitby Formation, which contains three members. The lower and upper members are traceable from Georgian Bay southward to Toronto; the middle member may be traced from Toronto to south of Duntroon. On lithological grounds the *Triarthrus*-free shales present between highest-known Blue Mountain and lowest-known Dundas strata, which have provided the problem of defining the Blue Mountain–Dundas contact, can now be easily assigned to the top of the Whitby Formation. Some of the strata now called Whitby were called Billings in the past (*see* Table IV). The writer believes, however, that the term Billings should be restricted to the Ottawa Valley, where it was originally defined, where it is still applicable, and where it can be used as A. E. Wilson (1937, 1946a) originally intended.

Definition

The name Whitby, introduced by Liberty (1955) as a group term, is here reduced to formational rank and redefined for the shales that overlie the limestone of the Lindsay Formation, and which are in turn overlain by the alternating limestone and shale strata of the Georgian Bay Formation. The formation is entirely present only in the Lake Ontario area, near Whitby, from which it gets its name, but nowhere in the map-area is it completely exposed. The formation consists of three members. Type sections include: lower member, creek east of Craigleith station; middle member, Rouge River, a mile northwest of junction with Little Rouge Creek; upper member, mouth of East Meaford Creek. The lower member embraces the black shales (of Collingwood and Gloucester age), the middle member constitutes the overlying brown shales (of Gloucester age), and the upper member comprises the grey and blue shales (that contain the Blue Mountain fauna).

The Whitby Formation is a rock unit. The writer supports A. E. Wilson (1938a) and Kay (1960) in their assignment of the names Collingwood and Gloucester to the status of time terms of at least substage rank. Moreover, the treatment here presented resolves the confusing Collingwood and Billings problems.

Distribution

The formation has been mapped from near Collingwood (Pl. XXV) southeastward to Whitby and Oshawa on Lake Ontario (Pl. XXVI). In the intervening drift-covered area, recourse has been made to bedrock topography and subsurface well-cuttings in order to determine its presence and to present an interpretation of its areal configuration. In contrast with its narrow belt at the base of the Niagara Escarpment in the Collingwood area, the formation occurs in the face of the buried Simcoe Escarpment in the Lake Simcoe area. Eastward it widens to about 30 miles. The middle member wedges out near Stayner and west of this the lower and upper members can be distinguished readily. Well records indicate that the formation is present beneath the younger formations throughout the map-area.

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PLATE XXV. Whitby Formation, lower member, between Camperdown and Craigleith, on Nottawasaga Bay.

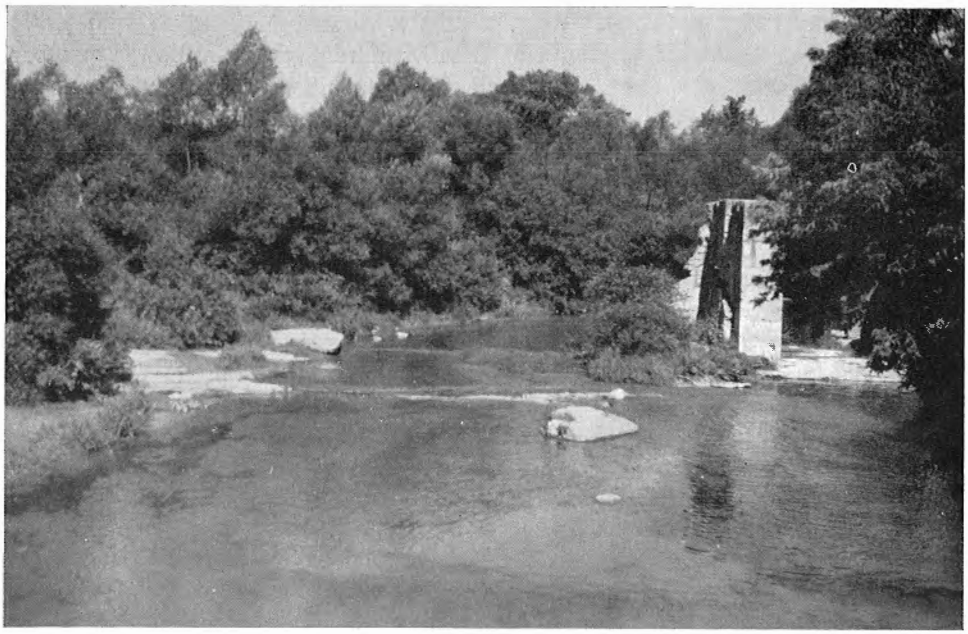

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PLATE XXVI. Whitby Formation, lower member; in creek north of Mill Street bridge, city of Oshawa, Ontario co.

The following reference sections are designated: lower member in a small creek passing beneath No. 26 highway east of Craigleith station, and in a road-cut on No. 26 highway north of Craigleith station; middle member on Rouge River east of Toronto, about a mile northwest of its junction with Little Rouge Creek; upper member at Camperdown, at the mouth of East Meaford Creek.

Thickness

The Whitby Formation is about 290 feet thick near Lake Ontario and 170 feet thick along Nottawasaga Bay. The lower member is consistently 30 feet thick throughout the map-area. The middle member ranges from about 90 feet in thickness at Toronto to its wedge-out near Stayner, about 10 miles southeast of Collingwood. The upper member ranges from about 140 feet in thickness at Meaford (Liberty and Bolton, *in preparation*) to 170 feet in the Canadian National Exhibition well in Toronto. This well, which is located at the midpoint of the eastern end of the Automotive Building just west of the Prince's Gate, is the reference well for the formation.

Lithology[1]

The *lower member* of the Whitby Formation comprises the strata to which the writer formerly applied the term Craigleith (Liberty, 1955). In addition to its two reference sections at Craigleith, the member is well exposed at the following three places: on the shore of Nottawasaga Bay between Craigleith and Camperdown (Pl. XXV); in an abandoned quarry 1½ miles west of Craigleith; and in the creek north of the Mill St. bridge in Oshawa (Pl. XXVI). In outcrop it appears as black to dark grey, fissile, highly petroliferous and calcareous shales. Interbedded with these black shales at Craigleith are two 8- to 10-inch beds of grey, sublithographic limestone, which must be considered to be of minor importance, i.e., less than 20 per cent. The member is very fossiliferous. Pyrite is common throughout and has coated many of the fossils. Portions of the shale may be described as limestone because of its calcareous nature and its lack of cleavage. In outcrop, however, most of the unit appears to be fissile and might even be termed a paper shale. Blocks of the underlying Lindsay Formation are enclosed in the black shale in the creek section east of Craigleith and provide evidence for a disconformity at the base of the member. Radioactivity in terms of per cent U_3O_8 equivalent is 0.002 on samples from Craigleith and Oshawa.

In subsurface, the lower member can be fairly readily separated from the overlying unit by its fissile nature and high petroliferous content, the calcareous nature of much of the rock, the presence of large amounts of pyrite, and by the graptolite and trilobite material in the samples. However, samples of typical lower member strata are generally limited to one or two 5-foot sampling intervals.

[1] These members have now been formally named Craigleith, Rouge River, and Thornbury, by the author in: Ordovician and Silurian stratigraphy of Manitoulin Island, Ontario; Michigan Basin Geological Society Annual Field Excursion Guidebook: the Geology of Manitoulin Island; 1968, pp. 25–37.

The *middle member* embraces the brown shales to which the writer formerly applied the name Rouge River Formation (Liberty, 1955). In addition to the reference section on Rouge River, east of Toronto (about a mile northwest of its junction with Little Rouge Creek), this member is well exposed on Little Rouge Creek about three-quarters of a mile north of Kingston Road; on the east branch of Duffin Creek 2 miles north of Pickering; and on the west branch of Lynde Creek 1.4 miles northwest of Whitby. In surface exposures the middle member appears as light brown, brownish grey, and grey soft shale, which may be slightly petroliferous and slightly calcareous, and contains a minor amount of black and blue shale, and thin beds of dark carbonaceous shale. Mud-cracks are common. The unit is moderately fossiliferous. Radioactivity in terms of per cent U_3O_8 equivalent is 0.004 on a sample from Whitby (East Lynde Creek).

In subsurface this member is less petroliferous and less calcareous than the lower member. In addition it is consistently brown and contains less fossiliferous material than the lower member.

The *upper member* comprises grey and blue shale and is well exhibited near Camperdown. The reference section is at the mouth of East Meaford Creek, but the member is also well exposed in the small stream that crosses No. 26 highway at Camperdown, and east of Toronto in Rouge River about a mile northwest of its junction with Little Rouge Creek, where it overlies the middle member.

In outcrop the upper member appears as grey, bluish and greenish soft shale and clay shale that weathers grey and bluish grey. Minor amounts of brown, bituminous and carbonaceous shale are present locally in the lower part. In some places the shale is more compact and breaks into hackly or conchoidal fragments. The member is moderately fossiliferous. In subsurface, it is grey, bluish grey, and greenish grey shale and micaceous shale. There are some 'traces' of limestone, but these are most probably cavings from the Georgian Bay Formation higher in the section. The member is generally neither bituminous nor calcareous, but locally contains 'traces' of both these characteristics.

Contacts

The lower contact of the Whitby Formation is defined where the first black fissile shale beds of the lower member overlie the grey, argillaceous limestone or grey, sublithographic limestone of the Lindsay Formation (Cobourg) (Pl. XXIV). Arbitrarily, any black shale partings are assigned to the top of the Lindsay Formation. Similarly, any marl or 'rotten' shale at this contact is arbitrarily placed in the lower member of the Whitby Formation.

The upper contact of the lower member is nowhere exposed, but at Craigleith it is in the 20-foot interval between the highest exposed strata of the lower member and the lowest strata of the upper member (the middle member is not present there). Careful examination of well cuttings reveals the black petroliferous lower member to be overlain by softer grey to greyish blue shale of the upper member. This change of lithology appears to take place within a narrow vertical range, that is, the 20 feet of section that is concealed. The exact nature of the contact cannot therefore be determined from surface exposures. An unconformity representing an erosional period or hiatus may thus exist at this contact, as was noted first by Parks (1928). On the other hand, between Lake Simcoe and Lake Ontario, well samples indicate that the black shale of the lower member grades upward into the soft brown shale of the middle member. Transition beds are arbitrarily assigned to the base of the middle member.

The upper contact of the middle member is exposed on Rouge River about a mile northwest of its junction with Little Rouge Creek, east of Toronto (Scarborough tp., lot 2, con. II, 300 yards east of the western boundary of the concession). There, brown shale of the middle member passes upward into blue shale of the upper member. Parks (1928) and Miller (1942) considered this to be the contact between the Gloucester and Blue Mountain beds (using the terms in a lithical sense). Transitional beds are arbitrarily assigned to the top of the middle member.

The upper contact of the Whitby Formation can be seen in the small creek that crosses No. 26 highway at Camperdown, and near the mouth of East Meaford Creek. The contact is at the lowest deposit of grey, impure, carbonate beds (limestone and dolomite) that alternate with the shale, and which represent the typical Georgian Bay (Dundas–Meaford) lithology (*see* Pl. XVII). In each place, the lowest carbonate beds are many feet above the highest deposit of the trilobite genus *Triarthrus*.

Stratigraphic Relations

The writer (Liberty, 1955) first used the term Whitby in a group sense to embrace his Craigleith black shales (herein called the lower member) and his Rouge River brown shales (herein called the middle member). The Whitby Group has now been reduced to formational status, assigned to the Nottawasaga Group, and redefined to incorporate the overlying greyish blue shales, as at Camperdown, of the Blue Mountain biostratigraphic unit as its upper member. Actually the term Whitby was first used by Chapman (1856) for the writer's lower member.

With reference to the lower contact of the Whitby Formation, Sproule (1936, p. 99) noted the contact on the beach at Craigleith as being

> ...marked by ½ to 2 inches of soft grey to buff coloured marl with thin undulating layers of rotten brown shale containing many broken fragments of *Dalmanella* and *Diplotrypa* "pebbles" up to 1 inch in diameter. The marly material of the contact is similar to that in the same zone at Little Current on Manitoulin Island. This bed is overlain by 9 inches of dark, nodular, limestone bands with undulating layers of rotten, brown and black, bituminous shale.

In 1956, the writer observed this contact in a better exposure in the railway culvert 100 yards east of Craigleith station. There, the Lindsay Formation was seen across a width of about 10 feet and appeared to be irregular with a maximum relief of about 10 inches. Several 3- to 7-inch rounded blocks of limestone were included in the black shale. There can be no doubt as to an unconformity, most probably subaqueous.

Similar observations were made by Logan (1863), Parks (1928), and Sproule (1936) concerning the now abandoned and flooded quarry at Bowmanville on Lake Ontario. This quarry was excavated in the contact zone. Sproule (1936, p. 99) stated: "In the waste dump, beside the quarry, are the same black limestone nodules and the same rotten brown shale of the Collingwood present at Craigleith. Many specimens of *Catazyga headi filistriata* var. nov. and *Diplotrypa neglecta* (Ulrich) were found here, both of which are abundant in zones within 20 feet below the contact on Georgian Bay". Unfortunately nothing can be seen or determined at this quarry now and the notes of previous workers must be accepted. From the foregoing evidence, the Algonquin Arch, in Middle Ordovician time, must have been sufficiently broad as to have had the present Collingwood and Port Hope localities on its flanks, at least. This arch may have been a composite structure that became more positive, relatively speaking, towards the cessation of Lindsay sedimentation, and at the beginning of Whitby sedimentation.

After the erosional period that took place before Whitby sedimentation, the source area was rejuvenated and the seas advanced over a much broader area than before, owing to a reshaping of the sedimentary basin. This action permitted the incursion of the black shale facies heretofore limited to New York state and eastward. This incursion probably took place in late Utica time, because the uppermost sediments of the Lindsay Formation are correlated with the Utica by Kay (1937) and the black shales of the lower member of the Whitby Formation are everywhere younger than the Lindsay strata. The abundance of the trilobite *Pseudogygites canadensis* through the lower member at Craigleith may indicate that the most widespread condition of the incursion took place in latest Collingwood time.

The change in fauna from that in the Lindsay Formation to that in the lower member of the Whitby Formation is mainly the result of ecological control, i.e., the change to black shale facies. Many fossils are common to both units, however, which may be due in part to the calcareous nature of the black shale. That a disconformity must separate these two units because of faunal changes is no longer a valid argument. Those faunal changes that do take place are attributed directly to initiation of a black shale environment.

On the basis of the foregoing statements, the writer considers that the uppermost strata in the Lindsay (Cobourg) Formation, at least, were deposited in Utica (Edenian) time. The sea depositing black shale transgressed late in Utica time and attained its most widespread distribution in latest Collingwood time. The plane of the unconformity produced by this transgression most probably transgresses Collingwood time.

The upper member, as at Camperdown, is the rock-unit equivalent to the biostratigraphic Blue Mountain unit, the upper contact of which was defined by the upper limit of the trilobite genus *Triarthrus*. The failure of this genus has been used by Fritz (1926) and others to separate the two biostratigraphic units. Caley (1940) did not interpret the presence of the upper member in the Toronto area, due to lack of exposures. As a result, his definition of Dundas excludes these strata, which must be placed in his Billings unit. In the past, the Blue Mountain strata were regarded as the facies equivalent of the Gloucester shale (Kay, 1937). In terms of the rock units used in this report such a relationship would make the upper member the equivalent of the middle member, which would limit the upper member to the Georgian Bay area. This is not so, however, for the upper member continues and thickens southward.

Although there was continuous sedimentation from the upper member of the Whitby Formation into the overlying units, a disconformity is probably present at the base of the upper member where that member lies on the lower member in the Collingwood area. The contact between these two members is not exposed at the surface, but well cuttings indicate that the change in lithology from the lower to the upper takes place within a narrow vertical range. The combined evidence suggests that strata of the middle member were once present over the Algonquin Arch and were removed before deposition of the upper member. Thus the middle member wedges out near Stayner, 10 miles southeast of Collingwood.

Correlation and Fauna

The strata of the lower member are of Collingwood–Gloucester age and are correlated faunally with the uppermost middle Utica, the third zone of the Utica shales. The member is also correlated faunally with part of the Eastview Formation and with the Billings Formation of the Ottawa Valley, the Deer River Formation of New York state, the 'Collingwood' black shales of Manitoulin Island, and the fauna from Newberry quarry in the Northern Peninsula of Michigan. The lower member is the lithological equivalent of the lowermost strata of the Billings Formation in the Ottawa Valley, the black shales called Collingwood on Manitoulin Island, and the lowermost strata of the Bills Creek Formation in northern Michigan. The more important fossil species in this member are:

Glossograptus quadrimucronatus
Climacograptus typicalis
'Dalmanella' emacerata
Geisonoceras tenuistriatum
Triarthrus eatoni
Leptobolus insignis
Lingula progne
Pseudogygites canadensis

Middle member strata enclose mainly a Gloucester fauna and are palaeontologically correlated with the upper Utica, uppermost zone 3, of New York state on the basis of *Triarthrus eatoni*. The Gloucester fauna of Ontario is strikingly similar to the fauna of the upper strata of the Utica shales at the type locality. The member is also palaeontologically correlated with the Billings Formation in the Ottawa Valley and with the Sheguiandah strata on Manitoulin Island. It is the lithological equivalent of the upper strata of the Billings Formation. Important fossils in this member include the following species:

Climacograptus rougensis
Triarthrus spinosus rougensis
Triarthrus spinosus narrawayi
Diplograptus cf. *foliaceus*
Cycloceras persculptum
Geisonoceras tenuistriatum
Triarthrus canadensis

To the writer's knowledge *Pseudogygites canadensis* has not been found within this member.

The upper member encloses a Blue Mountain fauna and is correlated palaeontologically with the Sheguiandah beds on Manitoulin Island, the Carlsbad Formation in the Ottawa Valley, and the Lorraine (Whetstone Gulf) of New York state. It is traceable lithologically from Lake Ontario to Manitoulin Island, but does not appear to have a lithological equivalent in the Ottawa Valley. Eighteen of the thirty-five species in the upper member start within the Blue Mountain fauna and range upward into the Dundas, whereas only six of the Collingwood fauna and eight of the Gloucester range upward into the Blue Mountain fauna. Thus the Blue Mountain fauna has a closer affiliation with the Dundas than with the Collingwood or Gloucester faunas. The upper member is not very fossiliferous, as the fossils are located in thin zones separated by much barren shale. The fauna includes the following species:

Mastigograptus tenuiramosus
Diplograptus cf. *vespertinus*
Pholidops cincinnatiensis
Cleidophorus planulatus
C. neglectus
Cryptolithus bellulus
C. tesselatus
Paleschara beani
'Dalmanella' fultonensis lorrainensis
Ctenodonta filistriata
Flexicalymeni meeki
Homotelus stegops
Triarthrus huguensis

Sedimentary Environment

The sediments of the Whitby Formation represent the shift and incursion of the shale lithosome that took place subsequent to the subaqueous erosional interval at the top of the Lindsay Formation. After that shallowing, but not complete recession, of the seas, the Appalachian source-area was rejuvenated and the basin and shelf areas underwent changes that permitted the widespread incursion of the resultant muddy sediments.

The lower member was probably deposited under reducing conditions in stagnant, non-aerated water. Most of the nautiloids and many of the trilobites collected from this member have been pyritized. Slow quiet sedimentation is postulated for the shales because of the abundance of trilobite limbs beside their respective thoraxes. The absence of ripple-marks and mud-cracks together with the fissile nature of the shale indicate moderate depth only. The processes involved were probably carried out in the zone of interfingering facies at reasonable depth, in view of the minimum amount of erosional material. Oscillating conditions would bring about the interbedding of the limestone and black shale under the necessary stagnant, reducing conditions. The lower member nevertheless was probably deposited in the same epicontinental sea and at the same depth as the underlying Trenton limestone.

The sediments of the middle member suggest a gradual shallowing of the epicontinental sea and a pause in sedimentation. They are indicative of slow sedimentation in quiet water and with clearing conditions, as the reducing conditions prevailing during the deposition of the lower member were no longer effective. These sediments thus represent transitional strata between the black shales of the lower member and the greyish blue shales of the upper member, as might be expected in an area of almost continuous sedimentation. The development of ripple-marks and the abundance of mud-cracked surfaces support the idea of marginal deposition and shallow seas. The presence of minor arenaceous shale bands is suggestive of the type of sedimentation that is represented by the rocks higher in the section (lower member of the Georgian Bay Formation). These broad shallow marine conditions were terminated by an hiatus of relatively short duration at which time the middle member was probably removed from what is now the Collingwood area. The distribution of this member may have been limited by erosion effected by positive movements of the Algonquin Arch over which it had been deposited.

For the upper member, shallow but clear water conditions may have existed. Quiescent conditions are indicated by the presence of disengaged limbs lying beside the thoraxes of trilobite remains. The soft, grey and blue shales of the upper member are transitional from the brown shales of the middle to the blue shales with carbonate hardbands that characterize the lower member of the Georgian Bay Formation.

Georgian Bay Formation

The terms Dundas and Meaford have long been used in central Ontario for Upper Ordovician units now interpreted as biostratigraphic units. Considerable conflict has arisen in the past as a result of attempts to use these terms for lithostratigraphic units (e.g., the separation of Dundas and Meaford strata on lithical grounds in the Toronto–Hamilton area, or the use of Meaford for a lithical unit on Manitoulin Island). The adoption of a lithostratigraphic term (Georgian Bay) resolves this conflict.

Definition

The name Georgian Bay is here proposed for the rock unit that overlies the bluish grey shales of the Whitby Formation and is in turn overlain by the red shales of the Queenston Formation. As defined, the formation consists of an alternation of grey carbonate beds and blue and grey shale, and represents the upper formation of the Nottawasaga Group in the Lake Simcoe district. The name has been chosen from Georgian Bay at whose southern end the strata of this unit are best exposed. The formation consists of a lower and an upper member. It comprises the combined strata of the biostratigraphic Dundas and Meaford units. However, the Dundas and Meaford units do not conform to the lower and upper members of the formation.

The type locality for the formation is on East Meaford Creek (Workman Creek), on the south shore of Nottawasaga Bay, in Georgian Bay. Reference sections in the Toronto area are at the following localities:

1. Humber River from Weston to Lake Ontario.
2. Mimico Creek from Islington to Highway No. 2.
3. Etobicoke Creek from Mount Charles to Lake Ontario.
4. Credit River near Erindale.

5. Don Valley brickyard.
6. Credit River at and near Streetsville.
7. Bronte Creek just above the C.N.R. railway bridge north of Oakville.
8. In a small creek near Meadowvale in lot 9, cons. I and II west, Toronto tp.
9. Along Etobicoke Creek throughout Cons. II and III, Toronto tp.

Localities 1 to 5 belong to the Dundas biostratigraphic unit; 6 to 9 belong to the Meaford biostratigraphic unit.

Distribution

The Georgian Bay Formation forms a belt varying in width from a fraction of a mile to more than 13 miles, which trends southwestward across the map-area from west of Meaford on Georgian Bay, to Toronto on Lake Ontario. The formation is well exposed in and near Toronto, which enabled Caley (1940) to subdivide it, but there are few exposures between Toronto and Georgian Bay, and subdivision is not possible. At the three localities in this district where the formation does outcrop, only the lower member has been recognized.

Near Lake Ontario, Georgian Bay strata are well exposed in the following places: on Humber and Credit Rivers, and on Mimico, Etobicoke, and Bronte Creeks, and in several quarries in the Toronto area. On Nottawasaga Bay, the formation is exposed on East Meaford Creek about 2 miles east of Meaford. The high steep banks along the bay between Boucher Point and Meaford are also formed by these strata.

Thickness

Only on Nottawasaga Bay can the thickness of the Georgian Bay Formation be measured directly. There, on East Meaford Creek, Caley (personal communication) measured 418 feet by plane table, which would embrace dip variations. The thickness of the formation southwest of Lake Simcoe cannot be determined directly, but is estimated to be about 580 feet. In the Toronto area it is not possible to measure the thickness directly because the surface truncates the formation. The base of the formation is not exposed, the lowest exposed strata being in the Don Valley brickyard, some 14 miles west of the Rouge River section where the base of the upper member of the Whitby Formation is exposed.

From data now available, the thickness of Parks' (1925) subdivisions of the Dundas and Meaford biostratigraphic units in the Toronto area are, in ascending order: Rosedale, 115 feet; Danforth, 104; Humber, 196; Credit, 50; Erindale, 65; Streetsville, 20; and Meadowvale, 30 (for details see Liberty, 1953h). The thickness of the Meaford strata remains fairly constant throughout the map-area (i.e., 108 feet near Meaford and 115 feet at Toronto), but the thickness of the Dundas strata increases southward from 310 feet near Meaford to about 465 feet at Toronto.

Lithology

The Georgian Bay Formation cannot be subdivided on a lithological basis into either the Dundas and Meaford biostratigraphic units or into the 'members' proposed by Parks (1925). The formation can be divided into two rock units, however, an upper member 30 to 50 feet thick, which has grey limestone as the dominant lithology, and the lower interbedded shale and carbonate member (Pl. XXVII). These two lithological members can be recognized also on Manitoulin Island, northwest of the present map-area.

In the Toronto area, Caley (1940) described the Rosedale and Danforth beds as " . . . bluish and grey soft shale with frequent thin hardbands"; the Humber as " . . . grey shale with both limestone and arenaceous layers throughout"; the Credit as " . . . shaly which becomes decidedly silty, greenish, and yellowish in colour with thin limestone layers"; the Erindale as " . . . chiefly shale but contains frequent limestone and calcareous sandstone beds throughout"; the Streetsville as " . . . about 20 feet of strata in which limestone bands are dominant though separated by relatively thin intervals of grey shale . . . contains a *Stromatocerium* reef, which averages about 3 feet in thickness"; and the Meadowvale as about 30 feet of ". . . clay shales with occasional argillaceous sandstones, as well as impure limestone bands throughout". The last unit also contains a biostromal reef, 2 to 5 feet thick, which lies at the base. On Nottawasaga Bay, Fritz (1926) recognized only the lowest three units and the Erindale, the Credit being replaced by the Christie, and the Streetsville and Meadowvale being occupied by the local Vincent. The *Columnaria* reef there lies in the base of the Queenston Formation.

The *lower member* consists essentially of bluish and grey shale with thin interbeds of sandstone, limestone, and dolomite. These interbeds generally are only a few inches thick and rarely more than a foot; they are not lensitic in character.

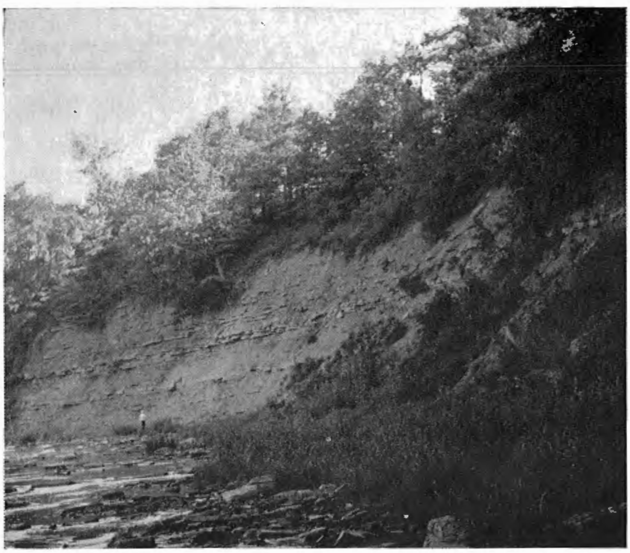

PLATE XXVII

Georgian Bay Formation, lower member; north of No. 26 highway, 2 miles east of Meaford, on East Meaford Creek.

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Stauft (1950) has indicated that many of the sandstones should be termed subgreywackes. The shale is commonly grey, bluish grey, and greenish grey, weathering buff and yellowish. An unbroken stratigraphic sequence near Nottawasaga Bay shows that the carbonate beds increase in number and thickness in the upper part of this lower member. In the subsurface the lower member appears as a thick section of grey shale, the presence of the hardbands being indicated solely by 'traces'. Strata in the upper part of this member appear as grey, bluish, and locally greenish shale with a much greater carbonate content, which is reflected by the increased number of hardbands. The lower member contains little bituminous material.

The *upper member* of the Georgian Bay Formation consists essentially of grey limestone, but does vary from calcarenite to crystalline limestone. Bedding thicknesses range from several inches to a foot and uppermost strata weather a rusty colour. Shale partings ranging from half an inch to 3 inches in thickness are common in the upper member and help to distinguish it from the lower. Two biostromal reefs 2 to 5 feet thick are present in the upper member, a *Columnaria* biostrome 30 feet below the top of the member and a *Stromatocerium* biostrome about 40 to 50 feet below the top of the formation (and member), in the Toronto area. In subsurface samples, the upper member appears as grey, fine-crystalline limestone with a small amount of shale. The upper part of the member is almost entirely limestone. Thickness of this member ranges from 30 to 50 feet.

Contacts

The writer has drawn the lower contact of the Georgian Bay Formation at the base of the lowest occurrence of grey, impure carbonate hardbands overlying the soft, bluish grey shale of the Whitby Formation. In the Georgian Bay area, the hardbands have been observed in outcrop many feet above the highest known deposit of the trilobite genus *Triarthrus*. In the Toronto area the contact is not exposed, but similar lithological phenomena appear in well cuttings and drill core.

The contact of the lower member with the overlying upper member is at the base of the main carbonate section of the latter. Of necessity this contact is an arbitrary one, the shale beds of the lower member having thinned to the status of shale partings rather than beds. The suggested limit is about 2½ to 3 inches and appeal is made to gross lithology.

The contact of the formation with the overlying Queenston Formation is transitional, the typical grey limestone (with shale partings) grading upward into red-mottled green shale and red arenaceous shale (and red limestone where present). Arbitrarily the red mottled beds are included in the Queenston Formation. Transitional strata are placed arbitrarily in the base of the Queenston Formation. Contact relations are well exposed in the creek at Derry West.

Stratigraphic Relations

The need for rock units in addition to the two time-rock (biostratigraphic) units (Dundas and Meaford) already in existence is borne out by the following two conditions: 1) the highest *Triarthrus* does not occur at the same stratigraphic level as the change in sedimentation (Whitby shales to the Georgian Bay (lower member) shales with carbonate hardbands); and 2) the dominance in carbonate sedimentation (in the upper member) does not conform with a faunal change. A redefinition of the two time-rock units would simply add to the present confusion of Ordovician terminology.

The term Georgian Bay Formation is intended to complement rather than replace the terms Dundas (Parks, 1925) and Meaford (Foerste, 1924). The Dundas is so similar lithologically to the Meaford that all investigators have had difficulty in separating the two on other than faunal grounds. Caley (1940) noted that Meaford strata became increasingly more calcareous some 20 feet above the lowest deposit of Richmond fossils. In well samples this criterion is not easily recognized and does not permit the demarcation of the contact between the Dundas and Meaford with either consistency or accuracy. For practical surface and subsurface investigations the strata form a single rock unit, here called the Georgian Bay Formation, both members of which are present in the Lake Simcoe district.

Reference should also be made to the units into which Parks subdivided the Dundas and Meaford (on faunal grounds) after detailed studies by himself, Fritz, Dyer, and Stewart. Later, Fritz (1926) recognized the lowest three on East Meaford Creek (Workman Creek), the stratigraphic position of the higher units there being occupied by local members. Parks ascribed member status to these units. They are here listed according to their areas, and their equivalency:

	Toronto Area	Meaford Area
Meaford	Meadowvale Streetsville Erindale	Vincent Erindale
Dundas	Credit Humber Danforth Rosedale	Christie Humber Danforth Rosedale

Because they are neither members in the modern sense, nor zones in the strict sense, the correction of which would require the elimination of familiar geographical names, the term 'units' is here proposed for these biostratigraphic entities in order that the usefulness of these terms may be continued and yet conform with modern stratigraphic nomenclature. If listed under their zone fossil they could be designated 'assemblage zone' (Hedberg, 1958).

Correlation and Fauna

The lower member of the Georgian Bay Formation is dated as Maysville–Richmond, for both Dundas and Meaford strata are included within its limits. The upper member is Richmond in age for its strata fall entirely within the Meaford time-rock unit. Lithologically the lower member may be correlated with the Wekwemikongsing beds of Manitoulin Island, the Bay de Noc Member of the

Stonington Formation in northern Michigan, and the Carlsbad of the Ottawa Valley. The upper member is traceable into the 'Meaford beds' and Kagawong strata also of Manitoulin Island, the Ogontz Member of the Stonington Formation in northern Michigan, and probably into the Russell Formation of the Ottawa Valley. The Georgian Bay Formation is thus the lithical equivalent of the Stonington Formation in northern Michigan. The lower member is very fossiliferous and includes:

Diplograptus foliaceus
Mastigograptus gracillimus
Hallopora onealli creditensis
H. dalei subalta
H. onealli danforthensis
Stigmatella lambtonensis
S. sessilis crassa
Leptotrypa expansa
Spatiopora varians
Rafinesquina alternata
R. mucronata torontonensis
Sowerbyella sericea
Zygospira modesta
Byssonychia radiata
Cymatonota lenior
Modiolopsis concentrica
M. ovata
M. valida
Psiloconcha sinuata borealis
Whiteavesia pholadiformis
Actinoceras crebriseptum
Isotelus maximus

The upper member of the Georgian Bay Formation is richly fossiliferous. Representative species include:

Stromatocerium huronense
Calapoecia cribriformis
Favistella ('Columnaria') alveolata
F. calicina
Streptelasma rusticum
Tetradium approximatum
Atactoporella densa
Bythopora meeki
B. vacua
B. similis
Homotrypa streetsvillensis
Homotrypella hospitalis
Catazyga headi
Hebertella occidentalis
Strophomena varsensis
S. planumbona erindalensis
Zygospira modesta
Byssonychia grandis
Ischyrodonta misneri
Pterinea demissa
Whiteavesia pholadiformis
Cyclonema bilix
Lophospira tropidophora
Orthoceras lamellosum
Spyroceras parksi

The Dundas biostratigraphic unit is correlated palaeontologically with the Carlsbad Formation of the Ottawa Valley and a part of the Wekwemikongsing beds of Manitoulin Island. The Meaford is correlated palaeontologically with the Meaford and a part of the Wekwemikongsing beds on Manitoulin Island and with the Russell Formation in the Ottawa Valley and St. Lawrence Lowland.

Sedimentary Environment

Deposition in water of moderately shallow depth is indicated by the abundance of life, and the absence of coarse clastic rocks within the Georgian Bay Formation. Similarly, ripple-marks, crinoids, nautiloids, and trilobites are indicative of only moderate depth. The limy hardbands are commonly richly fossiliferous and may well represent conditions specially conducive through temperature, pH, and salinity to the precipitation and deposition of lime, the included species being ecologically best suited to such conditions.

Deepening conditions and a facies shift of the lithosomes are postulated to account for the increasing dominance of limestone in the upper member. This member thickens northwestward to Manitoulin Island (Meaford and Kagawong beds). These phenomena are in direct contrast with the local shallow areas conducive to lime deposition in the lower member of the formation. As the upper member is very thin within the map-area, and as the Manitoulin dolomite (Silurian) overlies it on Manitoulin Island in contrast with the Queenston (Ordovician) Formation within the map-area, the writer considers this upper member to be but a southward extending tongue of carbonate into a dominantly shale lithosome.

Queenston Formation

Definition

The Queenston Formation, named by Grabau (1908), comprises the red shales overlying the grey limestone and interbedded bluish grey shale and grey limestone of the Georgian Bay Formation. The red shales in turn are overlain by either the sandstone of the Whirlpool Formation or dolomite of the Manitoulin Formation, depending on their geographical location. As so defined the Queenston Formation is a rock-unit. It overlies the marine strata of the Nottawasaga Group within the map-area and may be partly or wholly equivalent to the uppermost strata (Kagawong beds) of the group on Manitoulin Island. The name is taken from the town of Queenston, Ontario, on the Niagara River, where a part of the formation is exposed. The strata of the formation are known to be of Richmond (Ordovician) age, whereas the overlying formations are known to be of Silurian age.

Distribution

The Queenston Formation forms a belt 4 to 12 miles wide along the base of the Niagara Escarpment, from a few miles west of Meaford, on Nottawasaga Bay, southeast across the map-area to Campbellville, near Lake Ontario. As it does not outcrop within much of the map-area, its distribution on the accompanying geological map is 'traced in' from control outcrops in the adjoining area to the west. The formation is best exposed in the following places: along Credit River and its tributaries from Glen Williams to Huttonville, along Oakville Creek from below Drumquin to the Queen Elizabeth Highway; in the Terra Cotta, Brampton, and Milton Heights brickyards; on a small creek 5 miles south of Creemore; on a small creek on the south side of the road ascending the escarpment, 1½ miles west of Mair Mills, and on East Meaford Creek about a mile above No. 26 highway, east of Meaford. Well records indicate that the formation is present beneath younger formations southwest of its surface distribution.

Thickness

In outcrop the thickness of the Queenston Formation is difficult to ascertain owing to its non-resistance to erosion and the problems in finding complete sections, in finding the lowest red shale, and in estimating the dip where horizontal distances are great. The entire formation is nowhere exposed within the map-area. Well record data indicate the thickness to be 282 feet in the Flesherton well (town of Flesherton, Artemesia tp., Grey co.), and about 450 feet in Nassagaweya tp., Halton co.

Lithology

As seen in outcrop, the Queenston Formation consists of brick-red, micaceous and arenaceous shales, and clay shales, with little variation in character. The lowest few feet are often red-mottled green shale and locally contain greenish grey or reddish ripple-marked limestone and arenaceous and micaceous shales. Cross-bedding is fairly plentiful and fossils are generally absent. Near Meaford, a marine biostromal limestone is interbedded with the red shale and is believed to be a tongue from the Georgian Bay Formation's upper member, on Manitoulin Island. It consists of grey limestone and numerous fossil remains, in which corals, bryozoa, and brachiopods are especially important. This biostrome is probably the lower of the two found north of Owen Sound, west of the map-area.

In well cuttings, the formation appears as a uniform red shale with many sections of red-mottled green shale and a few sections, 10 to 20 feet thick, of green shale. The shale is both arenaceous and micaceous. In the Collingwood–Meaford area, traces of greenish grey and grey shale, and grey, fine-crystalline, fossiliferous limestone indicate the presence of the biostrome.

Contacts

The lower contact of the formation is generally a transitional one, grading through red-mottled green shale into the typical brick-red shale. Arbitrarily, the contact is defined at the base of the lowest red-mottled shale above grey limestone with grey shale partings of the Georgian Bay Formation. Near Meaford and westward the lowest biostrome of grey limestone is included in the base of the Queenston Formation (Liberty and Bolton, *in preparation*).

The upper contact of the formation (Pl. XXVIII) coincides with the boundary between the Ordovician and Silurian Systems. From Lake Ontario north to Duntroon this contact is drawn where the red shale is overlain by sandstone of the Whirlpool Formation. From a few miles west and northwest of Duntroon, however, the contact is drawn where the red and green shales of the Queenston Formation are overlain by buff-weathered grey dolomite of the Manitoulin Formation. These contacts are exposed at two places: on a creek just north of the road between lots 26 and 27, con. XI, Nottawasaga tp., Simcoe co., 2½ miles northwest of Duntroon; and on a small stream at Duncan in con. XII, Collingwood tp., Grey co. At both these localities the uppermost 6 to 24 inches of the Queenston Formation consist of soft, bluish grey shale. The undulating character of the contact, the abrupt change in lithology from shale to sandstone and shale to dolomite, and the Silurian fauna in the Manitoulin Formation suggest a stratigraphic break at the top of the Queenston Formation.

PLATE XXVIII

Contact between Queenston (Ordovician) and overlying Manitoulin (Silurian) Formations; east side of Owen Sound Bay, city of Owen Sound, Grey co.

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Correlation

The Queenston shales are generally barren of fossils, and within the map-area only Ulrich (1889) has reported fossils. T. E. Bolton (personal communication) has collected *Tetradium ontario* near Meaford. Where now the Queenston Formation rests visibly upon the underlying Georgian Bay Formation, Meaford species range upwards into the lowest 20 feet of the Queenston Formation. Near Collingwood, Foerste (1916) found a biostromal development in the lowest few feet of the Queenston Formation. Foerste found the fauna to include:

Bythopora delicatula	*Drepanella canadensis*
Zygospira meafordensis	*D.? striatomarginata*
Byssonichia radiata	*Leperditia caecigena*
Pterinea demissa	*Primitia lativia*
	Leperditella cf. *glabra*

This unit may well be one of the biostromes known in the Queenston Formation in the adjacent map-area to the west (Liberty and Bolton, *in preparation*). There, the biostromes contain a great many more species.

The combined faunal list places the age of the Queenston Formation as Richmondian. The formation shows a strong palaeontological correlation with the highest Whitewater and Saluda of southeastern Indiana. Grabau (1913 a and b) regarded the Queenston Formation to be contemporaneous with the Juniata sandstone of Pennsylvania and the extension of it. The formation is here correlated lithologically with the Juniata, and the Queenston of the Ottawa Valley, St. Lawrence Lowland, New York, and southern Michigan. It is the facies equivalent of the Kagawong beds of Manitoulin Island.

Sedimentary Environment

The Queenston sediments probably originated in the highlands of the Appalachian region as a result of erosional processes set up by the rejuvenation of that region at the beginning of the Saluda. The resulting sediments are commonly interpreted as deposits laid down in a 'deltaic' piedmont plain. The deltaic estuarine shale facies of the Queenston Formation in the map-area is equivalent to the Juniata sandstones in the central Appalachians nearer the source, and the marine, deeper water limestones and dolomites of the Kagawong beds with which it interfingers on the shelf towards Manitoulin Island.

Investigations indicate that the horizon at which the red colour of the Queenston Formation begins changes from place to place. A difference of 60 feet in the thickness of the red shale in less than half a mile occurs in Sarawak township north of Owen Sound, west of the present map-area. Of importance also, is the presence of sections of both green shale and red-mottled green shale at the base and at several levels within the formation. The red colour seems always to appear first above the base of the Meaford strata where it provides a useful reference line.

The uniform red colour, which makes the formation a distinctive lithological unit, is generally ascribed to certain climatic conditions that permitted extensive oxidation of the enclosed iron compounds while the sediments were undergoing transportation and deposition. Field evidence, however, suggests that the Queenston strata were deposited as shallow water sediments, generally unfossiliferous, green and grey, arenaceous marine shale whose iron content was subsequently oxidized. Into this sequence, biostromal reefs from the northwest (Kagawong beds on Manitoulin Island) intertongued and finally wedged out, owing to ecological conditions. The green shales were most probably oxidized as the sediments were being deposited, or shortly thereafter. The depth or shallowness of the oxidizing process would be entirely dependent upon cyclic oxidizing-reducing phenomena (Nagy, 1958). This idea would explain the variation in formational thickness, the presence of sections of red-mottled green shale and green shale, and the faunal correlations, which are otherwise quite confusing. Thus the writer recognizes that the red colour of the Queenston Formation starts at different stratigraphic levels, from place to place. The clastic content, the general unfossiliferous nature of the formation and the thicknesses concerned are interpreted as being indicative of the initiation of rejuvenation of the source area. The 'apparent' unfossiliferous nature of the formation was probably dictated by the ecological conditions. The finding by the late Dr. A. E. Wilson and the writer[1] of fossiliferous, marine, red shale in the Queenston Formation of the Ottawa Valley indicates that the formation should receive both careful scrutiny and collecting. Red shales need be neither non-marine nor unfossiliferous (as has been assumed for many years) and one cannot but wonder as to how carefully this formation was examined in the past[2].

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[1] Published since this manuscript was submitted for publication in Liberty, B. A.: Upper Ordovician stratigraphy of the Toronto area; *in* Guidebook, Geology of Central Ontario, *Amer. Assoc. Petrol. Geol.,* Toronto convention 1964, pp. 43–53.

[2] More recently the writer has collected fossils from the Queenston Formation in the Burlington area.

A time break at the top of the Ordovician section represents roughly the time at which last phases of the Taconic Revolution are presumed to have taken place in other areas. This minor break is indicated by the undulating character of the Ordovician–Silurian contact, the abrupt change in lithology from Queenston shales to sandstone and dolomite, and the incorporation of the underlying red shale into the basal few feet of the overlying formation, northwest of the map-area. Also, there is the thickness variation and 'local' development of the soft greenish or bluish clay shale at the top of the Queenston Formation at several localities in the Collingwood area.

Silurian

Silurian strata occur within the map-area, fringing the 80th degree west longitude parallel. They have been traced previously by Caley (1940, 1941), in the Toronto–Hamilton and Brantford areas, by Bolton (1957) in the Niagara Peninsula, and by Liberty and Bolton (*in press*) on the Bruce Peninsula, and are described at some length in each of these reports. Because of this and because the present report deals primarily with the Ordovician System, the Silurian rocks are described herein only very briefly. Formational names are those used by Liberty and Bolton in the Bruce Peninsula area.

The following six Silurian lithostratigraphic units are present along the western edge of the Lake Simcoe area: Whirlpool, Manitoulin, Cabot Head, Fossil Hill, Lockport and Amabel, and Guelph Formations. The Lockport and Amabel Formations form the main face of the Niagara Escarpment, the softer units below being more readily eroded and covered by talus. Well back from the escarpment face the Guelph Formation is present downdip.

The Whirlpool Formation consists of medium to light grey, fine- to medium-grained sandstone, commonly weathering buff into irregular and lensy beds from a few to 18 inches in thickness. Some beds have a mottled appearance because of iron oxide staining and ripple-marks are found at some outcrops. The most northerly outcrop known is at the falls in the village of Duncan, where at least 6 feet of the formation is exposed. The general lithological character of the sandstone appears quite similar to that at the type locality on the Niagara River. The formation thins northward. It is well exposed on the Nottawasaga tributary 36 miles south of Collingwood, and 2 miles east of No. 10 highway.

The Manitoulin Formation consists of grey, and bluish grey, fine-crystalline dolomitic limestone commonly weathering grey to buff and into thin irregular beds generally from 2 to 6 inches thick but some as much as 2 feet. The lower few feet may be argillaceous, and white-weathering chert in thin nodular layers or isolated nodules appears at some localities. Fossils are present though not numerous and seem to be most common along bedding surfaces. Thickness of the formation is about 40 feet. It can be seen on the Nottawasaga tributary with the Whirlpool Formation, and at Horning's Mills.

The Cabot Head Formation consists typically of red, green, and bluish grey shale and calcareous shale. It may be soft and plastic or firm and compact and with interbeds of grey and greenish grey impure limestone from half an inch to a few inches thick. The bedding surfaces of some of the thinner hard layers are characterized by a profusion of the bryozoan *Helopora fragilis*. Thickness of this formation is about 75 feet. It can be seen at the same two localities as the Manitoulin Formation.

The Fossil Hill Formation (Bolton, 1953, 1957) is the lower part of Williams' (1919) Lockport Formation. The beds containing *Pentamerus* are divided into an upper and lower unit by 6 to 8 feet of thin-bedded, brown, sublithographic to lithographic dolomite (an interbed), which may grade laterally into typical fossiliferous dolomite. These strata are moderately thin-bedded, grey weathering, brown, fine-crystalline dolomite. Where the fossils are absent the rock is closer to a tan colour and sublithographic. Chert nodules may also be present. Thickness of the Fossil Hill Formation is between 6 and 15 feet. The formation is exposed at the same two localities as the Manitoulin Formation.

The Lockport and Amabel Formations (Liberty and Bolton, *in preparation*) overlie the Fossil Hill Formation and form Bolton's (1953, 1957) Amabel Formation on the Niagara Escarpment. The Amabel may be subdivided into 3 lithical units: a lower member consisting of thin-bedded, light buff, fine-crystalline to lithographic dolomite, weathering grey; a middle member comprising massive, bluish grey to blue, fine-crystalline dolomite, weathering grey; and an upper member typically composed of thin-bedded, grey, dark grey, brown to black, cherty, very fine crystalline, petroliferous dolomite. The upper member is inter-reefal in character and may not always be present in the section, being replaced by biohermal equivalents. Whereas the Amabel and Guelph are lithical units and their mutual contact is time-transgressive, the upper member is arbitrarily assigned to the top of the Amabel. Thickness of the Lockport and Amabel Formations may exceed 150 feet. The Lockport and Amabel can be seen at Horning's Mills.

The Guelph Formation typically consists of buff and brown, fine- and medium-crystalline dolomite. Locally the colour may be grey, tan, or dark brown, and textures may include fine to medium granular, lithographic to sublithographic and fine- to coarse-crystalline ranges. The weathered surface appears irregular, very porous, and hummocky. The rock is vuggy and generally unfossiliferous. This formation is in reality a reefal complex in which biohermal units and their inter-reefal strata can be distinguished. A transition unit between typical reefal Amabel and typical reefal Guelph can be delimited readily and is arbitrarily assigned to the base of the Guelph Formation on the basis of gross lithology. The formation outcrops: (1) about 4½ miles northeast of Markdale on the banks of Saugeen River, and (2) west of the Wodehouse Creek tributary of Beaver River.

The Silurian and subjacent Palaeozoic strata within the map-area directly overlie the apex of the Algonquin Arch, which separates the Michigan Basin from the Appalachian Basin. The miogeosynclinal sediments of the northern

Appalachian Basin are continuous over this arch into the intracratonic Michigan Basin. In this arch area the Fossil Hill Formation is the extension of the Reynales, and the Amabel Formation is the extension of the Lockport Formation of the Niagara Peninsula. Sedimentary differentiation (within the formations) that might be due to the influence of the arch has not been found. Sedimentation is indicative of the stability of the arch area (within the map-area), and regional studies bespeak a late Niagaran dating for the inception of the Michigan Basin.

Chapter III

STRUCTURAL GEOLOGY

Regional and Local Structures

Much of the structure of the map-area is obscured by the veneer of glacial drift that covers the bedrock surface with material that varies from several feet to several hundreds of feet in thickness, as with the Simcoe Escarpment. There are few quarries to provide stratigraphic control, except within the outcrop belt that fringes the Precambrian Shield, and only a few wells have been drilled from which structural data are available. Furthermore, between Orillia and Barrie the bedrock surface is in the form of a subsurface terrace that keeps pace with the dip of the Ordovician formations. Accordingly the same unit remains the bedrock formation over a considerable area, and the glacial veneer becomes thicker as the terrace extends farther south.

The present attitudes on the Palaeozoic strata, relative to the Precambrian surface, are essentially those of their initial depositional dip; compactional processes by which the initial dip may have been steepened have played but a minor role. As can be seen on Figure 9, the Ordovician strata exhibit a gentle regional inclination to the southwest throughout the map-area. This dip varies from 20 to 30 feet to the mile, which is so low an attitude (about $2/9$ of a degree) that in individual exposures these strata appear flat lying.

Figure 1 (adapted from Roliff, 1954) portrays the surface on which the Ordovician strata were deposited and indicates the control for the presence of pre-Simcoe Group rocks. A. W. G. Wilson (1904, Pl. 10) would lead us to believe in the existence of a peneplain with many 'Precambrian' river courses trending southwestward across the surface. In corroboration of this idea there are low rolls and local broad reversals in the Ordovician strata that could only be due to Precambrian relief. Moreover, the results of joint pattern studies, variation in local strikes, and small three-point structural problems are quite sufficient to illustrate this idea.

Extending across the map-area in an east-west direction is the bedrock terrace previously referred to. The slope of this terrace does not keep pace with the dip, however, for the dip is considerably greater. This is indicated by the identity of the bedrock formations and by the width of the given formation with respect to its thickness. This area of structural steepening coincides with a line on which the Kawartha Lakes and Lake Simcoe lie, a line that is a striking feature

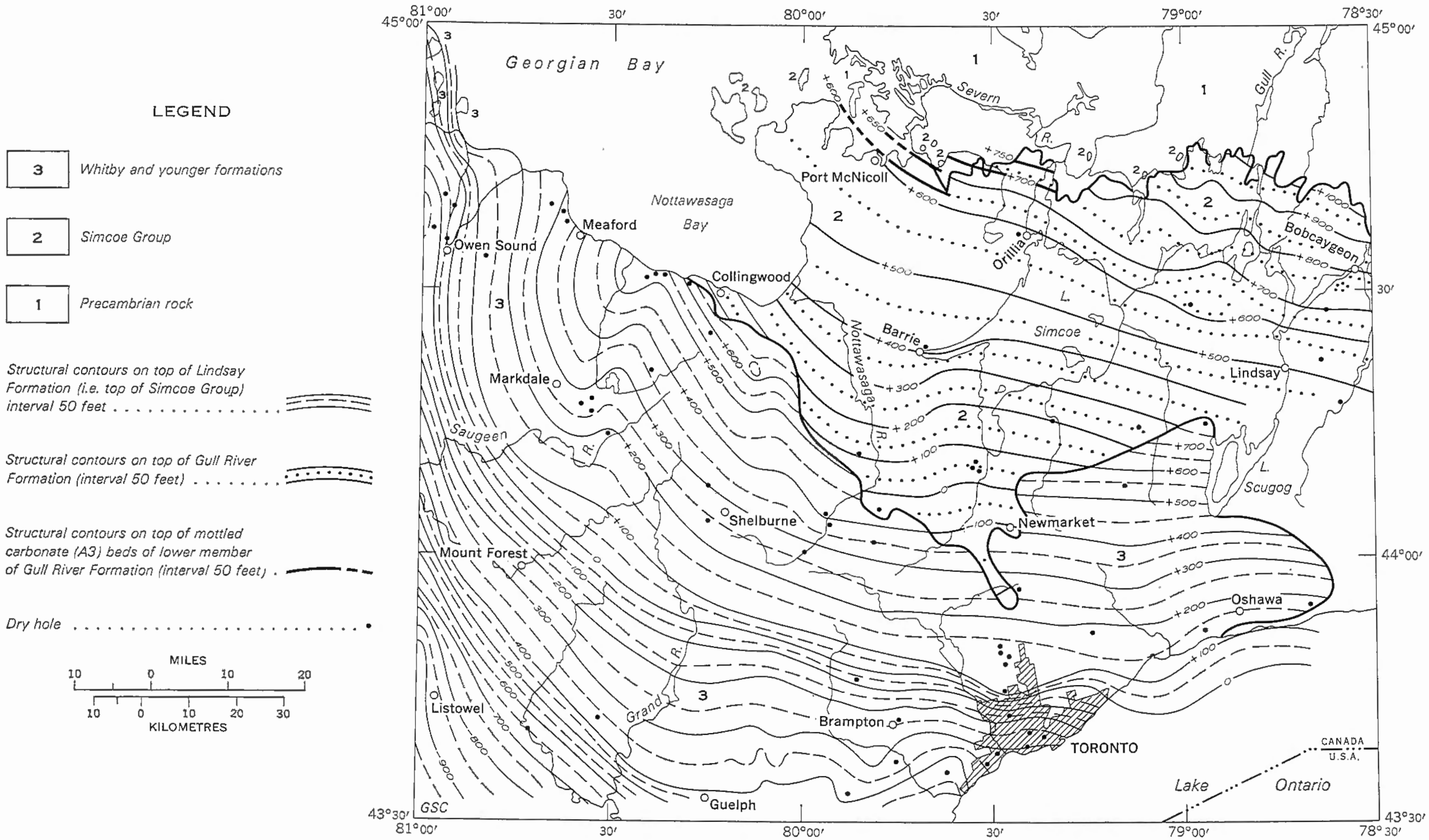

FIGURE 9. Structural contour map of the Lake Simcoe area.

(on a map of any scale) between Georgian Bay and the eastern end of Lake Ontario. Westward the line is traced into the long direction of Georgian Bay; eastward it is traceable into the Kawartha Lakes and the Bay of Quinte. The lakes lie transverse or slightly oblique to this lineament for which the term 'Kawartha Lineament' is proposed, half of which lies within the map-area. It is considered to be structurally controlled and traceable into a similar lineament across Manitoulin Island.

Dips higher than the regional dip are also found near the Ordovician–Precambrian contact. There, Black River strata flank hills and monadnocks on the Precambrian peneplain with evident truncation and related phenomena. Dips of as much as 15 degrees have been recorded on strata of the Gull River Formation and as high as 22 degrees within the Verulam Formation. The Verulam and underlying formations lie exposed upon the Precambrian monadnocks; elsewhere some domal physiographic features are suspected of having Precambrian cores with related high reliefs. The monadnocks have proven reliefs up to 350 feet and widths of as much as half a mile. On the flanks of the larger ones, the overlying bedrock formations smooth out the resultant depositional-compactional dips of the lower formations after having transgressed them.

Certain rock-unit contacts have proven more useful than others for structure contouring purposes, specifically the Whitby–Lindsay, Verulam–Bobcaygeon, and the Bobcaygeon–Gull River contacts. Figure 9 shows structural contours on the top of the Gull River Formation in that part of the map-area where Black River–Trenton rocks are present at the surface, and on the top of the Lindsay Formation in that part of the map-area where the Whitby Formation is at the surface.

Two broad structural arches cross the map-area towards the Ontario Dome (Grabau, 1920, p. 725): a heretofore unrecognized arch for which the name Peterborough is proposed, and the Algonquin Arch (an extension of the Cincinnati Arch), which is a prominent feature between Bruce Peninsula and Lake Simcoe northeastward to the Precambrian Shield (*see* Fig. 10). The Peterborough Arch is less pronounced and broader, and is known from detailed geological data only. West of the Peterborough Arch, the Simcoe Group thickens down dip in a basinwards direction; it also thickens east of the arch towards Lake Ontario. Also, this broad feature presently separates the Kingston embayment of Cambrian sediments from the Toronto re-entrant (Roliff, 1954, Fig. 3). Moreover the Peterborough Arch influenced sedimentation to a moderate degree in early Black River time. The following features illustrate in part the influence of this arch: the minor hiatuses during the deposition of the lower member of the Gull River Formation, and the local corrosion surfaces between the Gull River and Bobcaygeon Formations; the lithological changes within the Gull River's lower member from west to east; the indications of shallowing-water sedimentation phenomena, and presence of clastic limestone in the Bobcaygeon Formation; and the variation of shallow facies in the Lindsay Formation. The presence of this arch is also indicated by the 'nose' and outliers, east of Lake Simcoe, on the Palaeozoic-

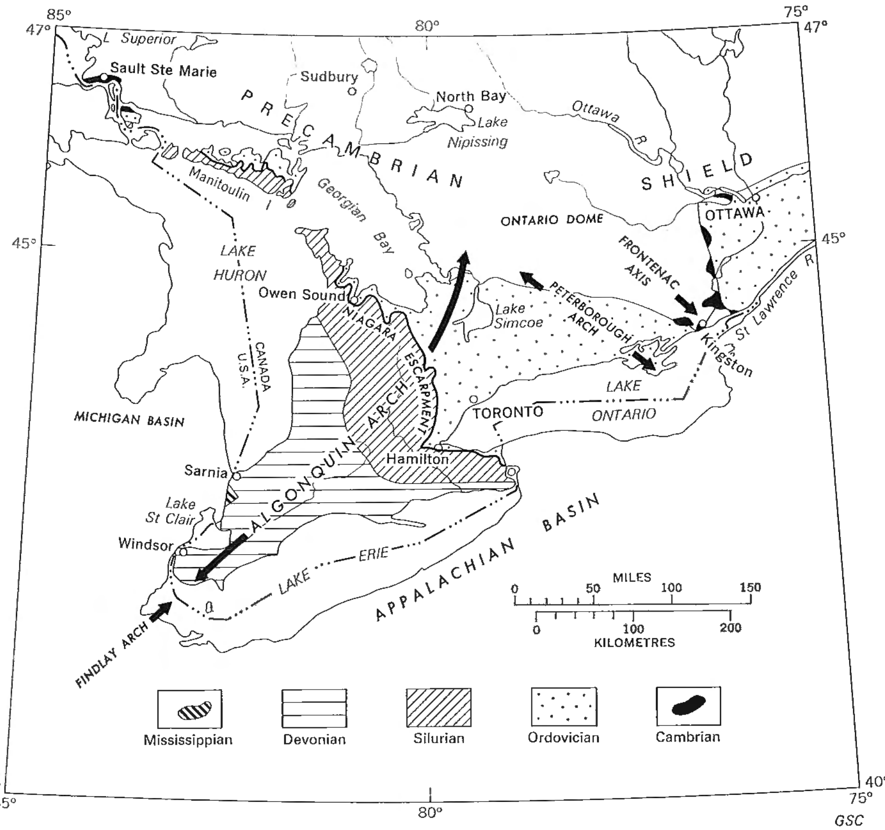

FIGURE 10. Structural elements of southern Ontario.

Precambrian boundary, and along the north shore of Lake Ontario by the broad bedrock belts for the individual formations. The areal configuration that is indicative of the Peterborough Arch is almost wholly within the Lake Simcoe area.

Details of the influence of the Algonquin Arch on sedimentation are not fully known yet. The topographic relief during the Ordovician Period was such that it did not influence thickening or thinning of formations. An isopachous map of the Simcoe Group would show little or no variation over the site of the Algonquin Arch (in Ordovician time). The Ordovician sediments were probably deposited over the arch and adopted the general structure and various attitudes dictated by the bedrock surface at that time. Nevertheless, the writer believes that this arch was in existence in Ordovician time (*see* inset on Fig. 1).

That the Algonquin Arch has varied in its degree of positiveness throughout Palaeozoic time is known from stratigraphic evidence in Upper Ordovician, Middle Silurian, and Middle Devonian strata. Nevertheless details indicate that the stratigraphic units over the arch incurred neither truncation nor thinning on the flanks, so gentle was the relief. Even today the steepest part of the arch is indicated by a 22-foot per mile apparent dip in the overlying formations.

Surface evidence for the existence of the Algonquin Arch is: 1) the northeastward extension of the Niagara Escarpment in the form of a 'nose' toward the Georgian Bay–Lake Simcoe sector; 2) the stratigraphy at the base of the escarpment: Queenston Formation from Niagara Falls to Orangeville; Whitby and Lindsay Formations in the Collingwood area; and Queenston Formation with full upward progression of the Silurian sequence to the Guelph Formation up the Bruce Peninsula at water level; and 3) the increased elevation of the crest of the Niagara Escarpment from 600 feet at St. Catharines to 1,700 feet in the Collingwood area, from which it decreases westwards to 700 feet along the Bruce Peninsula (all above sea-level). Dips between Collingwood and Hamilton are about 14½ feet per mile, the steepest (22½ feet per mile) being between Caledon and Georgetown. Apparent dip decreases to 5½ feet per mile south of Hamilton. On the other hand, northward from Collingwood the bedrock structure rises to Owen Sound at 25½ feet per mile, decreasing toward the top of the Bruce Peninsula at 10 feet per mile.

Several local structures are also known in the map-area. The K. Morrison No. 1 well (lot 12, con. V, Eldon tp., Victoria co.) and the W. Nelson No. 1 well (lot 29, con. VII, Gwillimbury East tp., York co.) were drilled to test potentially domal features, i.e., topographic highs, which were on bedrock highs. Other wells are located virtually in the outcrop belt 'close' to the Precambrian area and without the cover of the impermeable Whitby Formation shales. Within this outcrop belt are the following structural features: (1) the Orillia–Barrie bedrock terrace; (2) the Lindsay bedrock 'island' south of Barrie; (3) the bedrock and structural high 3 miles southwest of Bobcaygeon; (4) the small area of bedrock and structural highs in the southern part of Eldon tp.; and (5) Precambrian highs with their proven relief of as much as 200 feet and resultant draping of strata from their flanks.

In the Collingwood area where Whitby Formation shales act as cover there is the 'nose' of the Algonquin Arch and the irregular basement topography. On the other hand, in the Toronto area (*see* Fig. 4) the gentle monoclinal south-southwesterly slope is the main subsurface structure. Located on it are: the Milton Precambrian high, the crowding and spreading of the structural contours north of Toronto to form a small terrace; and the peculiar kinking of the same contours just east of the city.

Faults and Other Crustal Movements

A few faults occur within the map-area, but those so far recognized are small in both lateral and vertical extent. All lie east of Lake Simcoe in the 'outcrop belt' underlain by pre-Lindsay strata. Two types of faults have been recognized in the area: those that have produced moderate stratigraphic displacement, and those that show mainly on the surface as linears. In the first category are two faults, one half a mile west of Burnt River, south of the village of Burnt River, and the other about 3 miles northwest of Coboconk along the stratigraphic boundary between the Gull River and Bobcaygeon Formations. These faults have been recognized only as a result of detailed mapping and plane tabling. They are normal, probably high-angle faults with displacements of 15 to 20 feet. The second type of fault is marked only by a small straight or slightly curved linear with a topographic relief of about 5 feet and lateral extent of one-quarter to half a mile. Trenching into such features generally reveals little information; slabs on the flanks appear to dip in opposite directions. Their shape probably resulted from the hanging-wall being 'held up' in a low, concave upward bow by the footwall, soil subsequently smoothing over the small dragfold on the hanging-wall. Although their throw may vary from a few inches to 6 feet or more, there is generally little visible evidence of their lateral extent. West of the Kirkfield quarry, however, faulted strata are warped into a low fold (Pls. XXIX and XXX), whose physiographic expression can be traced for more than half a mile.

All observed faults of the second type are normal and of small displacement. They are readily recognized both on the ground, and on air photos, as linears. The

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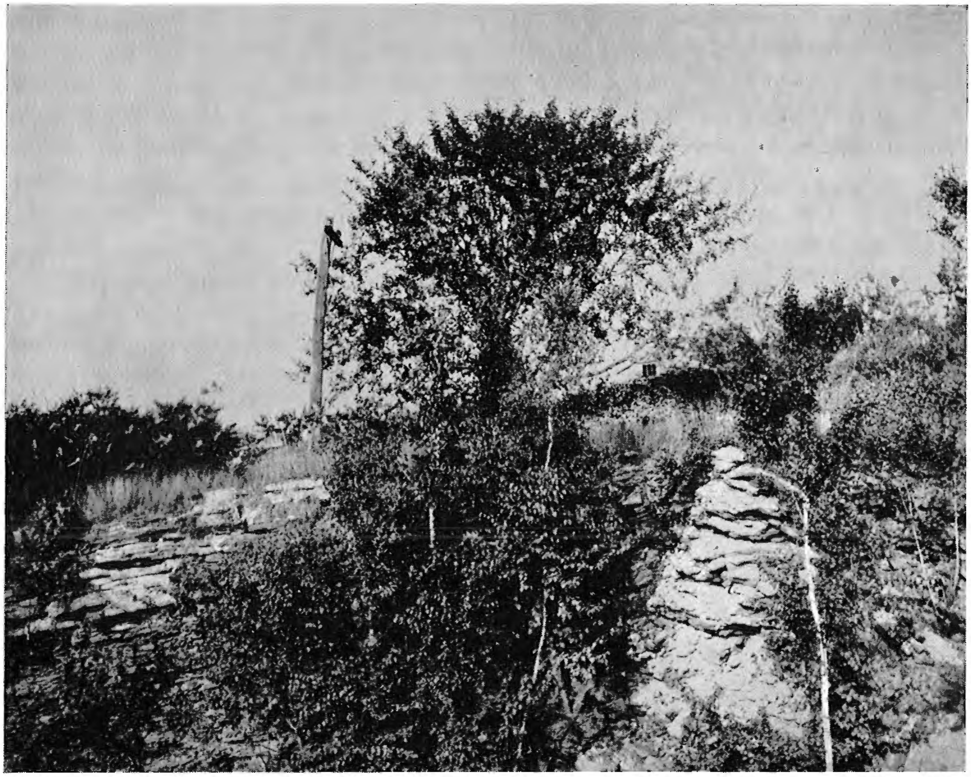
PLATE XXIX. Minor fold, related to a fault, upper member of Bobcaygeon Formation and lower member of Verulam Formation; Kirkfield quarry, 7 miles northeast of Kirkfield.



J. F. Caley 3-5-47

PLATE XXX. Minor fault in east side of Trent Valley Canal in upper member of Bobcaygeon Formation; immediately west of Kirkfield quarry, 7 miles northeast of Kirkfield.

process of formation of these fault linears may be gleaned from the operational history of any large quarry in which a considerable face has been worked. Structural rolls appear in the floor of the quarry and documented fractures actually took place in 1951 at Marmora, Ontario. The second type of faults, then, are considered to have resulted from vertical release following the retreat of the continental ice-sheet, i.e., the removal of the vast weight of the ice, for the linears have not been destroyed by glacial abrasion.

Positive movement of the land area north of Lake Ontario, with the resultant drowning of both the southern and southwestern shores of this lake, was hinted at by Moore (1948) to be due to crustal warping. On the other hand, some Pleistocene geologists have attributed the movement to areal rebound after the removal of the ice. Whatever the cause, the net product is the same. There has been positive movement of about 20 feet to the mile in a northwesterly direction, i.e., the glacial lake beaches dip southwesterly (Deane, 1950). The Palaeozoic strata also dip southwesterly at about 20 feet to the mile both regionally and locally (except in the outcrop belt of the individual member where the Precambrian surface expression may cause initial dips of as much as several degrees). The logical inference from these two facts is that the Palaeozoic strata were previously nearly horizontal over a wide area. Thus the timing for the final migration of the enclosed fluids (aqueous and/or petroleum) must be dated as late Pleistocene and Recent. However, it is not reasonable to assume that the Palaeozoic strata were deposited 'almost horizontally' or that they were always 'almost horizontal' in the interval between time of deposition and the Pleistocene. This is but one of the problems the writer is currently investigating in connection with petroleum possibilities in the Palaeozoic strata in southern Ontario.

Unconformities

Seven disconformities have been recognized within the stratigraphic succession in the map-area. Perhaps the most important unconformity is the disconformity separating the Lindsay and Whitby Formations. This disconformity is most pronounced on Manitoulin Island, but evidence for it can also be observed at Craigleith on Nottawasaga Bay, and in the Bowmanville quarry on Lake Ontario, where a conglomerate of water-worn bryozoans has been observed below the rotten, brown shales at the base of the Whitby Formation. Also at Craigleith, blocks of the underlying Lindsay limestone can be seen in the overlying Whitby shale, as relief on the disconformable surface is in the order of a foot. The porous dolomite in the top of the Lindsay Formation is considered to be recrystallized clastic dolomite formed on the flank of the Algonquin Arch. Similar conditions are known on Manitoulin Island.

Of equal importance to the disconformity mentioned last, is the one between the Cambrian and Ordovician rocks, which is probably present in the northwestern part of the map-area, where 'Jacobsville' strata have been logged in the Flesherton and Sarawak wells. The stratigraphic relations can best be appreciated by referring to Figure 1 with respect to wedge-out conditions. The duration of the hiatus between the two systems is indicated only by: 1) the time between deposition of the youngest Cambrian rocks (Eau Claire, 'Dresbach' Formations) and that of the oldest Ordovician rocks (Shadow Lake Formation); and 2) the present geographical distribution of the Cambrian formations on the flank of the Algonquin Arch, as compared with their probable original distribution. That the arch was moderately positive and became less so is indicated by the progressive overlap of the Cambrian formations. The distribution of these formations is fairly restricted. Subsequent movement is probably indicated by the presence of oil and gas shows in well locations high on the flanks.

No break resembling a Black River–Trenton stratigraphic break occurs within the map-area. There are, however, erosional products in the C_2 submember of the Bobcaygeon Formation, which may be explained by local shallowing of the Middle Ordovician seas over the Peterborough Arch, for there appears to have been continuous sedimentation from Black River to Trenton time. This time boundary is arbitrarily fixed within the lower submember of the Bobcaygeon Formation's lower member. The C_2 submember comprises fine to coarse calcarenites, fragmental fossiliferous limestone, and limestone conglomerate from the Gull River Formation. This unit is consistently present in the eastern part of the map-area. It is also present west of Lake Simcoe (A. Breedon No. 1 well, in lot 21, con. III, Adjala tp., Simcoe co.).

An erosional break is present between the lower and upper members of the Whitby Formation in the Nottawasaga Bay area, where the middle member is absent. This break lies within a shale sequence, however, and the thickness of the lower member shows considerable variation. This relationship may indicate the position of the Algonquin Arch near the beginning of the Late Ordovician Epoch, the position being the most logical one for shallowing and cutting out of the middle member of the Whitby Formation.

Of equal importance is the erosional break at the top of the Ordovician System, for it separates marine shales of the Queenston Formation from the good reservoir sandstone of the overlying Silurian Whirlpool Formation. This sandstone is a gas-producing unit in the Niagara Peninsula and may have derived its gas from the underlying Ordovician rocks.

Finally, minor diastems are recognized at the following stratigraphic levels: 1) within the lower member of the Gull River Formation in the A_3 submember (Pl. VIII); 2) between the Gull River and Bobcaygeon Formations; and 3) in the lowermost strata of the Lindsay Formation. These stratigraphic breaks are probably of local importance only and related to the Peterborough Arch.

Chapter IV

ECONOMIC GEOLOGY

As the mineral deposits of the Precambrian areas within the map-area have been adequately discussed by Satterly (1943 a, b), the following account refers only to mineral deposits and possibilities in the Palaeozoic and younger sediments. The apparent lack of economic minerals in the Lake Simcoe district has been a constant source of amazement to scientific writers. Materials which elsewhere in Ontario are of economic interest, such as quartz sand, salt, anhydrite, gypsum, and refractory shales in clays, are virtually non-existent within the map-area. Commercially interesting Upper Ordovician shales in the Toronto region have been described by Caley (1940) and similar shales are described in a report on the Bruce Peninsula (Liberty and Bolton, *in preparation*).

Accordingly the following discussion deals mainly with limestones of the Simcoe Group and the Whitby Formation. Table V shows analyses (Goudge, 1938) that are representative values for the various limestone units within these formations. Unfortunately there are no analyses for the B_1 and F_2 submembers. Table VI lists representative sections, road-cuts, and quarries where these various units can be seen, together with the formational units exposed in each section. Probable analysis for samples of each unit in these sections can be found in Table V. The section numbers in Table V are similar to those used in Appendix I.

Limestone Products

Some notes on specific limestone-bearing units within the Simcoe Group follow. Unit letters and numbers (e.g., A_1, A_3, etc.) are those shown in Table I.

Submember A_1, lower member, Gull River Formation (analysis No. 27, Table V). The analysis of this magnesian limestone is not considered typical because of the high clastic quartz content at this particular locality. Analysis No. 28 is considered atypical for the same reason. The normal A_1 facies 'tightens up' to a sublithographic texture eastward to Burnt River from Coboconk and westward to Waubaushene from Orillia and Coldwater. Both analyses (Nos. 27 and 28) came from these marginal regions. A typical specimen of A_1 probably would analyze close to A_4, although it would show a higher silica content. Pyrite and marcasite nodules and gypsum are included in this unit.

Submember A_2, lower member, Gull River Formation (analysis No. 26, Table V). The appearance of this unit is much like that of unit B_2 (lithographic limestone), but the analysis shows the Mg content to be high. Marcasite and pyrite nodules are common.

Submember A_3, lower member, Gull River Formation (analyses Nos. 24 and 25, Table V). The rock comprises an upper digitately mottled dolomitic limestone. Accordingly the magnesium content depends on lateral variations. Eastward from Lake Simcoe only the upper unit is present; it thins to a thickness of a foot and finally disappears. Near Coldwater the silica content is higher because of the presence of chert nodules. A form of glauconite is also present in these beds.

Submember A_4, lower member, Gull River Formation (analyses Nos. 19 to 23, Table V). To these strata belong the 'Rama buff' and 'Rama grey' building stone of central Ontario. The rock is mainly a buff to greenish grey, fine-grained dolomitic limestone. The uniformity of texture and ease with which it was worked were offset by its tendency to weather yellow, which proved an undesirable characteristic for users of this stone.

Submember B_1, middle member, Gull River Formation (no analysis). This unit is rarely seen in outcrop as it is generally covered by talus at the base of escarpments. It looks like shale, but is actually a thinly laminated lithographic limestone with thin argillaceous partings.

Submember B_2, middle member, Gull River Formation (analyses Nos. 12 to 17, Table V). These analyses possibly may include some B_1 samples. This unit comprises essentially the lithographic limestone section of the Black River strata. It includes the 'Longford stone', which was popular as a building stone in the Lake Simcoe district many years ago. This stone has fallen into disfavour as a commercial stone owing mainly to the difficulty with which it was worked (too hard and too brittle). In addition, its texture is not uniform because of irregular distribution of 'calcite eyes' (particles of crystalline calcite) in it. This unit is the high calcium, lithographic limestone of the Black River. Actually the CaO:MgO ratio is lower than that for the C unit, which is used near Coboconk (*see* Bobcaygeon Formation, lower member). Values for the calcium–magnesium ratio seem to be irregular in the B_2 unit. The values given in Table IV under the notation 'B' should suffice to evaluate the B_2 submember, for the samples were probably obtained from the B_2 part of the section. Goudge (1938) noted that this rock powders readily when it is calcined, a desirable characteristic in the limestone industry.

Submember B_3, upper member, Gull River Formation (Moore Hill beds of Okulitch, 1939) (analysis No. 11, Table V). This unit is a high-calcium limestone and has been used in the Coboconk area by Canada Lime Co. Ltd., and Toronto Brick Co. Ltd.

Submember C_1, lower member, Bobcaygeon Formation (analyses Nos. 9 and 10, Table V). The fine-grained, argillaceous limestone of the submember has a

Locality		Formation		Gougde Analysis No	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio CaO : MgO
No	Name		Unit												
	Craigleith Q	Whitby	L mbr	255	18.26	1.76	6.10	0.59	64.62	4.37	95.70	0.45	36.51	2.09	17:1
29	Collingwood	Lindsay	hi G	1	6.06	1.08	2.42	0.24	86.05	3.15	99.00	0.08	48.32	1.51	32:1
30	Collingwood	″	hi G	2	6.10	0.55	2.67	0.13	85.87	3.57	98.89	0.10	48.16	1.71	28:1
53	Lindsay	″	lo G	18	4.98	0.53	0.35	N.D.	91.69	2.26	99.81	0.18	51.40	1.08	48:1
	Beaverton	″	lo G	11	2.18	0.91	0.65	0.11	94.63	1.55	100.03	0.10	53.05	0.74	72:1
44	Gamebridge	Verulam	lo F1	10	5.70	0.59	1.13	0.13	91.36	1.93	100.84	0.11	51.23	0.92	56:1
10	Kirkfield Q	Bobcaygeon	E	12A	4.72	0.46	1.11	0.20	90.59	1.47	98.55	0.22	50.84	0.70	73:1
41	Millington	″	D	9	4.10	0.40	0.60	0.11	91.78	2.19	99.18	0.10	51.46	1.05	49:1
48	Coboconk	″	hi C1	13	1.38	0.31	0.51	0.02	96.55	0.76	99.53	0.03	54.08	0.36	150:1
48	Coboconk	″	C	13A	1.20	0.29	0.57	0.07	96.70	0.69	99.52	0.08	54.19	0.33	164:1
48	Coboconk	Gull River	B3	13B	1.54	0.33	0.55	0.04	95.61	0.74	98.81	0.02	53.56	0.35	153:1
39	Longford	″	B1 B2	8A	2.62	1.03	0.30	0.02	92.19	2.44	98.60	0.06	51.59	1.16	44:1
39	Port McNicoll	″	B	8	1.42	0.40	0.96	0.02	96.64	0.32	99.76	0.04	54.13	0.15	361:1
32	Uhthoff	″	B	3	1.82	0.38	0.86	0.11	95.88	0.55	99.60	0.04	53.75	0.26	207:1
35	Medonte	″	B	7	1.32	0.23	0.33	0.02	96.63	1.41	99.94	0.07	54.12	0.67	81:1
33	Longford	″	B	5	1.80	0.20	0.52	0.04	95.80	1.33	99.69	Tr	53.69	0.64	84:1
33	Port McNicoll	″	B	5A	1.56	0.38	0.54	0.02	96.98	1.07	100.55	Tr	54.32	0.51	106:1
39	Longford	″	A4	8B	2.82	1.01	0.67	0.02	60.19	34.50	99.21	0.01	33.72	16.51	2:1
39	Longford	″	A4	8G	3.48	1.03	1.95	N.D.	62.20	31.80	100.46	0.07	34.88	15.21	2.2:1
32	Port McNicoll	″	A4	3A	23.04	2.12	1.54	0.15	48.36	24.89	100.10	0.24	27.16	11.90	2:1
32	Port McNicoll	″	A4	3B	3.24	1.07	0.63	0.04	67.50	26.67	99.15	0.06	37.82	12.75	3:1
33	Medonte	″	A4	5B	6.04	0.96	2.42	0.04	59.46	30.02	98.94	0.18	33.32	14.35	2.3:1
33	Medonte	″	A4	5C	3.88	0.50	1.72	0.07	65.73	27.59	99.49	0.06	36.85	13.19	2.8:1
32	Port McNicoll	″	A3	3C	3.44	1.00	1.04	0.04	75.23	19.05	99.80	0.08	42.15	9.11	5:1
33	Medonte	″	A3	5D	1.58	0.19	0.33	0.02	92.20	5.00	99.32	Tr	51.64	2.39	22:1
50	Burnt River	″	A2	16	2.36	0.71	1.09	0.07	89.18	6.29	99.70	0.02	49.98	3.01	17:1
50	Burnt River	″	A1	16A	14.70	2.21	2.27	0.13	51.35	28.67	99.33	0.05	28.83	13.71	2:1
84	Waubaushene	″	A1	4	1.28	0.33	0.31	0.02	95.09	2.98	100.01	Tr	53.26	1.43	37:1

Analyses data from M.F. Goudge (1938)

Quarry . . . . Q *High* . . . . hi *Low* . . . . lo *GSC*

Table V. Chemical analyses for stratigraphic units.

Localities		Section number	Whitby, (lower member)	Lindsay	Verulam		Bobcaygeon			Gull River		Shadow Lake
				G	F2	F1	E	D	C	B	A	
Craigleith west	Simcoe, Collingwood, 25, IV	23	—									
Collingwood west	Simcoe, Nottawasaga, 48, XI	29		—								
Collingwood	Simcoe, Nottawasaga, 43, VIII	30		—								
Batteaux River quarry	Simcoe, Nottawasaga, 40, VI	31		—								
Port McNicoll quarry	Simcoe, Tay, 19, V	32								—	—	—
Coldwater, Medonte quarry	Simcoe, Medonte, 19-20, XIII	33							—	—	—	
Coldwater quarry, abandoned	Simcoe, Medonte, 21, XIV	34									—	
Uhthoff quarries (2)	Simcoe, Orillia, 10, IV	35							—	—		
Hampshire Mills quarry	Simcoe, Orillia, 12, VII	36							—	—		
Grass Lake quarry	Simcoe, Orillia, 17, XII	37									—	
Lake St. George quarries (2)	Simcoe, Orillia, 8-9, XII	38									—	
Longford quarries (2)	Ontario, Rama, Indian Reserve	39							—	—	—	
Uptergrove quarry	Ontario, Mara, 19, X	40					—					
Millington quarry	Ontario, Mara, 14, VIII	41					—					
Udney quarry	Ontario, Mara, 6, IX	42							—	—		
Brechin, east quarry	Ontario, Mara, 4, IV	43					—					
Gamebridge quarry	Ontario, Thorah, 13, XI	44				—						
Seabright quarry	Ontario, Rama, 16, A	45							—	—		
Kirkfield quarry	Victoria, Eldon, 31-32, IX	10				—	—	—				
Corson quarry	Victoria, Bexley, 4, IV	46					—					
Norland, south quarry	Victoria, Laxton, 1, XI	47									—	
Coboconk quarries (2)	Victoria, Somerville, 37, Front	48							—	—		
Dongola quarry	Victoria, Somerville, 13, XII	49									—	
Burnt River, west quarry (Britnell)	Victoria, Somerville, 14, VI	50									—	
Fell quarry	Victoria, Somerville, 17, III	51							—	—		
Burnt River, south quarry	Victoria, Somerville, 13, IV	52							—	—		
Little Bob quarry, Bobcaygeon	Peterborough, Harvey, 13, XIX	9						—	—			
Cobourg Hill No. 1		21		—	—							
Pleasant Point Cobourg Hill		22		—								
Lindsay north road-cut		53		—								
Downeyville north road-cut		54		—								
Eldon Hill No. 5, spring		15		—	—							
Zion south section, S7		18		—	—							
Cobourg Hill No. 1, west railway, S3		13		—								
Zion north section		55		—	—							
Eldon Hill No. 3, road-cut, S5		16		—	—							
Cobourg twin hill, barn section		56		—								
Cobourg Hill No. 1, railway section, S6		17		—								
Sturgeon Heights, cottage section, S1		11				—						
Sturgeon Heights, culvert section, S2		12				—						
Balsover section		57				—						
Cedar Glen		19				—						

Localities	Section number	Whitby, (lower member)	Lindsay	Verulam		Bobcaygeon			Gull River		Shadow Lake
			G	F_2	F_1	E	D	C	B	A	
Ancona Beach	20				—						
Gambridge railway-cut	58				—						
Fell, south hill	59				—						
Fenelon Falls section	60				—	—					
Spring section, south of Head Lake	61						—				
Victoria Road section	62						—	—			
Silver Lake road-cut	8							—			
Dalrymple south, 2.5 m south of Dalrymple	63					—	—	—	—		
Bobcaygeon, north road-cut	64								—		
Head Lake, east hill	65							—	—	—	
Escarpment section, 3.5 m. north of Coboconk	66								—		
Escarpment creek section, Simcoe, Orillia, 9-10, II	67						—	—	—		
Coboconk, south road-cut	68								—		
Moore Hill road-cut, north of Coboconk	69								—		
Hill No. 1 Laxton-Bexley Tp. road	70								—		
Dongola flat section	71								—		
Burnt River, south road-cut	72								—		
Burnt River, west road-cut	73							—	—	—	
Little Bob bridge, highway section	74						—	—			
Oak Lake, spring section	75									—	
Outlier, 2 m. south of Coopers Falls	76									—	
Foxmead section pit	77									—	
Shore section, northwest corner Lake St. John	78									—	
Oak Lake, south road-cut	79								—	—	
Fesserton, east road-cut	80									—	
Dongola, west road-cut	81									—	—
Schoolhouse section, Beech Lake	82									—	—
Shadow Lake road-cut 4 m. north of Coboconk	83									—	—
Waubaushene shore section	84										—

Localities		Section number	Queenston	Georgian Bay	Whitby		
					Upper member	Middle member	Lower member
East Meaford Creek	2 m. east of Meaford	28	—	—			
Rouge River	1 m. north of junction Rouge Cr.	27			—	—	
Lynde Creek	1.4 m. north of Whitby	26				—	
Oshawa Creek	Mill St, Oshawa	25					—
Craigleith station		24					—

GSC

Table VI. Stratigraphic units in roadcuts, quarries and other exposures.

higher CaO:MgO ratio than the lithographic stone of the B_2 submember, although its highest value is lower than the highest value for the B_2. The C_1 submember stone is used as high calcium limestone in the Coboconk east (arena) quarry by Cobo Minerals Ltd. Silica content increases pronouncedly in the uppermost few feet because of chert nodules.

Submember C_2, lower member, Bobcaygeon Formation (no analysis). Siliceous content is high because of silicified fossils and chert nodules. Its analysis should not be too different from the values for the C_1 submember. Insoluble residue studies indicate a relatively high argillaceous content.

Member D, middle member, Bobcaygeon Formation (analysis No. 8, Table V). This is a rather hard, massive, very fine grained to sublithographic limestone. The stone is generally even bedded and even textured, and contains some chert nodules.

Member E, upper member, Bobcaygeon Formation (analysis No. 7, Table V). This unit is exposed in its entirety in the Kirkfield quarry between 2 and 36 feet above the quarry floor (1950). Above the massive sublithographic limestone (between 25 and 26 feet) lies the light blue stone that makes the crushed Kirkfield quarry stone so distinctive. The stone of unit E is used as asphalt filler and road metal.

Member F_1, Verulam Formation (analysis No. 6, Table V). This analysis is representative of the lowest few feet of the unit only. Most of the member consists of an alternation of limestone and shale. The limestone varies in texture from fine grained to medium crystalline, and from bioclastic to lithographic. The shale is olive-green to grey and is plastic.

Member F_2, upper member, Verulam Formation (no analysis available). This unit is fine- to medium-crystalline bioclastic limestone and displays cross-bedding on some exposures. Bedding is massive and the rock appears very hard and resistant.

Unit G, Lindsay Formation (analyses Nos. 2 to 5, Table V). This formation comprises at least four separate units. Analyses 2 and 3 are from the G_4, a generally uppermost unit; analysis No. 4 is from the G_2 unit; and analysis No. 5 is from the lowest unit, G_1. A G_5 unit consisting of a pure porous dolomite is locally present at the top of the formation in the Collingwood area, in subsurface. It is not known to be exposed within the map-area.

Analysis No. 1 in Table V is from the lower member of the Whitby Formation, an essentially fissile, black, petroliferous shale. This shale is highly calcareous, and in subsurface cores some of it may be more correctly termed a black limestone.

District Activities

In the past, limestone of the Simcoe Group has been used for various purposes, including high-calcium limestone, crushed stone, building stone, lime, asphalt filler, and agricultural limestone. In 1955, when the writer completed field work in the area, there were only three quarries in operation, the Uhthoff, Kirkfield, and Coboconk. The Uhthoff quarry (operated by Limestone Products Ltd.) is about 6½ miles north of Orillia. There, the high calcium beds of the B_2 and B_3 submembers (Table VI) of the middle and upper members of the Gull River Formation provide chemical limestone and crushed stone. The Kirkfield quarry is about 12 miles northeast of Beaverton and 18 miles northwest of Lindsay and includes highest D, E, and low F strata (middle and upper members of the Bobcaygeon and Verulam Formations, respectively). This quarry produces crushed stone, agricultural limestone, and asphalt filler. It is operated by the Kirkfield Crushed Stone Ltd.[1] The Coboconk east quarry is presently being worked by Cobo Minerals Ltd.[2] There, the C_1 submember of the lower member, Bobcaygeon Formation, is worked for the production of lime. The C_1 is a high-calcium limestone.

In the past, quarries were numerous and widespread throughout the map-area. The more important of these with pertinent details are listed in Table VII. Some of these quarries are no longer being operated. The companies listed in Table VII are those noted in Goudge (1938).

TABLE VII | *Quarry Products*

Location	Company (location, etc.)	Units (from Figure 2)	Product
Coboconk	Canada Lime Co. Ltd.	B_3,C_1	High-calcium limestone
Longford	Longford Quarries Ltd.	A_4,B_1,B_2	Building stone
Burnt River	Somerville tp. 13, VI	A_1,A_2	Crushed and building stone
Burnt River	Somerville tp. 12, IV	B_2,B_3,C_1	Crushed and building stone
Burnt River	Somerville tp. 17, III	B_2,B_3,C_1	Crushed and building stone
Medonte	Coldwater Crushed Stone Ltd.	B_2,B_3	Flux and crushed stone
Pt. McNicoll	Canada Iron Furnace Co.	A_3,A_4,B_1,B_2	Flux

The stratigraphy of the remaining quarries is shown in Table VI. Most of these were worked for crushed stone for local use.

Sand and Gravel

Gravel pits are numerous owing to the mantle of glacial drift over most of the map-area. All were inactive in 1955. Large pits are located near Orillia and Barrie, near Cameron Lake at Fenelon Falls, and in lots 14 and 15, Clarke tp., on

[1] Operations were closed down in 1963.
[2] Operations were closed down in 1964.

No. 2 highway, near Morrish. In most areas, gravel is readily available for road metal, which accounts for the large number of small pits. Indeed for construction purposes, pits can be opened almost any place within the outcrop belt of the Bobcaygeon, Verulam, and Lindsay Formations. The economic importance of the sand and gravel deposits is limited to local construction projects and depends on the type of material at each location. Most of the pits are located in drumlins and ground moraine; pits near Cameron Lake are in esker deposits.

Marl

Several marl deposits are known near Bobcaygeon, the most notable of which is east of the Kinmount Bobcaygeon highway, about 6 miles due north of Bobcaygeon, in lot 31, con. XVIII, Harvey tp. In 1940, White Valley Chemicals Ltd. began production from this deposit, but operations appear to have been discontinued the same year. Production was used for whiting substitute, which may be used as a filler in paper and in the manufacture of explosives, rubber products, etc. The marl at this locality is white and fairly free from clay material, but has a remarkably high content of organic material, i.e., small snail shells.

Petroleum

The general term 'petroleum' will be used in the accompanying notes, except where the specific substance will be noted as oil or natural gas. Petroleum is one of the most economically important substances found in Ontario. The production, refining, and distribution of petroleum from the Palaeozoic rocks of southwestern Ontario constitutes a major industry in that part of the province, owing to a readily available industrial market. As a result, even low production-rate wells in the region may be classified as commercial producers[1].

To date little commercial production of petroleum within the Lake Simcoe district has taken place. Petroliferous 'shows' and some oil saturation have been noted, but, despite this, little concerted effort has been made to evaluate petroleum possibilities. Thus far, commercial production, in the form of natural gas, has been obtained only in the Acton field, Halton co., near the town of Acton, by the Anthony Gas and Oil Exploration Co. Available information indicates that production may be from lower, middle, and upper members of the Gull River Formation and the lower member of the Bobcaygeon Formation. Dolomitization is an important

[1] With a readily available local market, many wells are commercial producers that would not be so in more distant regions. For example, a commercial producer might consist of several wells, each of which produce only one or two barrels of oil per day, there being a sufficient number of wells to make a profitable daily total. It might be a well drilled only 2,500 feet with a production of 10 barrels of oil per day, which, because of shallow depth, can be operated commercially. It might be a low open-flow gas well that was adapted to supplying gas to local dwellings for heating purposes. Many such wells have been operating from 50 to 60 years. Although these examples are of wells presently south of a line joining Sarnia and Hamilton, the principles involved are equally applicable to the area north of that line.

factor in this field, even obscuring the Gull River–Bobcaygeon contact. The recoverable reserves of the company, in 1958, amounted to 400 million cubic feet of natural gas, with as much as 615,000 cubic feet open flow from one well.

In the A. Breedon No. 1 well (in lot 21, con. III, Adjala tp., Simcoe co.) were found not only several oil 'shows' but 11 feet of oil saturation (876 to 887 feet below the surface), in the C_2 submember of the Bobcaygeon Formation. Two offset wells were drilled but resulted in dry holes. The Coakwell No. 1 well near Markham showed an open flow of about 18,000 cubic feet of natural gas per day from the Simcoe Group, but was not classed as commercial production. There have been many natural gas 'shows', some of fair size from the lower member of the Georgian Bay Formation. These apparently were small 'pocket' accumulations. Tests until about 1940 have been reported on elsewhere (Caley, 1940, pp. 141–142).

Petroliferous Shale

The lower member of the Whitby Formation has been described as both petroliferous and bituminous shale. On even small samples a brown ring results readily upon the operation of the closed tube test. Keele (1924) reported that 2.1 per cent only was of organic carbon from samples from the Ottawa Valley and that "... certain beds at the base of the formation in Collingwood township, Grey county, were actually worked in 1860 for oil" (p. 14). Although Keele gave no further data on the latter point, Logan (1863, p. 784) did, for he noted a three to four per cent condensate into an oily liquid. Logan further reported: "It is said from thirty to thirty-six tons of shale were distilled daily, and made to yield 250 gallons of crude oil, corresponding to about three per cent of the rock". The figures from this are accordingly 7 gallons of crude oil to the ton or about a barrel to 4 tons. The writer's samples were from weathered material and therefore gave low figures.

The lower member of the Whitby Formation outcrops over an extensive area on Nottawasaga Bay and at Oshawa on Lake Ontario. Thus despite low yields a considerable reserve is probably present. The member is 20 to 30 feet thick; the lowest few feet appear to have the highest content.

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APPENDIX A

Descriptions of Ordovician Formations

(Composite Stratigraphic Sections 1 to 29)

Sections 1 to 29

The following notes comprise the lithological description of various important type and reference sections. A list of the type localities for the Ordovician formations in the Lake Simcoe district follows:

Shadow Lake Formation: Shadow Lake road-cut, 4 mi. north of Coboconk on No. 35 highway

Gull River Formation
- lower member: 4 mi. north of Coboconk on No. 35 highway
- middle member: Coboconk South road-cut
- upper member: Coboconk South road-cut

Bobcaygeon Formation
- lower member: C_1—Coboconk east quarry
  C_2—Silver Lake section, north of Bobcaygeon
- middle member: Little Bob quarry, south of Bobcaygeon
- upper member: Kirkfield quarry

Verulam Formation
- lower member: S_2, S_8, S_9 sections on south shore of Sturgeon Lake
- upper member: lot 21, con. 7, Eldon tp., Victoria co.

Lindsay Formation: 4 mi. northwest of Lindsay, on No. 35 highway

Whitby Formation
- lower member: Craigleith, in a small creek passing beneath No. 26 highway
- middle member: on Rouge River, a mi. northwest of junction with Rouge Creek
- upper member: mouth of East Meaford Creek, 5 miles west of Thornbury

Georgian Bay Formation: on East Meaford Creek, south shore of Nottawasaga Bay

In the following composite sections, the A-B nomenclature for the various submembers of the Gull River Formation is used for the sake of brevity. These abbreviations have also been used in the main body of this report.

Upper member
B_3 Moore Hill beds
Middle member
B_2 Upper lithographic beds
B_1 Laminated lithographic beds
Lower member
A_4 Upper buff beds
A_3 Mottled carbonate beds
A_2 Lower lithographic beds
A_1 Lower buff beds

Black River sections and composite sections are drawn up in chart form on Figures 2, 3, and 5.

By necessity the Trenton sections' descriptions are very detailed. Otherwise, almost every section could be described simply as follows, without any means of distinguishing it from any other section: so many feet of limestone, grey, brown and blue, fine- to medium-grained with minor amounts of clastic and crystalline limestone; weathers grey and brown and into thin beds with the occasional more massive stratum; fossiliferous. To mention a few of the common fossils in every described interval would be of little practical value, because, in almost each interval of the Bobcaygeon (lower, middle, and upper members), Verulam, and Lindsay Formations, there may be found: trepostomatous bryozoa, *Resserella rogata, Sowerbyella sericea, Rafinesquina alternata,* and varieties, *Zygospira recurvirostris, Hormotoma* sp., and *Isotelus* sp. Unless otherwise noted, the strata of these formations are fossiliferous. Appended to each described interval is the faunal collection number, e.g., C_1, C_2, or C_8 ('C' for collection). Trenton sections are drawn up in chart form in Figures 5, 7, and 8.

1. Black River Composite Section No. 1

Location: Vicinity of Coldwater and Pt. McNicoll, Tay, and Medonte tps., Simcoe co.

Black River composite section based on: Waubaushene exposures, Fesserton road-cut, Coldwater quarry, Pt. McNicoll quarry, and section in lots 9 and 10, con. XI, Orillia tp.

Thickness

TOP OF SECTION

BOBCAYGEON FORMATION, LOWER MEMBER (C_1)

20′ Limestone, grey, fine grained, argillaceous; weathers light steel blue and grey, and into thin rubbly beds and also massive beds; fossiliferous, large numbers of *Lyopora (Columnaria) halli,* and *Stromatocerium rugosum.*

GULL RIVER FORMATION, UPPER MEMBER

12′ Limestone, brown and grey, sublithographic and lithographic; weathers grey and into 3-foot beds (B_3).

GULL RIVER FORMATION, MIDDLE MEMBER

0.05′ Clay MH seam ('bentonite-metabentonite').

22′ Limestone, brown, grey and cream, lithographic, with 'eyes' of crystalline calcite; weathers grey and into thin and thick 4-foot beds (B_2).

2′ Limestone, grey, lithographic, thinly laminated with thin, green, argillaceous partings (B_1).

GULL RIVER FORMATION, LOWER MEMBER

0.1′ Clay MX seam ('bentonite-metabentonite')

8′ Limestone, magnesian; greenish grey, fine- and medium-grained; weathers buff and into 8- to 10-inch beds, with conchoidal fracture; stylolites present (A_4).

12′ Limestone, brownish grey and grey; uppermost 3½ feet is lithographic with 'fingers' of brown, fine-grained, argillaceous, magnesian limestone; lowermost 8½ feet is fine-grained magnesian limestone with 'fingers' of lithographic limestone; unit weathers to appear irregularly bedded and into beds as much as 4 feet thick; present are chert nodules and a glauconitic coating on the fossils and enclosed limestone conglomerate (A_3).

20′ Limestone, grey, brown and green, fine-grained to sublithographic; weathers grey and greenish grey and into 4- to 12-inch beds; lowermost beds often include limestone conglomerate, marcasite, and pyrite nodules, much disseminated pyrite and mud-cracked horizons (A_1).

SHADOW LAKE FORMATION

4′ Shale, red, green and grey, often calcareous; bed of grey porous arkose usually overlies the Precambrian directly.

BASE OF SECTION

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2. Black River Composite Section No. 2

Location: Lake Couchiching vicinity, northwest (Orillia tp., Simcoe co.) and northeast (Rama tp., Ontario co.) of Lake Simcoe.

Black River composite section based on: Lake St. George south quarry, Longford quarry, Uhthoff quarry, Hampshire Mills quarry, and Coopers Falls south outlier.

Thickness

TOP OF SECTION

BOBCAYGEON FORMATION, LOWER MEMBER (C_1)

9′ Limestone, grey, fine-grained, argillaceous; weathers grey and light steel blue and into thin rubbly beds and also massive beds: fossiliferous, large numbers of *Lyopora* (*Columnaria*) *halli*, and *Stromatocerium rugosum*.

GULL RIVER FORMATION, UPPER MEMBER

4′ Limestone, grey, sublithographic and lithographic with 'eyes' of crystalline calcite; weathers grey and into 6- to 18-inch beds; profusion of *Tetradium cellulosum* (B_3).

GULL RIVER FORMATION, MIDDLE MEMBER

0.1′ Clay MH seam ('bentonite-metabentonite').

18′ Limestone, grey, brownish grey and cream, lithographic, with 'eyes' of crystalline calcite; weathers grey and into 12- to 14-inch beds (B_2).

2′ Limestone, grey, lithographic; thinly laminated with thin, green, argillaceous partings (B_1).

GULL RIVER FORMATION, LOWER MEMBER

6′ Limestone, magnesian; grey to greenish grey, fine- to medium-grained; weathers buff and into 10- to 18-inch beds; stylolites present (A_4).

12′ Limestone, grey and brownish grey, lithographic, with 'fingers' of brown, fine-grained, argillaceous magnesian limestone; weathers mottled grey and brown to appear as irregular beds, and into 2-foot beds; glauconitic material coats both chert nodules and fossils present (A_3).

6′ Limestone, grey and brown, lithographic; weathers grey and into thin beds; concretions present; minor hiatus present in uppermost third, in the Lake St. George south quarry (Plate VII) (A_2).

12–30′ Limestone, magnesian; grey and green, fine-grained; weathers greenish grey and into thin beds (A_1).

SHADOW LAKE FORMATION

2′–3′ Shale, red and green.

BASE OF SECTION

NOTE: Presence of MX persistent clay seam ('bentonite') was not noted, due to nature of exposures.

3. Black River Composite Section No. 3

Location: Head Lake vicinity, Laxton tp., Victoria co.

Black River composite section based on: Head Lake East Hill (lots 8–9, con. VI, Laxton tp.), Schoolhouse Hill section (lot 9, con. IX, Laxton tp.) and Oak Lake south road-cut (lot 10, con. IX, Laxton tp.).

Thickness

TOP OF SECTION

BOBCAYGEON FORMATION, LOWER MEMBER (C_1)

23′ Limestone, grey, fine-grained, argillaceous; weathering light steel blue and grey, and into thin rubbly beds and also massive beds; great profusion of *Lyopora* (*Columnaria*) *halli* in lowermost strata.

GULL RIVER FORMATION, UPPER MEMBER

12.5′ Limestone, grey, sublithographic and lithographic; weathers grey and into massive beds; black nodular chert present in fair abundance; profusion of *Tetradium cellulosum* and *T. fibratum* (B_3).

GULL RIVER FORMATION, MIDDLE MEMBER

11′ Limestone, brown, grey and cream, lithographic, with 'eyes' of crystalline calcite; weathers grey and into massive beds (B_2).

4′ Concealed.

GULL RIVER FORMATION, LOWER MEMBER

5′ Limestone, magnesian; grey and greenish grey, fine- and medium-grained; weathers buff and into thick 8- to 10-inch beds; stylolites present (A_4).

6′ Concealed.

2.5′ Limestone, grey and brown, lithographic, with 'fingers' of brown, fine-grained, argillaceous, magnesian limestone (A_3).

4′ Limestone, grey and brown, lithographic; weathers grey and into massive beds (A_2).

26′ Limestone, grey and greenish grey, fine-grained and magnesian limestone; weathers buff and greenish grey, and into 4- to 8-inch beds; fracture is conchoidal and vugs are filled with calcite and gypsum crystals (A_1).

SHADOW LAKE FORMATION

8′ Shale, predominantly red but some green shale is present.

BASE OF SECTION

NOTE: Presence of MX and MH persistent clay seams ('bentonite') was not noted owing to nature of exposures.

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4. Black River Composite Section No. 4

Location: Coboconk vicinity, Bexley and Somerville tps., Victoria co.

Black River composite section based on: Shadow Lake road-cut (4 mi. north of Coboconk on No. 35 highway), escarpment sections (3 mi. north of Coboconk, on west side of No. 35 highway), and Coboconk east quarry (on the southern outskirts of the village).

TOP OF SECTION

BOBCAYGEON FORMATION, LOWER MEMBER (C_1)

24′ Limestone, grey, fine- and medium-grained, argillaceous; weathers light steel blue, grey, and brown, and into thin rubbly beds and massive beds; chert nodules present in uppermost few feet; fossiliferous, *Lyopora* (*Columnaria*) *halli*, *Stromatocerium rugosum*, *Lambeophyllum profundum*, and *Hesperorthis tricenaria*.

Thickness

GULL RIVER FORMATION, UPPER MEMBER

12′ Limestone, grey, and brownish grey, sublithographic and lithographic; weathers grey and into massive beds; profusion of *Tetradium cellulosum* and *T. fibratum* (B_3).

GULL RIVER FORMATION, MIDDLE MEMBER

0.05′ Clay MH seam ('bentonite-metabentonite').

12′ Limestone, grey, brownish grey and cream, lithographic, with 'eyes' of crystalline calcite; weathers grey and creamy grey into thin and massive beds (B_2).

6′ Concealed interval, generally, but within which lies 2 to 3 feet, at least, of limestone, grey, thinly laminated with thin, green, argillaceous partings; and with a pelecypod and ostracod fauna (B_1).

GULL RIVER FORMATION, LOWER MEMBER

12′ Limestone, brown and grey, fine-grained and sublithographic, respectively (A_4).

1.2′ Limestone, grey and brown, lithographic, with 'fingers' of brown, fine-grained, argillaceous, magnesian limestone (A_3).

8′ Limestone, brown and grey, lithographic; weathers grey and into massive beds with pyrite and marcasite nodules, and with horizontal faint mottled brown markings caused by fine-grained, magnesian limestone content (A_2).

1′ Shale, red, calcareous.

8.5′ Limestone, and magnesian limestone, grey and greenish grey, fine- and medium-grained; weathers buff and greenish grey with pinkish mottlings, and into massive 8- to 10-inch beds, with conchoidal fracture; quartz sand grains enclosed (A_1).

SHADOW LAKE FORMATION

6′ Shale, red and green, with 16-inch beds of argillaceous limestone which enclose quartz grains up to half an inch in diameter.

BASE OF SECTION

NOTE: Presence of lower MX clay seam ('bentonite') could not be determined owing to nature of exposures.

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5. Black River Composite Section No. 5

Location: Dongola vicinity. Somerville tp., Victoria co.

Black River composite section based on: (1) Dongola west road-cut (one-quarter mi. west of Dongola corner); (2) Dongola flat section (one-quarter mi. east of Dongola corner and 1,000 feet south of Monck Road); and (3) a section in lot 15, con. XI, Somerville tp.

TOP OF SECTION

BOBCAYGEON FORMATION, LOWER MEMBER (C_1)

10′ Limestone, grey, fine grained, argillaceous; weathers light steel blue and grey, and into thin rubbly beds and also massive beds; fossiliferous, *Lyopora* (*Columnaria*) *halli.*

Thickness

GULL RIVER FORMATION, UPPER MEMBER

12′ Limestone, grey, brownish grey, sublithographic and lithographic; weathers grey and into massive beds, profusion of *Tetradium cellulosum* and T. *fibratum* (B_3).

GULL RIVER FORMATION, MIDDLE MEMBER

12′ Limestone, brownish grey and cream, lithographic, with 'eyes' of crystalline calcite; weathers grey and into massive beds (B_2).

14.5′ Limestone, grey, lithographic, thinly laminated with thin, green, argillaceous partings (B_1).

6′ Concealed.

GULL RIVER FORMATION, LOWER MEMBER

22′ Limestone, grey, fine-grained to sublithographic to lithographic; weathers brown and grey and into fairly massive beds; lowermost 14 feet is predominantly lithographic limestone and the fifth foot from the base shows horizontal brown mottlings caused by fine-grained magnesian limestone content ($A_{2\text{-}3\text{-}4}$ interval).

1′ Shale, grey

24′ Limestone and magnesian limestone, grey, greyish green, and green and pink mottling, fine-grained; weathers to show the green and pink mottling predominantly; quartz sand grains enclosed (A_1).

SHADOW LAKE FORMATION

10′ Shale, red and some green.

BASE OF SECTION

NOTE: Presence of the MH and MX clay seams ('bentonite') was not noted owing to the nature of the exposures.

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6. Black River Composite Section No. 6

Location: Burnt River vicinity, Somerville tp., Victoria co., and Galway tp., Peterborough co.

Black River composite section based on: Burnt River west quarry (Britnell quarry), Burnt River south quarry and road-cut (lot 13, con. IV, Somerville tp.) and Bobcaygeon north road-cut (lot 1, con. V, Somerville tp.), and east side of road in Galway tp., Peterborough co., on Kinmount–Bobcaygeon Highway.

TOP OF SECTION

BOBCAYGEON FORMATION, LOWER MEMBER (C_1)

27′ Limestone, grey, brownish grey, fine-grained, argillaceous; weathers to light steel blue and grey, and into thin rubbly beds and also massive beds; chert nodules present in uppermost few feet; fossiliferous, *Lyopora* (*Columnaria*) *halli.*

GULL RIVER FORMATION, UPPER MEMBER

13′ Limestone, grey, sublithographic and lithographic; weathers grey and into massive beds; profusion of *Tetradium cellulosum* and *T. fibratum* (B_3).

Thickness

GULL RIVER FORMATION, MIDDLE MEMBER

0.7′ Clay, MH seam ('bentonite-metabentonite').

13′ Limestone, grey, brownish grey, brown, and cream, lithographic, with 'eyes' of crystalline calcite; weathers grey and into massive beds (B_2).

14′ Limestone, grey, lithographic, thinly laminated with thin, green, argillaceous partings; encloses a pelecypod and ostracod fauna; a middle section of some 4 feet about 2½ feet above the base is more heavily bedded and consists of grey, fine-grained limestone (B_1).

GULL RIVER FORMATION, LOWER MEMBER

5′ Concealed.

5′ Limestone, grey and greyish brown, fine-grained and sublithographic; weathers brown and buff and into 6- to 8-inch beds (A_4).

10.5′ Limestone, grey, lithographic; weathers grey and into moderately heavy beds; shows horizontal brown mottled markings caused by fine-grained, magnesian limestone content (A_{2-3}).

0.5′ Shale, reddish, calcareous.

9′ Limestone, reddish, mottled red and green, and alternations of red and green 'laminae', fine-grained, and argillaceous and dense sublithographic; weathers into thin and massive beds; encloses rounded quartz sand grains which vary in size up to half an inch in diameter (A_1).

SHADOW LAKE FORMATION

? Concealed.

0.3′ Arkose, grey, fine- to medium- to coarse-grained; weathers grey and porous; is comprised essentially of very small and large quartz and plagioclase grains.

BASE OF SECTION

NOTE: Presence of the lower MX bentonite seam was not noted owing to the nature of the exposures.

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7. Marmora West Composite Section

Location: Road-cut and lower strata on the west side of the town of Marmora, Hastings co.

Stratigraphic location of section: Lowest few feet of lower member of Bobcaygeon Formation, and almost complete section of Gull River Formation, upper and middle members.

TOP OF SECTION

BOBCAYGEON FORMATION, LOWER MEMBER (C_1)

2′ Limestone, grey, fine-grained, argillaceous; weathering into light grey, rubbly and more massive beds; fossiliferous, *Lyopora* (*Columnaria*) *halli*.

GULL RIVER FORMATION, UPPER MEMBER

13′ Limestone, light grey, grey and brown, sublithographic and lithographic; weathers grey and into thin and more massive beds; black nodular chert present; profusion of *Tetradium cellulosum* and *T. fibratum* (B_3).

Thickness

GULL RIVER FORMATION, MIDDLE MEMBER

0.1′	Clay MH seam ('bentonite-metabentonite').
37′	Limestone, grey, brownish grey, brown and cream, essentially lithographic limestone, but with some sublithographic, and minor amount of medium granular (clastic) lithographic limestone; weathers grey and creamy grey, and into thin and more massive beds; present are limestone conglomerates and an important stratum enclosing large mineral moulds is present near the base (B_2).
0.1′	Clay ('bentonite-metabentonite').
10′	Limestone, grey, lithographic, thinly laminated, with thin, green, argillaceous partings; encloses a pelecypod and ostracod fauna; a middle section of some 2 feet of brown sublithographic limestone is located some 5 feet above the base of the roadcut (B_1).

BASE OF SECTION

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8. Silver Lake Section

Collecting locality: SL–Type section, Bobcaygeon Formation, lower member, upper submember C_2.

Location: Lot 1, cons. II and III, Galway tp., Peterborough co., 9½ mi. north of Bobcaygeon, and three-quarters mi. east of Bobcaygeon–Kinmount Highway.

Stratigraphic location of section: Top of lower member, of Bobcaygeon Formation.

Elevations: Top of section + 1013.15′.

TOP OF SECTION

BOBCAYGEON FORMATION, LOWER MEMBER (C_2 beds)

12.0′–13.5′	Limestone, grey, fine-grained, argillaceous, and light brown, sublithographic with 'eyes' of crystalline calcite; weathers grey, smooth, and into 3-inch beds ($C_{12-13.5}$).
11.0′–12.0′	Covered.
10.0′–11.0′	Limestone, light grey, coarsely granular (clastic); weathers into 6-inch beds (C_{10-12}).
9.0′–10.0′	Limestone, dark grey, medium granular (clastic); weathers rough and into massive beds (C_{8-10}).
8.0′– 9.0′	Limestone, grey to light brown, finely granular, thinly bedded (C_{8-10}).
6.5′– 8.0′	Limestone, brownish grey, medium granular (clastic); weathers grey and rough; fossils few and mostly fragmental (C_{6-8}).
6.0′– 6.5′	Limestone, brown, sublithographic, hard (C_{6-8}).
5.0′– 6.0′	Limestone, light grey, fine to medium granular, 1½-inch band of chert in top (C_{4-6}).
4.0′– 5.0′	Limestone, light grey and brown, fine and medium granular, hard; bed varies slightly in texture; fossils few, many fragmental remains (C_{4-6}).
2.5′– 4.0′	Limestone, grey, fine-grained, with some dense brown limestone, hard; weathers grey and into 8-inch beds; fossils weathered out (C_{2-4}).
2.0′– 2.5′	Limestone, grey, coarsely granular and minor amount of light brown, sublithographic limestone; weathers grey and smooth to rough; fossiliferous (C_{2-4}).

Thickness

BOBCAYGEON FORMATION, LOWER MEMBER (C_{1B} beds)

0.5′– 2.0′	Covered.
0.0′– 0.5′	Limestone, greyish brown, fine-grained; siliceous material and silicified remains present (i.e., beekite); weathers grey and heavily bedded (C_{0-2}).

BASE OF SECTION

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9. Little Bob Quarry

Collecting locality B–Type section of Bobcaygeon Formation, middle member.

Location: Lot 13, con. XIX, Harvey tp., Peterborough co., immediately south of the town of Bobcaygeon, south side of Little Bob River and a quarter mi. east of No. 36 highway.

Stratigraphic location of section: Strata represent 21 feet of Bobcaygeon Formation, constituting the middle member, with lower member in floor of quarry.

Elevations: quarry floor + 821.79′
top of quarry + 843.11′

TOP OF SECTION

BOBCAYGEON FORMATION, MIDDLE MEMBER (D)

19.0′–21.0′	Limestone, grey, fine-grained, argillaceous; silicified remains present; weathers grey and into 2- to 3-inch beds; fossiliferous (C_{18-20}, C_{20-21}).
18.4′–19.0′	Limestone, grey, medium-grained to sublithographic, hard; weathers into massive beds (C_{18-20}).
18.0′–18.4′	Limestone, grey, fine-grained, argillaceous; sparsely fossiliferous (C_{18-20}).
16.0′–18.0′	Limestone, grey, fine-grained, argillaceous, with 'fingers' of yellow argillaceous material; some grey, medium-grained limestone; weathers brown and into massive 4- to 6-inch beds (C_{16-18}).
14.0′–16.0′	Limestone, grey and brownish grey, fine- and medium-grained, hard; weathers into 3- to 6-inch beds; some yellow shale partings which contain fucoidal material (C_{14-16}).
13.2′–14.0′	Limestone, grey, medium-grained with some grey, fine-grained, argillaceous limestone; weathers into massive beds; fucoidal material present (C_{12-14}).
12.0′–13.2′	Limestone, light grey, fine-grained to sublithographic, hard; weathers light brown and into 3-inch beds; fucoidal material present (C_{12-14}).
11.5′–12.0′	Limestone, grey, fine- to medium-grained; black nodular chert in upper half; weathers into massive beds (C_{10-12}).
10.1′–11.5′	Limestone, grey, fine-grained to sublithographic; weathers grey and smooth into massive beds (C_{10-12}).
9.2′–10.1′	Limestone, grey, fine-grained; weathers grey and smooth into 3-inch beds (C_{8-10}).
8.9′– 9.2′	Limestone, grey, fine-grained; very fossiliferous with fossils weathering out on upper surface (C_{8-10}).
8.7′– 8.9′	Shale, brown (C_{8-10}).
8.2′– 8.7′	Limestone, grey, fine-grained; weathering into 3-inch beds (C_{8-10}).
7.6′– 8.2′	Limestone, grey, fine-grained, with shale partings; weathers into thin 1- to 2-inch irregular beds (C_{6-8}).

Thickness

4.3′– 7.6′ Limestone, dark grey, fine-grained to sublithographic, hard; weathers greyish brown and into two 12-inch beds at base followed by two 3-inch beds (C_{4-6}, C_{6-8}).

4.0′– 4.3′ Limestone, dark grey, medium-grained with dark shale parting at top (C_{4-6}).

2.3′– 4.0′ Limestone, grey, medium-grained with bands of brown, sublithographic, dense limestone; weathers grey, smooth and into massive 14- to 16-inch beds (C_{2-4}).

0.0′– 2.3′ Limestone, brownish grey and grey, fine- and medium-grained, hard, stylolites present; weathers grey and smooth into one bed; conglomerate at base; also enclosed are very small bioherms of *Stromatocerium* and bryozoa which are in part silicified (C_{0-2}).

LOWER MEMBER, CALCARENITE (C_2 beds)

Limestone, grey, medium granular (clastic), with banded black chert; encloses small bioherms of *Stromatocerium* and bryozoa. This lithology is in the quarry floor and extends across the flat to the Little Bob River. Below water level, typical C_1 lower member lithology may be seen.

BASE OF SECTION

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10. Kirkfield Quarry

Collecting locality K–Type section of Bobcaygeon Formation, upper member.

Location: Lots 31–32, con. IX, Eldon tp., Victoria co., 2 mi. northeast of village of Kirkfield.

Stratigraphic location of section: As measured, described, and collected in the north face of the northwest corner of the quarry the footage —4 to +2 comprises the middle member, the footage 2–36 comprises the upper member of the Bobcaygeon Formation, and the footage 36–43 comprises the lowest beds of the Verulam Formation.

Elevations: top of quarry, northwest corner, side of road +857.8′
quarry floor, northwest corner, +817.0′

TOP OF SECTION

VERULAM FORMATION, LOWER MEMBER (F_1)

42.0′–43.0′ Limestone, light bluish grey, fine-grained, argillaceous, with some grey, medium-grained limestone, with green shale, partings; mud-cracks on upper surface; weathers light brown; fossiliferous, *Prasopora*-like bryozoa quite abundant; crinoids (C_{42-43}).

40.2′–42.0′ Limestone, grey, fine- and medium-grained, argillaceous, alternating in thin irregular beds with shale partings; weathers grey and brown and into thin beds; fossiliferous, *Prasopora*-like bryozoa, bryozoa and brachiopods abundant, i.e., *Resserella* and *Platystrophia;* crinoids (C_{40-42}).

40.0′–40.2′ Limestone, greyish blue, fine-grained; weathers bluish grey (C_{40-42}).

39.1′–40.0′ Limestone, grey, bluish grey, medium-grained; weathers into 1- to 2- to 4-inch beds; very fossiliferous, *Prasopora*-like bryozoa abundant (C_{38-40}).

Thickness

38.5′–39.1′ Limestone, grey, fine-grained, argillaceous, with 'fingers' of argillaceous material; weathers to rusty yellow and thin-bedded, many olive-green shale partings; very fossiliferous, *Prasopora*-like bryozoa, *Resserella* sp. and *Platystrophia* sp. abundant (C_{38-40}).

38.0′–38.5′ Shale, olive-green (C_{38-40}).

37.5′–38.0′ Limestone, blue and bluish grey, fine-grained, argillaceous; weathers rusty yellow and thin-bedded with shale partings; fossiliferous, *Prasopora*-like bryozoa found (C_{36-38}).

36.0′–37.5′ Limestone, bluish grey, fine- and medium-grained, argillaceous; weathers rusty and thin-bedded with shale partings; fossiliferous, *Prasopora*-like bryozoa found at 36.5 (C_{36-38}).

Bobcaygeon Formation, upper member (E)

32.5′–36.0′ Limestone, grey to bluish grey, fine- and medium-grained, hard; weathers light bluish grey into beds an inch to 10 inches thick but are usually massive and sparsely fossiliferous. These strata have a tendency to show rusty yellow efflorescence which may 'appear' to be normal weathering colour (C_{34-36}).

31.5′–32.5′ Limestone, grey, fine- and medium-grained; weathers greyish blue and into 4- to 6-inch beds (C_{30-32}, C_{32-34}).

26.7′–31.5′ Limestone, grey, fine-grained, thinly laminated by argillaceous partings; weathers grey and rubbly into a shaly mass (C_{26-28}, C_{28-30}, C_{30-32}).

26.0′–26.7′ Limestone, grey, medium-grained; weathers grey and into one massive heavy bed (C_{26-28}).

25.5′–26.0′ Limestone, grey sublithographic to lithographic, hard, dense; weathers grey and into one massive bed, on the upper surface of which are crinoids and asteroids. Represents a good key horizon (C_{24-26}).

24.0′–25.5′ Limestone, grey, fine-grained to argillaceous; fucoidal remains (C_{24-26}).

23.5′–24.0′ Limestone, grey, fine-grained, argillaceous; limestone conglomerate present (C_{22-24}).

21.5′–23.5′ Limestone, brown and greyish blue, medium-crystalline; non-fossiliferous (C_{20-22}, C_{22-24}).

20.5′–21.5′ Limestone, grey, fine- and medium-grained; weathers grey and into 4-inch beds; fossiliferous (C_{20-22}).

19.5′–20.5′ Limestone, grey, fine-grained, with black shale partings; weathers grey; crinoids (C_{18-20}, C_{20-22}).

16.5′–19.5′ Limestone, grey, fine- and medium-grained; weathers grey and alternately smooth and rough into 2- to 8-inch beds (C_{16-18}, C_{18-20}).

16.0′–16.5′ Limestone, light brown, fine and medium granular (clastic); weathers light brown and massive into 6-inch bed which varies in thickness from 5 to 16 inches within the quarry; crossbedding present and a limestone conglomerate included. This represents a good key horizon both within the quarry and the surrounding district (C_{16-18}).

13.5′–16.0′ Limestone, grey to dark brown, fine-grained with argillaceous partings; weathers grey and into beds 1- to 3- to 6-inches thick; fossiliferous. Beds thicken laterally to replace the lower portion of the overlying beds and accordingly vary in thickness to 24 inches (C_{12-14}, C_{14-16}).

13.0′–13.5′ Limestone, greyish brown, medium granular; weathers brown and into one massive bed (C_{12-14}).

12.3′–13.0′ Limestone, grey, fine-grained, with argillaceous partings; weathers grey (C_{12-14}).

10.5′–12.3′ Limestone, greyish brown to light brown, fine-grained; weathers grey and smooth into 3- to 6-inch beds; fucoidal layer at top (C_{10-12}, C_{12-14}).

10.0′–10.5′ Limestone, grey, fine-grained; weathers grey and into one bed; very fossiliferous, *Resserella* (*Dalmanella*) sp. particularly abundant (C_{10-12}).

8.7′–10.0′ Limestone, grey to grey brown and bluish grey, fine- and medium-grained, in part finely crystalline; weathers grey, smooth and rough alternately and into 3- to 6-inch beds; fossiliferous, *Resserella* in particular (C_{8-10}).

Thickness

7.0′– 8.7′ Limestone, grey, fine- and medium-grained, in part finely crystalline; weathers grey, smooth and rough alternately, and into 3- to 10-inch beds; fossiliferous, *Resserella* in particular and crinoids in the argillaceous partings (C_{6-8}, C_{8-10}).

6.5′– 7.0′ Limestone, grey, fine-grained; weathers grey, and into one bed; fossiliferous (C_{6-8}).

4.8′– 6.5′ Limestone, grey, fine- and medium-grained and finely crystalline; weathers grey, smooth and rough alternately and into 1- to 6-inch beds; fossiliferous, *Resserella* in particular and fucoidal material (C_{4-6}, C_{6-8}).

2.0′– 4.8′ Limestone, light grey, fine-grained, argillaceous, with some medium-grained; weathers grey and smooth and into 3- to 10-inch beds with argillaceous partings; fossiliferous, *Resserella* in particular (C_{2-4}, C_{4-6}).

BOBCAYGEON FORMATION, MIDDLE MEMBER (D)

1.0′– 2.0′ Limestone, grey and brownish grey, fine to very fine grained; weathers grey and into 3- to 4-inch beds (C_{0-2}).

0.0′– 1.0′ (Zero footage is quarry floor.) Limestone, grey, fine-grained, argillaceous; weathers light bluish grey and into 3- to 4-inch beds; sparsely fossiliferous, fucoidal material (C_{0-2}).

—4.0′– 0.0′ Limestone, grey, fine-grained to sublithographic, hard; weathers grey and smooth and into 3-inch beds; sparsely fossiliferous, *Gonioceras* sp. This interval represents the 4-foot-deep ditch in the quarry floor.

BASE OF SECTION

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11. 'Sturgeon Heights Cottage' Section (near Pleasant Point)

Collecting locality S1.

Location: Lot 9, con. XI, Fenelon tp., Victoria co., on south shore of Sturgeon Lake.

Stratigraphic location of section: Verulam Formation, lower member, near top of lower half.

Elevations: base of section +812′
top of section +833.6′
lowest strata of upper member +931.7′

TOP OF SECTION

VERULAM FORMATION, LOWER MEMBER (F_1)

21.4′–21.6′ Limestone, greyish blue, fine-grained to sublithographic; sparsely fossiliferous (C_{20-22}).

21.0′–21.4′ Limestone, grey and bluish grey, fine-grained and finely crystalline; weathering to rusty colour (C_{20-22}).

20.8′–21.0′ Limestone, blue and brown, medium-grained (C_{20-22}).

20.4′–20.8′ Limestone, grey, fine-grained, argillaceous; weathers grey and into thin beds; sparsely fossiliferous (C_{20-22}).

20.0′–20.4′ Limestone, grey, fine-grained, and blue, medium-grained and finely crystalline; weathering rusty green (C_{20-22}).

19.6′–20.0′ Limestone, grey and greyish blue, fine-grained (C_{18-20}).

18.6′–19.6′ Limestone, grey, very fine grained to sublithographic, with shale partings; sparsely fossiliferous (C_{18-20}).

18.0′–18.6′ Limestone, blue and grey, medium-grained (C_{18-20}).

16.8′–18.0′ Alternating shale, olive-green, and limestone, grey, fine-grained, argillaceous and sublithographic (C_{16-18}).

Thickness

16.0′–16.8′	Limestone, brownish blue, blue, and grey, fine-grained; weathering to rusty colour; irregular contact with the underlying shale (C_{16-18}).
14.0′–16.0′	Alternating shale, olive-green, and limestone, grey and greyish blue, fine-grained; the latter weathering to rusty colour and into ½- to 1-inch beds (C_{14-16}).
13.7′–14.0′	Limestone, grey, fine-grained; weathering rusty and into one bed; sparsely fossiliferous (C_{12-14}).
12.0′–13.7′	Alternating limestone, grey, fine-grained, and shale, olive-green, calcareous (C_{12-14}).
11.8′–12.0′	Limestone, grey, fine-grained; uneven upper surface (C_{10-12}).
11.0′–11.8′	Alternating limestone, grey, fine-grained, and shale, olive-green; former weathering rusty; sparsely fossiliferous (C_{10-12}).
10.0′–11.0′	Limestone, grey, fine-grained, and grey-blue, argillaceous; weathers rusty grey and into even ½- to 3-inch beds (C_{10-12}).
6.5′–10.0′	Limestone, grey and greyish blue, fine-grained, with some blue, medium-grained limestone; thin olive-green shale partings (C_{6-8}, C_{8-10}).
6.0′– 6.5′	Limestone, blue, medium-grained; weathers into 3-inch beds; sparsely fossiliferous (C_{6-8}).
0.0′– 6.0′	Alternating limestone, grey, fine-grained to sublithographic, and shale, olive-green; former weathers into 2- to 3-inch beds with minor amount of argillaceous material; fossiliferous, *Rafinesquina* and 'three dimensional' graptolites, *Diplograptus*, in particular (C_{0-2}, C_{2-4}, C_{4-6}).

BASE OF SECTION

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12. Sturgeon Heights Culvert Section

Collecting locality S2 – Type section of Verulam Formation, lower member.

Location: lot 9, con. XI, Fenelon tp., Victoria co., south shore of Sturgeon Lake.

Stratigraphic location of section: Verulam Formation, lower member, lower portion of upper half; overlaps slightly with S5 but represents lower strata.

Elevations: base of section +858.4′
top of section +881.0′
lowest strata of upper member +931.7′

TOP OF SECTION

VERULAM FORMATION, LOWER MEMBER (F_1)

21.55′–22.60′	Limestone, grey, fine-grained; weathers grey, smooth and into thin 1-inch beds (C_{20-22}, $C_{22-22.6}$).
20.75′–21.55′	Limestone, grey, coarsely crystalline; weathers grey and rough; very fossiliferous (C_{20-22}).
20.30′–20.75′	Limestone, blue, fine- and medium-crystalline; weathers brown (C_{20-22}).
19.80′–20.30′	Limestone, grey, fine-grained with 'fingers' of yellow argillaceous material; weathers to rusty colour (C_{18-20}, C_{20-22}).
19.55′–19.80′	Limestone, grey, medium granular (clastic); weathers rough and into one bed (C_{18-20}).
19.40′–19.55′	Limestone, grey, fine-grained to sublithographic (C_{18-20}).
18.55′–19.40′	Limestone, grey, fine-grained, argillaceous; weathers to rusty colour (C_{18-20}).
18.35′–18.55′	Limestone, blue, fine-grained, with 'fingers' of yellow argillaceous material (C_{18-20}).

Thickness	
18.05′–18.35′	Limestone, grey, fine-grained; weathers grey and smooth; sparsely fossiliferous (C_{18-20}).
17.55′–18.05′	Limestone, grey, fine-grained and sublithographic (C_{16-18}, C_{18-20}).
16.55′–17.55′	Limestone, grey, fine- and medium-grained; weathers into thin beds (C_{16-18}).
15.95′–16.55′	Limestone, grey, fine-grained, argillaceous, with ‘fingers’ of yellow argillaceous material; very fossiliferous (C_{14-16}, C_{16-18}).
15.65′–15.95′	Limestone, grey, fine-grained to sublithographic, hard; weathers rusty and into thin, irregular beds; very fossiliferous (C_{14-16}).
15.25′–15.65′	Covered (C_{14-16}).
14.55′–15.25′	Limestone, grey, medium-grained; weathers grey and massive; unfossiliferous (C_{14-16}).
14.25′–14.55′	Limestone, grey, fine-grained; weathers smooth and grey (C_{14-16}).
13.55′–14.25′	Limestone, grey, fine-grained to sublithographic; weathers brown and into irregular beds (C_{12-14}, C_{14-16}).
12.75′–13.55′	Limestone, grey, fine-grained to sublithographic; weathers massive (C_{12-14}).
12.55′–12.75′	Shale, olive-green (C_{12-14}).
12.05′–12.55′	Limestone, grey, fine- and medium-grained; sparsely fossiliferous (C_{12-14}).
11.10′–12.05′	Limestone, grey, fine-grained to sublithographic (C_{10-12}, C_{12-14}).
10.75′–11.10′	Limestone, blue, medium-grained (C_{10-12}).
10.55′–10.75′	Limestone, grey and brown, fine-grained, argillaceous (C_{10-12}).
9.70′–10.55′	Limestone, grey, fine-grained, argillaceous, weathers to thin beds with shale partings (C_{8-10}, C_{10-12}).
9.30′– 9.70′	Limestone, grey, medium-grained and coarsely crystalline; weathers grey and rough; fossiliferous (C_{8-10}).
8.90′– 9.30′	Limestone, grey and brown, finely granular (clastic) (C_{8-10}).
8.55′– 8.90′	Limestone, grey, fine-grained, hard; weathers massive and resistant (C_{8-10}).
7.70′– 8.55′	Limestone, grey, fine- and medium-crystalline and medium-grained; weathers into 4-inch beds (C_{6-8}, C_{8-10}).
7.20′– 7.70′	Limestone, blue, medium-grained and granular, weathers rough and massive (C_{6-8}).
6.55′– 7.20′	Limestone, grey and bluish grey, fine-grained; weathers grey, smooth, and into irregular beds (C_{6-8}).
6.25′– 6.55′	Limestone, grey, fine-grained; weathers to thin beds with shale partings (C_{6-8}).
5.45′– 6.25′	Limestone, grey, medium-grained; encloses a conglomerate of grey, fine-grained limestone (C_{4-6}, C_{6-8}).
4.80′– 5.45′	Limestone, grey, fine-grained to sublithographic; weathers into 2-inch beds (C_{4-6}).
3.55′– 4.80′	Covered (C_{2-4}, C_{4-6}).
2.70′– 3.55′	Shale, green, calcareous, with very thin beds of argillaceous limestone (C_{2-4}).
2.20′– 2.70′	Limestone, grey, medium-grained and finely crystalline limestone (C_{2-4}).
1.20′– 2.20′	Shale, green, olive-green, calcareous (C_{0-2}, C_{2-4}).
0.20′– 0.70′	Limestone, grey, fine-grained; weathers rusty (C_{0-2}).
0.00′– 0.20′	Limestone, brown, fine-grained (C_{0-2}).

BASE OF SECTION

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13. Cobourg Hill No. 1, West Railway Section

Collecting locality S3.

Location: Lot 16, con. VII, Eldon tp., Victoria co., a few hundred feet west of jog in road, north side of abandoned railway.

Stratigraphic location of section: Verulam Formation, upper member, upper part.

Thickness

TOP OF SECTION

VERULAM FORMATION, UPPER MEMBER (F_2)

8.3′–9.2′ Limestone, grey, coarsely crystalline, crinoidal; weathers grey and rough into massive bed; fossiliferous (C_{8-10}).

8.1′–8.3′ Limestone, grey, medium granular (clastic), crinoidal; weathers grey and rough; fossiliferous (C_{8-10}).

7.9′–8.1′ Limestone, grey and blue, fine-grained, dense; fossiliferous (C_{6-8}, C_{8-10}).

7.2′–7.9′ Limestone, grey, medium-grained, with minor amount of fine-grained limestone (C_{6-8}).

6.0′–7.2′ Limestone, brown and blue, fine-grained, dense, weathers brown, smooth, and into irregular beds (C_{6-8}).

4.0′–6.0′ Limestone, grey, medium to coarsely granular; weathers grey, rough and into 3½- to 6-inch beds; fossiliferous (C_{4-6}).

3.2′–4.0′ Limestone, bluish grey, fine-grained to sublithographic; weathers grey, smooth, and into thin one-inch beds (C_{2-4}).

2.9′–3.2′ Limestone, purplish grey, finely granular (clastic); limestone conglomerate present; changes laterally into 12 inches of grey, medium-crystalline limestone, becoming blue and coarsely crystalline in eastern part of section where it may be used as a key bed (C_{2-4}).

2.6′–2.9′ Limestone, grey, fine-grained and finely granular; fossiliferous (C_{2-4}).

2.0′–2.6′ Limestone, bluish grey and grey, fine-grained, dense (C_{2-4}).

0.0′–2.0′ Limestone, brown, fine- and medium-crystalline; iron-stained; massive beds which weather into thin plates that are oblique to the bedding, and pass through it (*see* Pls. XXII, XXIII, XXV, and XXVI) (C_{0-2}).

BASE OF SECTION

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14. Cobourg Hill No. 1, West Railway Section

Section S3 A.

Location: Lot 16, con. VII, Eldon tp., Victoria co., at corner, a few hundred feet east of section S3, north side of abandoned railway.

Stratigraphic location of section: Verulam Formation, upper member, to show changes from section S3.

TOP OF SECTION

VERULAM FORMATION, UPPER MEMBER (F_2)

10.70′–11.70′ Limestone, grey, finely crystalline (C_{10-12}).

9.70′–10.70′ Limestone, greyish blue, fine- and medium-crystalline, some grey, fine-grained limestone; weathers grey, and into thin beds (C_{8-10}, C_{10-12}).

8.90′– 9.70′ Limestone, grey, fine-grained, weathers into thin beds; fossiliferous, bryozoa and *Cyclospira bisulcata* (C_{8-10}).

8.70′– 8.90′ Shale, green (C_{8-10}).

6.90′– 8.70′ Limestone, grey and blue, medium- and coarsely crystalline; weathers rough and into 6-inch beds; fossiliferous (C_{6-8}, C_{8-10}).

6.55′– 6.90′ Limestone, grey, fine-grained, argillaceous; weathers platy (C_{6-8}).

5.65′– 6.55′ Limestone, blue, coarsely crystalline; weathers rough and massive; fossiliferous. This is the key bed of section S3 (2.9′–3.2′) (C_{4-6}, C_{6-8}).

5.55′– 5.65′ Limestone, grey, fine-grained (C_{4-6}).

5.50′– 5.55′ Shale parting, green; bentonite? (C_{4-6}).

4.50′– 5.50′ Limestone, grey and brown, medium-crystalline (C_{4-6}).

Thickness	
0.00′– 4.50′	Limestone, brown and grey, medium-crystalline; slightly iron-stained, weathers greyish and brown and into 8- to 12-inch massive beds; peculiar to these beds are the 1- to 2-inch 'discoidal' plates that are oblique to the bedding and that pass through it (*see* Pls. XXII, XXIII, XXV, and XXVI), which is a weathering feature (C_{0-2}, C_{2-4}, C_{4-6}).

BASE OF SECTION

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15. Eldon Hill No. 5, Spring Section

Collecting locality S4–Type section, Verulam Formation, upper member.

Location: Lot 21, con. VII, Eldon tp., Victoria co., some 500 feet north of the east-west road.

Stratigraphic location of sections: Contact section between lower and upper members of Verulam Formation.

Elevations: Contact between lower and upper members +906.5′
top of section +919.8′

TOP OF SECTION

VERULAM FORMATION, UPPER MEMBER (F_2)

19.1′–19.5′	Limestone, grey, coarsely crystalline, crinoidal; weathers grey and rough; fossiliferous, bryozoa in particular (C_{18-20}).
14.1′–19.1′	Limestone, brown and grey, fine- to medium-crystalline, crinoidal; weathers grey and rough (C_{14-16}, C_{16-18}, C_{18-20}).
13.7′–14.1′	Limestone, grey, coarsely crystalline, crinoidal; weathers dark grey and rough; fossiliferous (C_{12-14}, C_{14-16}).
6.2′–13.7′	Limestone, brown and grey, fine- and medium-crystalline, crinoidal; weathers dark grey, rough, and into 1- to 3-inch beds (C_{6-8}, C_{8-10}, C_{10-12}, C_{12-14}).

VERULAM FORMATION, LOWER MEMBER (F_1)

4.6′– 6.2′	Limestone, grey, fine-grained to sublithographic, brittle, hard; weathers brown, smooth, and into 1¼- to 2-inch beds (C_{4-6}).
0.2′– 4.6′	Covered, but many loose slabs of limestone, grey, granular (clastic) and medium-crystalline; weathered into 6- to 8-inch beds (C_{2-4}, C_{4-6}).
0.0′– 0.2′	Limestone, grey and bluish grey, fine-grained, argillaceous; weathers grey and thin-bedded (C_{0-2}).

BASE OF SECTION

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16. Eldon Hill No. 3 Section

Collecting locality S5.

Location: Lot 19, con. VIII, Eldon tp., Victoria co., lower road-cut.

Stratigraphic location of section: Verulam Formation, upper and lower members; lower part of upper half; overlaps with S2 but represents higher strata.

TOP OF SECTION

VERULAM FORMATION, UPPER MEMBER (upper road-cut) (F_2)

65.25′–74.25′	Limestone, brown, fine- and medium-crystalline, crinoidal; weathers greyish brown and into 1- to 2-inch 'discoidal' plates that are oblique to the bedding and cross it (*see* Pls. XVIII, XIX, and XX).

Thickness

VERULAM FORMATION, LOWER MEMBER (S5 section) (F_1)

22.00′–65.25′	Covered.
21.20′–22.00′	Limestone, bluish grey, fine-grained; weathers grey, smooth and into 1-inch beds; slightly fossiliferous (C_{20-22}).
20.60′–21.20′	Limestone, blue and brown, fine-grained and medium-crystalline; weathers smooth and rough, and into 2-inch beds (C_{20-22}).
20.00′–20.60′	Limestone, bluish grey, fine-grained, argillaceous; fossiliferous (C_{20-22}).
19.80′–20.00′	Limestone, grey, fine-grained to dense; fossiliferous (C_{18-20}).
19.25′–19.80′	Limestone, grey, fine-grained to dense, hard; very fossiliferous, gastropods in particular (C_{18-20}).
19.00′–19.25′	Limestone, blue, medium-grained, hard; fossiliferous (C_{18-20}).
18.00′–19.00′	Limestone, blue, medium-grained; weathers rusty and into 1-inch beds; sparsely fossiliferous (C_{18-20}).
17.90′–18.00′	Limestone, bluish grey, fine-grained (C_{16-18}).
17.60′–17.90′	Limestone, dark blue, medium-grained, hard; weathers into irregular beds (C_{16-18}).
16.50′–17.60′	Limestone, bluish grey, fine- to medium-grained; weathers grey and into 1- to 2-inch beds; fossiliferous at base (C_{16-18}).
16.00′–16.50′	Limestone, bluish grey, fine-grained (C_{16-18}).
15.60′–16.00′	Limestone, light blue, fine-grained, crinoidal in part; weathers rusty; unfossiliferous (C_{14-16}).
15.10′–15.60′	Limestone, grey, fine-grained with 'fingers' of yellow argillaceous material; weathers into platy, thin beds (C_{14-16}).
14.00′–15.10′	Limestone, light blue, medium-crystalline, crinoidal, heavy; weathers grey, rough, and into 6- to 8-inch beds which may weather, laterally, into 2- to 3-inch beds (C_{14-16}).
13.90′–14.00′	Limestone, bluish grey, fine-grained (C_{12-14}).
13.40′–13.90′	Limestone, blue, medium-grained (C_{12-14}).
13.00′–13.40′	Limestone, blue, fine-grained, with shale partings; fossiliferous (C_{12-14}).
12.00′–13.00′	Limestone, blue, medium-grained; one hard prominent stratum (C_{12-14}).
11.45′–12.00′	Limestone, grey, fine-grained, semi-crystalline to sublithographic, dense, brittle; weathers grey and smooth (C_{10-12}).
11.00′–11.45′	Limestone, blue, medium-grained, weathers rusty brown and rough (C_{10-12}).
10.50′–11.00′	Limestone, bluish grey, fine-grained, with 'fingers' of yellow, argillaceous material (C_{10-12}).
10.20′–10.50′	Limestone, blue, medium-crystalline; weathers grey, rough, and into 1½-inch beds (C_{10-12}).
10.00′–10.20′	Limestone, grey, fine-grained to dense; fossiliferous (C_{10-12}).
9.60′–10.00′	Limestone, bluish grey, fine-grained (C_{8-10}).
9.40′– 9.60′	Shale, grey (C_{8-10}).
9.00′– 9.40′	Limestone, bluish grey, fine-grained and medium-grained; weathered grey and into thin beds (C_{8-10}).
8.70′– 9.00′	Covered (C_{8-10}).
8.40′– 8.70′	Limestone, greyish blue, fine-grained; weathers into thin beds (C_{8-10}).
8.00′– 8.40′	Limestone, blue, medium-grained, hard; fossiliferous, gastropods in particular (C_{8-10}).
7.40′– 8.00′	Limestone, grey, fine-grained to sublithographic; weathers into irregular thin beds; fossiliferous (C_{6-8}).
7.20′– 7.40′	Limestone, grey, fine-grained, argillaceous (C_{6-8}).
6.45′– 7.20′	Limestone, greyish blue, fine- and medium-grained; weathers into irregular 1½-inch beds (C_{6-8}).
6.00′– 6.45′	Shale, green; with the occasional 1-inch bed of limestone, grey, sublithographic, dense (C_{6-8}).
5.90′– 6.00′	Limestone, grey, sublithographic, dense (C_{4-6}).
5.40′– 5.90′	Limestone, dark blue, medium-grained, hard (C_{4-6}).
4.80′– 5.40′	Covered (C_{4-6}).
4.15′– 4.80′	Limestone, dark blue, medium-grained, hard (C_{4-6}).
4.00′– 4.15′	Shale, yellow (C_{4-6}).

Thickness	
3.00′– 4.00′	Limestone, light blue, fine- to medium-grained, partly crystalline (C_{2-4}).
2.60′– 3.00′	Shale, olive-green (C_{2-4}).
0.80′– 2.60′	Covered (C_{0-2}).
0.40′– 0.80′	Limestone, dark blue, medium-grained and medium-crystalline; weathers to thin beds in upper part (C_{0-2}).
0.00′– 0.40′	Limestone, greyish blue, fine- to medium-grained; very fossiliferous (C_{0-2}).

BASE OF SECTION

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17. Cobourg Hill No. 1, Railway-cut

Collecting locality S6.

Location: Lot 15, con. VIII, Eldon tp., Victoria co.

Stratigraphic location of section: Verulam Formation, upper member, uppermost portion.

Elevations: base of section +893.5′
top of section +900.00′

TOP OF SECTION

VERULAM FORMATION, UPPER MEMBER (F_2)

6.15′– 6.50′	Limestone, grey, coarsely crystalline; weathers grey, rough and into 2- to 3-inch beds; fossiliferous (C_{4-6}).
5.70′– 6.15′	Limestone, grey, medium-grained; weathers grey; fossiliferous (C_{4-6}).
5.60′– 5.70′	Shale, grey (C_{4-6}).
5.20′– 5.60′	Limestone, brown, fine-grained and dense, crinoidal in part; weathers grey and rough; fossiliferous (C_{4-6}).
4.10′– 5.20′	Limestone, grey to brown, in part medium-crystalline, in part medium-granular; weathers grey, rough and into one heavy bed; fossiliferous (C_{4-6}).
3.90′– 4.10′	Limestone, grey, fine-grained; weathers grey (C_{4-6}).
3.30′– 3.90′	Limestone, grey, medium-granular (clastic) and medium-crystalline; weathers grey and rough; fossiliferous (C_{2-4}).
3.00′– 3.30′	Limestone, grey, fine- and medium-grained; weathers grey and rough; fossiliferous, is almost a coquinoid limestone (C_{2-4}).
2.50′– 3.00′	Limestone, brown and grey, medium-granular (clastic), weathers grey and rough (C_{2-4}).
2.00′– 2.50′	Limestone, grey, fine- and medium-grained, some crystalline content (C_{2-4}).
1.85′– 2.00′	Shale, grey calcareous alternating with limestone, grey, fine-grained; weathers grey; fossiliferous (C_{0-2}).
1.00′– 1.85′	Limestone, dark grey and greyish brown, coarsely crystalline, crinoidal; weathers grey, rough and into 2- to 3-inch beds; fossiliferous (C_{0-2}).
0.70′– 1.00′	Limestone, brownish grey, medium-crystalline; weathers grey and rough (C_{0-2}).
0.50′– 0.70′	Limestone, grey, fine-grained, argillaceous; weathers grey and smooth (C_{0-2}).
0.00′– 0.50′	Limestone, greyish brown, medium- to coarsely crystalline; weathers grey; fossiliferous (C_{0-2}).

BASE OF SECTION

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18. Zion South Section

Collecting locality S7.

Location: Lots 10–11, con. IV, Fenelon tp., Victoria co.

Thickness

Stratigraphic location of section: Verulam Formation, uppermost strata of lower member, and lowermost strata of upper member.

Elevations: base of section +847′
contact between lower and upper members +864.8′
top of section +866.8′

TOP OF SECTION

VERULAM FORMATION, UPPER MEMBER (F_2)

19.20′–19.80′	Limestone, brown and grey, medium-crystalline; weathers brown and rough; fossiliferous (C contact + 2.0).
19.00′–19.20′	Limestone, grey, medium-grained and medium-crystalline; weathers grey; fossiliferous, bryozoa very abundant (C contact + 2.0).
18.25′–19.00′	Limestone, brown and blue, coarsely crystalline; weathers brown and rough (C contact + 2.0).
17.80′–18.25′	Limestone, brown and blue, medium-crystalline; weathers brown and rough; non-fossiliferous (C contact + 2.0).

VERULAM FORMATION, LOWER MEMBER (F_1)

17.25′–17.80′	Limestone, bluish grey, medium-grained; weathers grey and smooth; sparsely fossiliferous (C contact —1.9).
17.00′–17.25′	Shale, green (C contact —1.9).
16.70′–17.00′	Limestone, grey, fine-grained to sublithographic, hard; weathers grey, smooth, into one bed; sparsely fossiliferous (C contact —1.9).
16.30′–16.70′	Limestone, greyish brown and blue, medium-grained (C contact —1.9).
15.90′–16.30′	Shale, grey and green; fossiliferous (C contact —1.9).
15.35′–15.90′	Interbedded limestone, bluish grey, sublithographic, in 1-inch beds, and shale, green (C_{14-16}).
15.15′–15.35′	Limestone, bluish grey, sublithographic (C_{14-16}).
14.60′–15.15′	Shale, brown, with a single 1-inch bed of grey, fine-grained, argillaceous limestone interbedded; fossiliferous (C_{14-16}).
14.50′–14.60′	Limestone, greyish blue, fine-grained to sublithographic (C_{14-16}).
14.00′–14.50′	Limestone, blue and grey, fine- to medium-crystalline, with some fine-grained limestone, and yellow shale partings; weathers grey and into one bed; fossiliferous (C_{14-16}).
13.75′–14.00′	Limestone, bluish grey, fine-grained; weathers into grey, thin beds (C_{12-14}).
13.50′–13.75′	Shale, yellow (C_{12-14}).
12.20′–13.50′	Limestone, greyish blue and blue, fine-grained; weathers grey and into thin 1-inch beds (C_{12-14}).
12.00′–12.20′	Shale, bluish grey, calcareous (C_{12-14}).
11.50′–12.00′	Limestone, light brownish grey, sublithographic; weathers grey, smooth, and into 1-inch beds (C_{10-12}).
10.90′–11.50′	Limestone, greyish blue, fine-grained and fine-crystalline; weathers grey, smooth, and into ¾-inch beds; fossiliferous (C_{10-12}).
10.00′–10.90′	Limestone, blue to bluish grey, coarsely crystalline, crinoidal; weathers grey and rough; fossiliferous (C_{10-12}).
9.80′–10.00′	Limestone, brown and blue, medium-grained; fossiliferous (C_{8-10}).
9.50′– 9.80′	Shale, grey and green (C_{8-10}).
9.00′– 9.50′	Limestone, dark blue, fine- and medium-grained; weathers grey, smooth, and massive (C_{8-10}).
8.60′– 9.00′	Covered (C_{8-10}).
8.20′– 8.60′	Limestone, grey and blue, fine- to medium-grained, in part sublithographic and in part crystalline (C_{8-10}).
8.00′– 8.20′	Covered (C_{8-10}).
6.25′– 8.00′	Limestone, bluish grey, and brown, fine- and medium-grained, some shale partings (C_{6-8}).
5.65′– 6.25′	Limestone, grey and brown, fine-grained and lithographic (C_{4-6}, C_{6-8}).

Thickness	
5.10′– 5.65′	Limestone, grey, fine-grained; weathers grey, rubbly and into 3-inch beds; fossiliferous (C_{4-6}).
4.70′– 5.10′	Limestone, grey, fine-grained to sublithographic, hard (C_{4-6}).
4.30′– 4.70′	Shale, olive-green (C_{4-6}).
4.00′– 4.30′	Limestone, grey and dark grey, fine-grained to sublithographic (C_{4-6}).
3.50′– 4.00′	Limestone, grey, fine-grained, dense, with green shale partings; weathers grey, smooth and into thin beds (C_{2-4}).
2.90′– 3.50′	Limestone, grey and brownish grey, fine- and medium-grained, crinoidal; weathers grey, rough and into one massive bed (C_{2-4}).
2.50′– 2.90′	Shale, olive-green, with occasional thin band of grey, fine-grained limestone (C_{2-4}).
2.00′– 2.50′	Limestone, grey, fine- and medium-grained; weathers grey and smooth; sparsely fossiliferous (C_{2-4}).
1.80′– 2.00′	Covered (C_{0-2}).
1.50′– 1.80′	Limestone, bluish grey and blue, fine- and medium-grained, dense, hard; weathers grey and smooth (C_{0-2}).
1.00′– 1.50′	Covered (C_{0-2}).
0.00′– 1.00′	Limestone, blue, fine- and medium-grained, some argillaceous and medium-crystalline limestone; weathers grey; sparsely fossiliferous (C_{0-2}).

BASE OF SECTION

19. 'Cedar Glen' Section (near Greenhurst–Thurstonia)

Collecting locality S8 – Type section 2, of Verulam Formation, lower member.

Location: Lot 11, con. III, Verulam tp., Victoria co., south shore of Sturgeon Lake.

Stratigraphic location of section: Verulam Formation, lower member low strata but slightly higher than S9 or K sections.

TOP OF SECTION

VERULAM FORMATION, LOWER MEMBER (F_1)

22.35′–22.70′	Limestone, blue, medium-crystalline and medium-grained; weathers grey and into thin beds; fossiliferous (C-E).
22.25′–22.35′	Limestone, grey, medium crystalline (C-E).
22.00′–22.25′	Limestone, blue, very fine grained to sublithographic; weathers grey and smooth; sparsely fossiliferous (C-E).
20.50′–22.00′	Limestone, purplish grey, fine-grained, argillaceous, with some blue, medium-grained (C-E).
20.35′–20.50′	Limestone, blue, medium-grained (C-D).
20.00′–20.35′	Limestone, grey, fine-grained, argillaceous (C-D).
19.55′–20.00′	Limestone, fine-grained, argillaceous, with minor amount of blue, dense limestone; fossiliferous (C-D).
19.30′–19.55′	Limestone, blue and brown, medium-grained, hard; weathers brown and smooth; sparsely fossiliferous (C-D).
18.40′–19.30′	Limestone, grey, brownish grey, fine-grained and argillaceous with grey shale partings (C-D).
18.20′–18.40′	Limestone, grey, fine-grained, argillaceous (C-D).
15.90′–18.20′	Covered (C-D).
15.75′–15.90′	Limestone, grey, fine-grained; weathers grey and into one bed (C-C).
15.40′–15.75′	Shale, brown (C-C).

Thickness	
15.00′–15.40′	Concealed partially; seems to consist of limestone, grey, fine-grained; weathered into thin 1- to 2-inch beds; irregular contact and truncation of beds (C-C).
14.65′–15.00′	Limestone, blue and brown, fine- and medium-grained; weathers grey and smooth; fossiliferous (C-C).
14.45′–14.65′	Limestone, brown and blue, fine-grained, argillaceous; fossiliferous; and brown shale partings (C-C).
14.20′–14.45′	Limestone, bluish grey, fine-grained, argillaceous; weathers grey and rubbly (C-C).
14.00′–14.20′	Shale, brown (C-C).
13.90′–14.00′	Covered (C-B).
13.50′–13.90′	Limestone, bluish grey, fine-grained; minor amount of shale at base (C-B).
13.00′–13.50′	Shale, brown; minor amount of limestone at base (C-B).
12.80′–13.00′	Limestone, bluish grey, fine- and medium-grained (C-B).
12.60′–12.80′	Limestone, bluish grey, medium- and coarsely crystalline, minor amount of grey shale; weathers grey; sparsely fossiliferous (C-B).
11.85′–12.60′	Shale, grey, calcareous; with a few thin limestone bands (C-B).
11.70′–11.85′	Limestone, grey and blue, fine- and medium-grained, argillaceous; weathers grey and rubbly in part; fossiliferous (C-B).
1.40′–11.70′	Covered (C-A).
0.80′– 1.40′	Limestone, grey and blue, medium-grained (C-A).
0.00′– 0.80′	Limestone, grey and blue, fine-grained argillaceous; weathers brown and into ½-inch beds; sparsely fossiliferous (C-A).

BASE OF SECTION

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20. Ancona Point Section

Collecting locality S9 – Type section 3, Verulam Formation lower member.

Location: Lot 12, con. V, Verulam tp., Victoria co., on south side of Sturgeon Lake.

Stratigraphic location of section: Verulam Formation, very low in the lower member, estimated to be only a few feet above the Verulam strata in the top of the Kirkfield quarry.

TOP OF SECTION

VERULAM FORMATION, LOWER MEMBER (F_1)

5.30′–5.50′	Limestone, grey, medium-grained and finely granular; weathers grey; sparsely fossiliferous (C-B).
4.50′–5.30′	Covered (C-B).
4.35′–4.50′	Limestone, greyish blue, medium-grained; weathers brownish grey, smooth, and into one bed (C-B).
3.75′–4.35′	Limestone, light blue and blue, fine-grained; weathers into thin beds; fossiliferous (C-B).
2.65′–3.75′	Limestone, grey, fine-grained, dense; weathers into thin beds. Some alternations of grey shale (C-B).
2.15′–2.65′	Limestone, blue, medium-grained; weathers grey and into one bed; fossiliferous (C-A).
1.70′–2.15′	Limestone, bluish grey, fine-grained; weathers into thin beds; fossiliferous (C-A).
1.25′–1.70′	Limestone, blue, medium-grained; weathers grey, and into thin beds; fossiliferous, bryozoa in particular, *Prasopora*-like bryozoans very abundant (C-C).
1.00′–1.25′	Covered (C-C).

Thickness

0.00′–1.00′ Limestone, greyish blue and blue, medium-grained; weathers to thin beds, with thin interbeds of grey shale; fossiliferous, bryozoa particularly noteworthy, *Prasopora*-like bryozoans very abundant (C-C).

BASE OF SECTION

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21. Lindsay North Road-cut

Type Section, Lindsay Formation.

Location: Lindsay North road-cut, 4 mi. north of Lindsay on No. 35 highway.

Stratigraphic location of section: Near the top of the lowest 60 feet of the Lindsay Formation.

14′ Blue, very fine crystalline to sublithographic limestone, hard, brittle. Strata weather blue and to thin (1- to 1½-inch) beds that are pseudo-nodular or fragmentary. These are irregularly shaped fragments of limestone that are more resistant to weathering than the surrounding film or layer of argillaceous material. Calcarenites and coarse conglomerates are located in uppermost 5 feet. There are a few thin, dark, shale partings throughout the section.

NOTE: Although this road-cut is sparsely fossiliferous, a Cobourg fauna containing *Hormotoma trentonensis, Fusispira subfusiformis,* and *Pasceolus globosus* is known to exist below this unit in the Verulam Formation.

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22. Cobourg Hill No. 1, Middle Road-cut

Collecting locality H1.

Location: Lot 15, con. VII, Eldon tp., Victoria co.

Stratigraphic location of section: Low in Lindsay Formation, some 9 feet above upper member of Verulam Formation.

Elevations:	base of S6 railway-cut	+893.5′
	top of S6 railway-cut	+900′
	base of middle road-cut	+909.03′
	top of road-cut	+915.95′
	top of Cobourg Hill No. 1	+959′

TOP OF SECTION

LINDSAY FORMATION (G)

30.00′–50.00′ Limestone; essentially grey, fine-grained, argillaceous, but with occasional heavy bed of bluish grey and grey, fine- and medium-grained limestone and clastic limestone. For the most part this section is slumped and covered. Weathers to a rubble generally and is quite fossiliferous.

21.00′–30.00′ Covered.

6.95′–21.00′ Limestone; essentially grey, fine-grained, argillaceous; weathers grey and to a rubble; fossiliferous.

(Road-cut section proper)

6.65′– 6.95′ Limestone, blue and grey, fine-grained, hard; weathers rusty and brown and to thin beds; sparsely fossiliferous (C_{5-7}).

6.35′– 6.65′ Limestone, brownish grey, medium-crystalline (C_{5-7}).

Thickness	
6.00′– 6.35′	Limestone, grey and blue, fine-grained, dense, hard; weathers rusty brown and into one bed; sparsely fossiliferous(C_{5-7}).
5.20′– 6.00′	Limestone, brown, medium-grained; weathers rusty and into one massive bed (C_{5-7}).
4.20′– 5.20′	Limestone, bluish grey, fine- and medium-grained, with a 3-inch interbed of shale (C_{3-5}).
3.20′– 4.20′	Limestone, alternating blue and grey, fine-grained, dense with shale partings; weathers rusty brown and into thin beds; sparsely fossiliferous (C_{3-5}).
2.65′– 3.20′	Alternating shale, olive-green, and limestone, grey and blue, fine-grained, which weathers into 1-inch beds; sparsely fossiliferous (C_{1-3}).
2.10′– 2.65′	Limestone, blue, medium-grained; weathers greyish brown, sparsely fossiliferous (C_{1-3}).
1.70′– 2.10′	Limestone, grey, fine-grained and granular; encloses limestone conglomerate; weathers brown and into thin beds; sparsely fossiliferous (C_{1-3}).
1.05′– 1.70′	Limestone, blue, fine- and medium-grained (C_{1-3}).
0.75′– 1.05′	Limestone, brown and blue, fine-grained, dense; sparsely fossiliferous (C_{0-1}).
0.20′– 0.75′	Alternating shale, grey and yellow, and limestone, purplish grey, fine-grained, weathering into thin beds; sparsely fossiliferous (C_{0-1}).
0.00′– 0.20′	Limestone, blue, fine- to medium-grained, hard dense; weathers brown and thin-bedded; sparsely fossiliferous (C_{0-1}).
9′	Covered interval.

VERULAM FORMATION, UPPER MEMBER (S6 in abandoned railway cut) (F_2)

6.5′	Limestone; essentially grey, fine-, medium-, and coarsely crystalline, crinoidal; weathering into grey, rough, thin and massive beds; very fossiliferous.

BASE OF SECTION

23. Pleasant Point Cobourg Hill Section

Location: East side of lot 6, con. X, Fenelon tp., Victoria co., north of No. 36 highway.

Stratigraphic location of section: Lindsay Formation, low strata, in about the 20- to 33-foot interval above the lower contact.

TOP OF SECTION

LINDSAY FORMATION (G)

13.30′–13.40′	Limestone, grey, medium- to coarsely crystalline; fossiliferous.
12.90′–13.30′	Limestone, grey and brown, fine-grained, argillaceous; weathers grey and into a rubble; sparsely fossiliferous.
12.00′–12.90′	Limestone, purplish grey, medium-granular, weathers into 2- to 3-inch beds.
11.10′–12.00′	Limestone, blue, medium-grained.
9.90′–11.10′	Limestone, blue and grey, medium- to fine-grained to dense, sublithographic; weathers grey, smooth and rough, and into 2-inch beds; sparsely fossiliferous.
8.50′– 9.90′	Limestone, blue and brownish grey, medium-granular; weathers brown, rough, and into 6-inch beds.
8.10′– 8.50′	Limestone, greyish blue and brown, fine-grained; weathers grey and into thin beds; sparsely fossiliferous.
7.50′– 8.10′	Shale, olive-green, plastic; encloses a ½-inch bed of grey and blue, fine-grained limestone.

Thickness	
6.60′– 7.50′	Limestone, blue, medium-grained, about 6 inches thick; a minor disconformity separates this from the overlying 5 inches of purplish grey, medium-granular limestone.
6.20′– 6.60′	Limestone, blue, medium-grained and greyish brown, very fine grained, dense; former includes a limestone conglomerate.
5.30′– 6.20′	Alternating shale, grey, and limestone, greenish grey, fine-grained to dense, with 'fingers' of argillaceous material; sparsely fossiliferous.
4.40′– 5.30′	Limestone, grey, alternating fine-grained and medium-grained, argillaceous; weathers rubbly and into thin beds; sparsely fossiliferous.
3.60′– 4.40′	Limestone, blue, medium-grained; weathers brown and into regular beds.
1.90′– 3.60′	Limestone, grey and bluish grey, fine-grained to dense; weathers brown, and rubbly into one bed.
1.00′– 1.90′	Limestone, blue, medium-grained and fine-grained; weathers brown, and into irregular 2- to 3-inch beds.
0.40′– 1.00′	Limestone, grey, fine-grained; weathers grey and into thin, irregular beds.
0.00′– 0.40′	Limestone, blue, medium-grained; weathers brown; sparsely fossiliferous.

BASE OF SECTION

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24. Craigleith West Station

Location: On small creek entering Nottawasaga Bay, a mile west of Craigleith station; in lot 24, con. III, Collingwood tp., Grey co.

Stratigraphic location of section: Lower member of Whitby Formation.

TOP OF SECTION

WHITBY FORMATION, LOWER MEMBER

17.25′–18.75′	Limestone, brownish grey, sublithographic, dense, with calcareous shale partings.
14.75′–17.25′	Shale, black, fissile, highly petroliferous and calcareous; fossiliferous.
14.15′–14.75′	Limestone, brownish grey, sublithographic, dense.
13.15′–14.15′	Shale, black, fissile, highly petroliferous and calcareous; fossiliferous.
12.75′–13.15′	Limestone, brownish grey, sublithographic, dense.
8.25′–12.75′	Shale, black, fissile, highly petroliferous and calcareous; thin interbeds of hard, dense, limestone; very fossiliferous, trilobite, brachiopod and graptolite remains.
7.40′– 8.25′	Limestone, brownish grey, sublithographic.
6.65′– 7.40′	Shale, black, fissile, highly petroliferous and calcareous; fossiliferous.
6.15′– 6.65′	Limestone, brownish grey, sublithographic.
5.15′– 6.15′	Shale, black, fissile, highly petroliferous and calcareous; fossiliferous.
4.50′– 5.15′	Limestone, brownish grey, sublithographic.
3.00′– 4.50′	Limestone, brownish grey, very fine grained, thinly laminated.
2.25′– 3.00′	Limestone, grey, sublithographic.
0.00′– 2.25′	Shale, black, fissile, highly petroliferous and calcareous; fossiliferous, with trilobite, brachiopod and graptolite remains.

BASE OF SECTION

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25. Craigleith Station Section

Type section, Whitby Formation, lower member.

Location: Small creek immediately east of Craigleith station; lot 21, con. II, Collingwood tp., Grey co.

Thickness

Stratigraphic location of section: Uppermost Lindsay and lowermost Whitby Formations.

TOP OF SECTION

WHITBY FORMATION LOWER MEMBER

7.75′–9.75′	Shale, black, fissile, highly petroliferous and calcareous; fossiliferous, with trilobite, brachiopod and graptolite remains.
7.25′–7.75′	Limestone, brownish grey, sublithographic.
6.25′–7.25′	Shale, black, fissile, highly petroliferous and calcareous; fossiliferous.
5.25′–6.25′	Limestone, grey, sublithographic, hard.
4.00′–5.25′	Shale, black, fissile, highly petroliferous and calcareous; fossiliferous. On the beach, about 300 yards to the west, the lowermost "½ to 2 inches" consists "... of soft grey to buff coloured marl, with thin undulating layers of rotten brown shale, containing many broken fragments of *Dalmanella* and *Diplotrypa* 'pebbles' up to one inch in diameter" (Sproule, 1936, p. 99).

LINDSAY FORMATION (G)

2.00′–4.00′	Limestone, grey, fine-grained, argillaceous and sublithographic, with greenish grey shale partings; weathers rubbly and thin-bedded; fossiliferous.
0.00′–2.00′	Covered.
	At water's edge; limestone, grey, fine-grained, argillaceous, and sublithographic, with greenish grey shale partings; weathers rubbly; fossiliferous.

BASE OF SECTION

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26. Oshawa Creek Section

Location: About 100 feet north of Mill St. bridge over Oshawa Creek, in the town of Oshawa.

Stratigraphic location of section: probably low in Whitby Formation, lower member.

WHITBY FORMATION LOWER MEMBER

4′	Section of shale, black, fissile, highly petroliferous and calcareous; uppermost foot approximates the character of a paper shale; lower shales are thicker and tougher; very fossiliferous: *'Dalmanella' emacerata, Lingula progne, Leptobolus insignis, Geisonoceras tenuistriatum, Triarthrus eatoni,* and *Pseudogygites canadensis,* the last named in abundance.

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27. Whitby Section

Location: On west branch of Lynde Creek, northwest of the town of Whitby, in lot 30, con. II, Whitby tp., Ontario co.

Stratigraphic location of section: About middle of Whitby Formation, middle member.

TOP OF SECTION

WHITBY FORMATION MIDDLE MEMBER

4.3′–5.0′	Shale, bluish black, petroliferous and slightly calcareous; fossiliferous; *Leptobolus insignis, Geisonoceras tenuistriatum, Triarthrus canadensis.*

Thickness

3.2′–4.3′ Shale, bluish black, petroliferous and slightly calcareous, minor amount of paper shale; irregularly bedded, and with mud-cracks at several horizons; fossiliferous; *Geisonoceras tenuistriatum, Triarthrus canadensis, Climacograptus typicalis.*

2.8′–3.2′ Shale, brown, petroliferous; irregularly bedded and with mud-cracks at several horizons; fossiliferous: *Diplograptus montis, Climacograptus rougensis.*

2.1′–2.8′ Shale, bluish black, petroliferous and slightly calcareous; harder and more thickly bedded; fossiliferous.

1.4′–2.1′ Shale, brown, petroliferous and slightly calcareous with black shale partings at base; irregularly bedded with mud-crack horizons; sparsely fossiliferous, *Leptobolus insignis* is most common.

0.9′–1.4′ Shale, black, slightly petroliferous and slightly calcareous; fossiliferous.

0.3′–0.9′ Shale, brown; irregularly bedded; sparsely fossiliferous, *Glossograptus quadrimucronatus, Triarthrus canadensis,* graptolitic fragments.

0.0′–0.3′ Shale, black; fossiliferous, *Lingula* sp., *Geisonoceras tenuistriatum, Triarthrus canadensis.*

BASE OF SECTION

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28. Rouge River Section

Type section of Whitby Formation, middle member.

Location: On Rouge River, a mile northwest of its junction with Little Rouge Creek, 16 mi. east of Toronto, lot 2, con. II, Scarborough tp., 200 yds south of north boundary, 300 yds east of west boundary.

Stratigraphic location of section: Whitby Formation, middle and upper members.

6.7′ Brown shale at base grades upward imperceptibly into blue shale at the top of the section. The former is typical Gloucester shale, i.e., brown with the occasional petroliferous black shale parting in the lower part only; the latter is typical Blue Mountain shale.

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29. East Meaford Creek Section

Type section of Whitby Formation, upper member and Georgian Bay Formation.

Location: Creek (Workman Creek) 2 mi. southeast of Meaford, crossing No. 26 highway and extending from Nottawasaga Bay to the top of the 'Ordovician escarpment'.

Stratigraphic location of section: Uppermost few feet of Whitby Formation, upper member Georgian Bay Formation, and Queenston Formation.

TOP OF SECTION

QUEENSTON FORMATION

7′ Shale, red, with thin, ripple-marked, bluish grey limestone bands.

Thickness

GEORGIAN BAY FORMATION

418′ Shale, grey, bluish grey, and greenish grey, with thin limestone interbeds that become more prominent in upper strata and become the dominant lithology in highest Georgian Bay Formation, very fossiliferous; trepostomatous bryozoa very abundant, *Zygospira modesta, Rafinesquina alternata, Sowerbyella sericea, Orthodesma subangulatum, Whiteavesia pholadiformis, Byssonychia radiata, Lophospira tropidophora.*

WHITBY FORMATION, UPPER MEMBER

10′ Shale, light grey and bluish grey, soft, conchoidal fracture; sparsely fossiliferous: *Glossograptus quadrimucronatus, Cryptolithus bellulus, Triarthrus spinosus rougensis, Geisonoceras tenuistriatum.*

BASE OF SECTION

APPENDIX B

Descriptions of Type Sections of Okulitch's Shadow Lake and Gull River Formations

Descriptions of Type Sections of Okulitch's Shadow Lake and Gull River Formations

The following descriptive notes are those of the type sections of the Shadow Lake, Gull River, and Bobcaygeon Formations. The lithological descriptions are those of Okulitch (1939), but the formation, member, and submember (A_1, A_2 etc.) assignments are those of the writer.

1. Road-cut and small quarry (west of road-cut), 4 mi. north of Coboconk on No. 35 highway. Type section, Gull River Formation, lower member, and Shadow Lake Formation.

   Location: Lot 1, con. XI, Laxton tp., Victoria co.

   Stratigraphic location of section: Shadow Lake Formation, and lower member of the Gull River Formation (almost complete).

   Elevations: top of section about +924′.

Depth

TOP OF SECTION

GULL RIVER FORMATION, LOWER MEMBER (A unit)

Depth	
27′ 4½″–32′ 1½″	Light brownish grey, aphanitic limestone. Somewhat fractured. Contains some very fine intraformational conglomerate. Not fossiliferous. Bed no. 19 (A_4).
26′ ½″–27′ 4½″	Light brownish grey, aphanitic limestone, light grey to buff on weathering. The rock is honeycombed with numerous tubes or cavities filled with brownish shaly material. On weathering the shale is in many cases washed out, leaving the rock with numerous irregular depressions. General appearance of "birdseye limestone". *Rafinesquina minnesotensis, R. clara, Strophomena* sp., *Lophospira perangulata, Hormotoma* sp., Bryozoa. Bed no. 18 (A_3).
25′ 4½″–26′ ½″	Brownish grey limestone weathering to light dove-grey. Contains numerous calcite-filled tubes and stylolitic partings. Few fossils: *Rafinesquina* cf. *alternata, Bathyurus extans, Leperditia canadensis.* Bed no. 17 (A_2).
24′ ½″–25′ 4½″	Similar to bed 17, some greenish shaly layers. Bed no. 16 (A_2).
23′ 6½″–24′ ½″	Mottled, greenish grey, aphanitic limestone. Bed no. 15 (A_2).
23′ ½″–23′ 6½″	Aphanitic, dove-grey limestone, brown on non-weathered surfaces. Bed no. 14 (A_2).
22′ 2½″–23′ ½″	Brownish, but dove-grey on weathering, aphanitic limestone. *Tetradium cellulosum, Lophospira* cf. *bicincta,* trilobite fragments, *Isochilina* cf. *ottawa.* Bed no. 13 (A_2).
21′ 5½″–22′ 2½″	Brownish grey to dove-grey aphanitic limestone, light grey on weathering. Stylolitic partings, crystals of pyrite. Numerous poorly preserved fossils. *Rafinesquina* cf. *alternata, Isotelus gigas,* ostracod fragments. Bed no. 12 (A_2).

Depth	
21′ 4″–21′ $5\frac{1}{2}$″	Bluish grey or dove-grey aphanitic limestone. Bed no. 11 (A_2).
21′ 2″–21′ 4″	Shaly parting. Greenish to buff shale. Ostracods, Bryozoa. Bed no. 10 (A_2).
19′10″–21′ 2″	Brownish grey, aphanitic limestone; dove-grey to buff on weathering; greenish shaly layer on top. Calcite stringers or tubes filled with calcite. *Lophospira perangulata, Isochilina* cf. *ottawa, Leperditia canadensis.* Bed no. 9 (A_2).
18′ 9″–19′ 10″	Aphanitic, dove-grey limestone breaking irregularly into thinner beds. Buff to greenish on weathering. Stylolitic parting. Bed no. 8 (A_2).
18′ 4″–18′ 9″	Dove-grey, aphanitic limestone in a single bed. Fragments of small fossils. Bed no. 7 (A_2).
17′ 11″–18′ 4″	Dense, dove-grey limestone, lithologically resembling beds above. Bed no. 6 (A_2).
16′ 1″–17′ 11″	Thin-bedded (1 inch to 2 inches), greenish shaly limestone or dolomite. Very soft and crumbly. No fossils. Bed no. 5 (A_1).
13′ 4″–16′ 1″	Fine-grained to aphanitic, greenish to buff, magnesian limestone; hard; with conchoidal fracture; mottled with reddish patches. No fossils. Bed no. 4 (A_1).
11′ 0″–13′ 4″	Brownish to green, somewhat mottled magnesian limestone or dolomite. Medium-grained. Interbedded with greenish shale. Not fossiliferous. Bed no. 3. (Bottom of section in the quarry, lower beds exposed on the side of the road) (A_1).

SHADOW LAKE FORMATION

7′ 0″–11′ 0″	Soft greenish shale and argillaceous magnesian limestone or dolomite. Bed no. 2.
0′ 0″– 7′ 0″	Purple and green, mottled shale and argillaceous limestone or dolomite. Bed no. 1.

Covered interval of about 5 feet.

Precambrian surface.

BASE OF SECTION

The writer's stratigraphic résumé of the new road-cut at this locality follows:

GULL RIVER FORMATION LOWER MEMBER (A unit)

24′ 8″–29′ 8″	Upper buff beds: brown, fine-grained to sublithographic limestone; *Strophomena* cf. *minuta.* (A_4).
23′ 6″–24′ 8″	Mottled beds: digitate mottling of fine-grained dolomite within grey and brown, lithographic limestone (A_3).
14′ 6″–23′ 6″	Lower lithographic beds: brown and grey, lithographic limestone with horizontal dolomitic mottling; weathers grey; includes one foot of thinly laminated lithographic limestone in the base (A_2).
6′ 0″–14′ 6″	Lower buff beds: buff to greenish buff to brown, fine to very fine grained, magnesian limestone and dolomite; conchoidal fracture; with pink mottlings throughout; uppermost foot includes red, calcareous shale (A_1).

SHADOW LAKE FORMATION

0′ 0″– 6′ 0″	Green shale, red mottled green shale and red shale; occasional bed of very argillaceous limestone with high content of quartz sand grains.

Covered interval of 16 feet to Precambrian surface.

2. Road-cut, No. 35 highway, southern outskirts of village of Coboconk. Type section, Gull River Formation, upper member, middle member.

Location: Lots 36 and 37, Somerville tp., Victoria co.

Stratigraphic location of section: Upper member of Gull River and lower member of Bobcaygeon Formation (almost complete).

Elevations: Top of section: just below 900′ contour; 875′ contour runs through middle of section.

Depth

TOP OF SECTION

BOBCAYGEON FORMATION LOWER MEMBER

24′ 7″–29′ 2″ Composite bed consisting of four or five beds. Fine-grained, grey to brownish grey limestone. Brown on weathering. Upper surface bluish grey, and somewhat nodular due to partial solution and weathering. Very numerous *Columnaria halli* and *Stromatocerium*, as in bed 14. *Stromatocerium rugosum*, *S.* cf. *canadense*, *Columnaria halli*, *Fletcheria* cf. *sinclairi*, *Lambeophyllum profundum*, *Lichenaria carterensis*, *Lichenaria coboconkensis*, *Rafinesquina* sp., *Nicholsonella laminata*. Bed no. 15 (C_{1a}).

20′ 7″–24′ 7″ Medium-grained to fine-grained, grey to brownish grey limestone. Brown on weathering; irregularly fractured; and actually consisting of several irregular beds. *Stromatocerium rugosum*, *Columnaria halli*, *Lichenaria* sp., *Lambeophyllum profundum*, *Fletcheria sinclairi*, Bryozoa, *Rafinesquina alternata*, *R. clara*, *Rhynchotrema increbescens*, *Doleroides* sp., *Zygospira recurvirostris*, *Lophospira perangulata*, *Liospira* sp., *Phragmolites compressus*, *Leperditia* cf. *fabulites*. Bed no. 14(C_{1a}).

GULL RIVER FORMATION, UPPER MEMBER

Moore Hill beds (beds 7 to 13 inclusive of Okulitch)

16′ 6″–20′ 7″ A heavy massive bed; some fracturing. Dove-grey, grey-weathering aphanitic to fine-grained limestone. Very few *Tetradium cellulosum*. *Tetradium cellulosum*, *T. clarki*?, *Rafinesquina* cf. *alternata*, *R. clara*, *Zygospira recurvirostris*, *Isotelus gigas*, *Bumastus* sp., ostracods. Bed no. 13 (B_3).

15′11″–16′ 6″ Brownish to greenish grey, fractured and rubbly limestone. *T. cellulosum*, *T. fibratum*, Bryozoa, *Rafinesquina minnesotensis*, *R.* cf. *alternata*, *Rafinesquina* n. sp., *Zygospira recurvirostris*. Bed no. 12 (B_3).

14′10″–15′11″ Fine-grained, medium grey limestone, weathering to lighter grey. *Tetradium cellulosum* very abundant. *Tetradium cellulosum*, *T. fibratum*, *T.* cf. *syringoporoides*, *Orthoceras* cf. *multicameratum*. Bed no. 11 (B_3).

8′ 5″–14′10″ Form together a prominent heavy bed. Dark grey, slightly brownish aphanitic limestone. Bed 10 is noticeably lighter in colour and makes a convenient key horizon. Beds 7 and 8 are not fossiliferous, whereas bed 9 contains abundant *Tetradium cellulosum*. *Tetradium cellulosum*, *T. fibratum*, *T. halysitoides*, *T.* cf. *syringoporoides*, *Rhynidictya* sp., *Hormotoma gracilis*, *Isotelus* cf. *gigas*, *Leperditia* cf. *fabulites*? Beds no. 7,8,9 and 10 (B_3).

Depth

GULL RIVER FORMATION, MIDDLE MEMBER

Upper lithographic beds.

7′ 0″– 8′ 5″	Darker than the previous beds, aphanitic, mottled, buff-weathering limestone; stylolites on partings in the bed. Calcite-filled tubes. Large and small ostracods. *Leperditella inflata*? Ulrich, *Leperditia canadensis*? Bed no. 6 (B_2).
5′10″– 7′ 0″	Light grey, light grey to buff-weathering, aphanitic limestone. Upper layer green, contains some pyrite and is mottled with reddish patches. Calcite-filled tubes (birdseyes), numerous ostracods, *Leperditia amygdalina* Jones. Bed no. 5 (B_2).
5′ 0″– 5′10″	Light grey to brownish grey limestone, mottled with reddish patches and containing paper thin partings of shaly material within the bed. Upper layer weathers greenish; cubes of pyrite. Not fossiliferous. Bed no. 4 (B_2).
2′ 7″– 5′ 0″	Very light grey, weathering to buff-grey limestone. Upper surface pitted, contains siliceous stringers, which might be worm burrows, some very fine brecciation. General appearance of "birdseye" limestone. A few extremely small crinoid stems less than 1 mm in diameter. Not fossiliferous. Bed no. 3 (B_2).
1′ 5″– 2′ 7″	Similar to 1, buff-weathering limestone with stylolitic partings and some pyrite. Bed no. 2 (B_2).
0′ 0″– 1′ 5″	Aphanitic, light dove-grey, weathering to whitish grey limestone. Not fossiliferous. Bed. no. 1 (B_2).

BASE OF SECTION

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3. Coboconk east quarry; Canada Lime Co.; south of the village of Coboconk and east of No. 35 highway. Type section, Bobcaygeon Formation, lower member.

Location: Lot 37, Somerville tp., Victoria co.

Stratigraphic location of section: Upper member of Gull River Formation, and lower member of Bobcaygeon Formation (almost complete).

Elevations: top of section: just below 900′ contour.

TOP OF SECTION

BOBCAYGEON FORMATION, LOWER MEMBER

18′ 8″–32′ 2″	Light grey, fine- to medium-grained limestone. Beds 2 to 3 inches thick, in contrast with the heavy beds just below. The lower 20 inches show distinct crossbedding. Some of the beds are oolitic. *Receptaculites occidentalis, Stromatocerium rugosum, S. canadense, Lambeophyllum profundum, Calapoecia canadensis, Lichenaria coboconkensis, Graptodictya proava, Phyllodictya varia, Hesperorthis tricenaria, Rafinesquina alternata, R. minnesotensis, R. clara, Strophomena filitexta, S.* cf. *corrugata, Leptaena* cf. *radialis, Zygospira recurvirostris, Rhynchotrema increbescens, Maclurites logani, Actinoceras bigsbyi, Isotelus gigas, Leperditia fabulites.* Bed no. 16(C_{1A}).

Depth	
11′10″–18′ 8″	Dove-grey, medium- to fine-grained limestone, weathering to darker grey or brownish grey. Splitting into several thinner beds. The transition from 13 to 14 and 15 is not sharp and is established by observing the upper range of *Tetradium cellulosum* which does not extend above 13. *Columnaria* and *Stromatocerium* are very abundant in 14 and 15. The top of 15 looks like a top of a sedimentary series. The surface is very irregular and may represent a slight erosional unconformity. Above this contact the limestone is thin-bedded with coarser grain, the lower beds showing very well developed crossbedding. *Stromatocerium rugosum, Columnaria halli, Lichenaria carterensis, Lambeophyllum profundum, Rafinesquina alternata, R. clara, Liospira* sp. Beds no. 14 and 15 (C_{1A}).
	GULL RIVER FORMATION UPPER MEMBER
	(Moore Hill beds)
8′ 1″–11′10″	Dove-grey, fine-grained limestone splitting into several 6- to 12-inch beds. *Tetradium cellulosum.* Bed no. 13 (B_3).
6′ 6″– 8′ 1″	Massive, light grey, darker weathering aphanitic limestone. Abundant *Tetradium. Tetradium cellulosum, T. fibratum.* Bed no. 12 (B_3).
6′ 4″– 6′ 6″	Light grey aphanitic to fine-grained limestone. Beds no. 10 and 11 (B_3).
1′ 8″– 6′ 4″	Composite bed consisting of several 10- to 12-inch beds. Light grey aphanitic to fine-grained limestone. Numerous *Tetradium cellulosum.* Typical Lowville limestone (B_3).
	Upper surface shaly, containing ostracods and fragments of trilobites. *Tetradium cellulosum, Pterygometopus callicephalus.* Bed no. 9 (B_3).
0′ 0″– 1′ 8″	Grey limestone. A few straight nautiloid cephalopods. Beds no. 7 and 8 (B_3).
	BASE OF SECTION, i.e., bottom of quarry

The following are brief notes that are pertinent to the section of Okulitch described above.

1. Some beds of the lower lithographic unit of the lower member of the Gull River Formation may be seen below section 2 and below the Coboconk west quarry, immediately west of No. 35 highway.
2. The writer believes the “pitted surface” in bed 3 of no. 2 section, to be a corrosion zone as described by Weiss (1954).
3. The MH persistent clay seam (metabentonite of Kay) is located between beds 6 and 7 in section 2 and is also present below section 3, below the quarry floor. This seam consists of a ½-inch parting of greenish and bluish grey clay.
4. The writer does not agree with Okulitch in section 3 where the latter notes that “the top of bed 15 looks like a top of a sedimentary series”. There was continuous sedimentation in the limestone sequence here, except for the corrosion zone phenomena noted above in item 2.

5. In section 3, bed 16, the writer does not agree in describing the rock noted as oolitic. Rather, it is a medium- to coarsely grained clastic limestone that is a calcarenite. This limestone may vary in thickness up to 24 inches.
6. The forms *Receptaculites occidentalis, Calapoecia canadensis, Maclurites logani,* and *Hesperorthis tricenaria* listed from bed 16 of Section 3 are designated to be indicative of Rockland strata (i.e., Trenton) by most workers. The writer would point out, however, that these species are present in limited numbers and in the uppermost 6 feet or so.

APPENDIX C

Well Logs

Geological log of: J. Perdue No. 1; The Downeyville well.

Location: Lot 2, con. XI, Emily tp., Victoria co.

Completed: 1924. Elevation: 870′ (est.).

Total depth: 440′. Result: dry hole.

Rig: Standard Cable Tool.

Samples examined by: B. V. Sanford, 1948.

Depth	
0′– 11′	Limestone, light grey, finely crystalline, coral fossils; few angular quartz fragments.
11′– 14′	Limestone, buff, crystalline, to brown finely crystalline, few fragments of calcite and quartz. Brachiopoda and coral.
14′– 28′	Limestone, light grey argillaceous to buff, fine to crystalline; chert and quartz fragments.
28′– 38′	Limestone, grey to grey-buff, finely crystalline, argillaceous, few fragments of grey calcareous shale; fossiliferous.
38′– 60′	Limestone, grey-buff, semi-crystalline; few small angular quartz fragments and light greyish brown, highly argillaceous limestone.
60′– 70′	Limestone, grey to grey-buff, fine to crystalline. The former quite argillaceous; shale, medium grey, calcareous.
70′– 75′	Limestone, light grey-buff to greyish brown, argillaceous, finely crystalline. Shale, medium grey, calcareous; fossiliferous.
75′– 85′	Limestone, buff to buff brown. The latter slightly argillaceous, finely crystalline; few fragments of light grey calcareous shale; fossiliferous.
85′–100′	Limestone, light grey, with brownish cast, finely crystalline, argillaceous, fossiliferous. Few fragments of grey calcareous shale.
100′–105′	Limestone, grey-buff to brown, crystalline, fossiliferous; few medium grey calcareous shale fragments.
105′–125′	Limestone, grey-buff, fine to crystalline, fossiliferous; shale as above.
125′–130′	Limestone, buff to brownish grey, argillaceous, finely crystalline; shale, medium to brownish grey, calcareous; Brachiopoda fragments.
130′–140′	Limestone, buff, finely crystalline, highly fossiliferous; shale, medium greyish green, calcareous; calcite.
140′–155′	Limestone, grey to buff, finely crystalline, fossiliferous; shale, greyish green, calcareous; trace of pyrite.
155′–160′	Limestone, light grey, with brownish cast, finely crystalline, argillaceous; few fragments of greyish green calcareous shale.
160′–165′	Limestone, light buff, finely crystalline, fossiliferous shale, medium greyish green, calcareous.

Depth	
165′–175′	Limestone, greyish brown, argillaceous, finely crystalline. Bryozoa and Brachiopoda, few fragments of dark grey calcareous shale.
175′–185′	Limestone, light buff to brown, crystalline, shale, dark grey calcareous. Fossiliferous: *Zygospira recurvirostris* Hall.
185′–190′	Limestone, light grey to buff, argillaceous in part, finely crystalline. Fossiliferous: Bryozoa. Few fragments of grey calcareous shale.
190′–195′	Limestone, buff to grey, the latter very argillaceous, finely crystalline, fossiliferous.
195′–205′	Limestone, light grey, fragmental, to brownish grey, finely crystalline, fossiliferous; shale, medium grey calcareous.
205′–215′	Limestone, light buff to brownish grey; the latter argillaceous, finely crystalline, fossiliferous, few fragments of grey calcareous shale.
215′–220′	Limestone, light to dark buff, finely crystalline, slightly argillaceous in part; shale medium to dark grey, calcareous; fossiliferous.
220′–235′	Limestone, light buff, crystalline, brachiopoda, and corallite; few fragments of dark grey calcareous shale. Calcite.
235′–240′	Limestone, buff to light brown, quite dense, fossiliferous, calcite.
240′–250′	Limestone, buff to dark greyish brown, the latter argillaceous, finely crystalline, fossiliferous; few dark grey calcareous shale fragments.
250′–255′	Limestone, buff to brownish grey, the latter argillaceous, finely crystalline, fossiliferous; shale, medium dark grey, calcareous.
255′–265′	Limestone, buff, finely crystalline; few fragments of dark grey shale. *Chert.*
265′–275′	Limestone, buff to light brown, dense, fossiliferous; few fragments of dark grey slightly calcareous shale.
275′–280′	Limestone, buff to greyish brown, finely crystalline; the latter argillaceous, fossiliferous, scattered shale.
280′–285′	Limestone, grey-buff to buff-brown, finely crystalline, few fragments dense, one or two fragments finely sandy. Light grey *chert.*
285′–290′	Limestone, buff to buff-brown, finely crystalline, few fragments of milky *chert.*
290′–295′	Limestone, light brown, very finely crystalline, dense, few fossil fragments, and light grey *chert.*
295′–315′	Limestone, buff to brown, not as dense as above, fossiliferous *chert.*
315′–325′	Limestone, dark brown, *lithographic,* argillaceous in part, calcite, ostracods.
325′–330′	Limestone, grey-buff to greyish brown, dense, fossiliferous.
330′–335′	Limestone, medium brown, lithographic, calcite fragments.
335′–340′	Limestone, lithographic as above, grey-buff to light brown, slightly argillaceous in part.
340′–345′	Limestone, brown, lithographic; shale, greyish green, calcareous.
345′–350′	Limestone, light grey, to light brown, finely crystalline, dense in part; few fragments of light grey limestone, finely sandy to argillaceous.
350′–355′	Limestone, light grey to grey-buff, finely crystalline.
355′–360′	Limestone, buff, dense, calcite.
360′–365′	Limestone, buff to light brown, slightly crystalline.
365′–370′	Limestone, light greyish buff, crystalline.
370′–375′	Limestone, medium brown, lithographic.
375′–380′	Limestone, buff to brown, finely crystalline, slightly argillaceous in part.
380′–385′	Limestone, light grey-buff, sandy throughout, sand-grains are rounded to angular, fine to coarse; few fragments of light green, finely sandy shale.
385′–390′	Limestone, light grey, sugary; green arkose, containing sand-grains and biotite mica.
390′–395′	Arkose; green, much mica.

Depth

395′–420′ Arkose, red, containing many angular sand-grains and mica. Samples become more consolidated at 420′ having a light green shale matrix.

420′–440′ Biotite granite, contains graphite.

Total depth 440′

Formational summary:	(feet)
Lindsay	0– 11
Verulam, upper member	11– 38
Verulam, lower member	38–235
Bobcaygeon, upper member	235–280
Bobcaygeon, middle member	280–295
Bobcaygeon, lower member	295–315
Gull River, upper and middle members	315–345
Gull River, lower member	345–388
Shadow Lake	388–420
Precambrian	420–440

Geological log of: W. Arnot No. 1; Dunsford well.

Location: Lot 5, con. IV, Verulam tp., Victoria co.

Completed: October, 1943. Elevation 816.2′.

Total depth: 230′. Result: dry hole.

Rig: Standard Cable Tool.

Samples examined by: H. R. Belyea, 1948.

Depth

10′– 30′ Limestone, buff, crystalline, fragmental with numerous fossil fragments; especially Bryozoa and Brachiopoda greenish grey to light brownish grey soft limy shale intermixed.

30′– 70′ Limestone, buff, coarsely crystalline, fossiliferous; grey shale partings.

70′– 75′ Limestone, buff, coarsely crystalline; a few fragments of chert.

75′– 80′ Limestone, buff, coarsely crystalline, in part speckled with grey; dark grey shale partings.

80′– 90′ Limestone, buff, crystalline to coarsely crystalline.

90′–100′ Limestone, buff, crystalline, cherty; milky and translucent chert.

100′–105′ Limestone, buff, finely crystalline.

105′–115′ Limestone, buff, crystalline.

115′–120′ Limestone, buff, very finely crystalline to matte.

120′–130′ Limestone, light buff, matte, pyritic.

130′–135′ Limestone, brown, matte, argillaceous.

135′–140′ Limestone, light buff, to buff, matte.

140′–145′ Limestone, buff, matte.

145′–150′ Limestone, buff, same as above; some greenish shaly limestone with large quartz sand-grains and a slight oil stain.

150′–155′ Limestone, shale: greenish grey, shaly limestone in part sandy; green shale in part sandy, with some large quartz grains.

155′–160′ Limestone, light grey, matte, a few large quartz grains.

160′–165′ Limestone, light buff, matte.

165′–175′ Dolomite, limy, cream, sugary; scattered sand-grains.

175′–180′ Limestone, deep buff, matte.

180′–185′ Shale, green, sandy, calcareous; scattered large rounded frosted quartz grains.

Depth	
185′–190′	Dolomite, shale: pinkish buff, finely sugary dolomite with scattered sand-grains; green shaly dolomite and dolomitic shale; large sand-grains.
190′–195′	Sand and pebbles, coarse, chiefly quartz, subangular to subrounded, fine to very coarse sand and pebbles; green and red, sandy, finely sugary dolomite matrix.
195′–230′	Quartz–feldspar–hornblende-biotite granite. Total depth 230′

Formational summary:	(feet)
Drift	0– 10
Verulam, lower member	10– 30
Bobcaygeon, upper and middle members	30– 90
Bobcaygeon, lower member	90–115
Gull River, upper and middle members	115–155
Gull River, lower member	155–190
Shadow Lake	190–195
Precambrian	195–230

Geological log of: A. Breedon No. 1; Adjala well.

Location: Lot 21, con. III, Adjala tp., Simcoe co.

Completed: 1949. Elevation: 785′.

Total depth: 978′. Result: dry hole.

Rig: Diamond Drill Hole.

Samples examined by: M. J. Quantz, 1949.

Depth	
0′–195′	Missing.
195′–210′	Shale, medium dark grey, hard, very calcareous, finely micaceous, slightly silty, with Ostracods (200′–205′) and other shell imprints and fragments.
205′–210′	Thin, lighter grey banding in shale.
210′–214′	Shale, medium grey with greenish tint, hard, calcareous, finely micaceous, slightly pyritic.
214′–250′	Shale, medium dark grey, hard, finely micaceous, calcareous, slightly silty.
250′–265′	Shale as above, greenish grey with pyrite traces.
265′–270′	Shale as above, darker greenish grey to grey—Ostracods.
270′–285′	Shale, greenish grey, as above.
285′–295′	Shale, greenish grey, as above, also dark brown calcareous shale.
295′–340′	Shale, dark brownish grey, hard, finely micaceous, calcareous, slightly silty, buff streak.
340′–345′	Shale, medium grey as above, with grey streak, more calcareous.
345′–370′	Shale, dark brownish grey, buff-brown streak, as above.
370′–375′	Shale and limestone: very dark brownish grey shale, brown streaks as above, limy, grading into dark brown shaly limestone—shell fragments.
375′–380′	Shale, very dark brownish grey, limy with small veins of brown limestone.
380′–385′	Shale as above grading into limestone, medium greyish brown, very shaly, dense, with shell fragments. Ostracods.
385′–395′	Limestone, dense, brown, very shaly, with bands of coarsely crystalline brown limestone.
395′–400′	Limestone as above grading into limy shale, scattered fossil evidence (shell fragments, crinoid stems, etc.) giving fragmental appearance.

Depth	
400′–410′	Limestone, dense, greyish brown, shaly, intergrading with coarse, fragmental, fossiliferous limestone.
410′–420′	Limestone, medium brownish grey, to greyish brown dense, slightly shaly, with scattered fossil fragments.
420′–425′	Shale, greenish tinted grey with scattered large mica flakes, fossiliferous, calcareous, grading into dense limestone as above.
425′–440′	Limestone as above, medium greyish brown, very fossiliferous and shaly.
440′–485′	Limestone as above, medium greyish brown. 460′–465′ Limestone very fossiliferous, in part fragmental.
485′–520′	Limestone as above, banded with brown, coarsely crystalline, fragmental, fossiliferous limestone.
520′–525′	Limestone, brown, coarsely crystalline, fragmental, fossiliferous, with dense shaly patches.
525′–545′	Limestone, medium greyish brown, dense, shaly, with fossil fragments, banded with coarsely crystalline, fragmental, fossiliferous limestone.
545′–565′	Limestone, medium greyish brown to brownish grey, dense, very shaly, with scattered fossil fragments. 560′–565′ Limestone very fossiliferous, in part almost fragmental.
565′–570′	Limestone as above, medium- to finely crystalline to dense.
570′–580′	Limestone, greyish brown, dense, shaly to medium- to coarsely crystalline, fragmental; scattered fossil evidence.
580′–585′	Limestone, greyish brown, finely crystalline, slightly shaly.
585′–595′	Limestone, medium brownish grey, very shaly, banded with slightly coarser crystalline limestone.
595′–600′	Shale, dark greyish green, calcareous, slightly fissile, with scattered fossiliferous areas.
600′–605′	Shale as above grading into dense limestone; limestone, greyish brown, very coarse, fragmental, fossiliferous.
605′–610′	Shale, limy: greenish grey limy shale grading into dense very shaly limestone.
610′–620′	Limestone, dark brownish grey, coarsely crystalline, fragmental, fossiliferous, shaly; a little dense shaly limestone to 615′.
620′–625′	Limestone as above, medium- to fine-grained, grading into dense limestone.
625′–635′	Limestone, greenish grey, dense, very shaly, grading into limy shale, with scattered, thin finely crystalline bands.
635′–640′	Limestone, greyish brown or green, medium- to finely crystalline, slightly shaly, banded with greyish green limy shale and some dense very shaly limestone.
640′–645′	Shale, limy: greenish grey limy shale grading into dense very shaly limestone; a little crystalline limestone as above.
645′–650′	Limestone, medium- to coarsely crystalline, as above.
650′–660′	Limestone, greenish grey to brownish, medium- to finely crystalline to dense, shaly, grading into bands of greenish limy shale; some fossil evidence.
660′–665′	Limestone, greyish brown, coarsely crystalline, fragmental, fossiliferous; some greenish grey limy shale.
665′–670′	Shale as above interbedded with brownish medium- to finely crystalline to dense limestone.
670′–685′	Limestone, greyish brown to greenish, slightly shaly, coarsely crystalline, fossiliferous, fragmental, interbedded with dense very shaly limestone grading into limy shale as above.
685′–690′	Limestone, light brown, finely crystalline to dense, shaly.
690′–695′	Shale, dark brown, limy, banded with coarse fossiliferous brown limestone.
695′–700′	Limestone, greenish brown, dense, fossiliferous, shaly, interbedded with greenish grey limy shale.

Depth	
700′–705′	Limestone, greenish brown, slightly shaly, coarsely crystalline, fossiliferous, fragmental, interbedded with shale, greenish grey, in part waxy, calcareous to limy.
705′–710′	Limestone as above, medium-crystalline, interbedded with limy shale grading into shaly limestone.
710′–740′	Shale, limy, greenish grey, grading into dense, very shaly limestone in part brownish, some fossil evidence. 720′–725′ Shale in part waxy with evidence of slickensiding. 725′–730′ Brown fossiliferous limestone. 735′–740′ Greenish brown finely crystalline to dense limestone.
740′–760′	Limestone, buff to greenish grey, dense, very shaly. 750′–760′ Coarsely crystalline limestone bands.
760′–775′	Limestone, greenish, coarsely to finely crystalline to dense, shaly, with shaly partings (to 765′); shale, greenish grey, limy, grading into shaly limestone, some fossil evidence. 770′–775′ Shale in part waxy; widely scattered pyrite.
775′–780′	Shale with crystalline limestone bands as above.
780′–785′	Limestone as above with shaly partings.
785′–790′	Limestone, greenish grey, dense, very shaly, grading into limy shale, with coarser crystalline limestone bands.
790′–795′	Shale as above; some medium-crystalline shaly limestone.
795′–820′	Limestone, greyish brown, medium- to coarsely crystalline becoming finer grained and shaly with increasing depth to 810′, slightly fossiliferous, and fragmental, banded with limy shale grading into shaly limestone.
820′–830′	Shale, dark greenish grey, compact, waxy (to 825′), limy, grading into shaly dense limestone—scattered crystalline limestone bands.
830′–850′	Shale, limy to shaly limestone, dark greenish grey, as above.
850′–855′	Limestone, light brown, coarsely crystalline, fragmental, dolomitic.
855′–860′	Limestone, greyish brown, finely crystalline to dense, slightly shaly, with patches of greenish limy shale.
860′–865′	Shale, dark greenish grey, limy, in part slightly waxy, grading into dense shaly limestone.
865′–870′	Limestone, brownish grey, finely crystalline to dense, shaly, with limy shale partings.
870′–875′	Limestone, light brown, medium- to finely crystalline (banded), slightly fragmental, dolomitic, silty.
875′–880′	Limestone, brown, medium-crystalline with finely crystalline patches, fragmental, scattered pinpoint porosity, slightly silty.
880′–885′	Limestone as above, medium- to finely crystalline, no appreciable porosity.
885′–905′	Limestone, pale grey-buff, dense, with widely scattered thin veins and lenses of clear crystalline calcite. 895′–900′ Grey slightly shaly limestone lenses.
905′–910′	Limestone, brown, dense, with associated pyrobitumen.
910′–915′	Limestone, buff, dense, with interbedded clear crystalline calcite; pale greenish white metabentonite.
915′–920′	Limestone, medium to light grey (banded), dense, fossiliferous, shaly.
920′–925′	Limestone, grey-brown, dense, slightly shaly, with associated pyrobitumen.
925′–930′	Limestone as above, finely crystalline.
930′–935′	Metabentonite, pale greenish white trace of pyrite.
935′–940′	Limestone, pale grey-buff, dense with trace of clear crystalline calcite and shell fragments.
940′–955′	Limestone as above, buff, trace of pyrobitumen.
955′–960′	Limestone, brown, medium- to finely crystalline, scattered fossil evidence, slightly shaly; two fragments of limy dolomite, pale greenish grey; finely conglomeratic, sandy with interbedded quartz pebbles.

Depth	
960′–965′	Dolomite with quartz pebbles as above; some brown, finely crystalline limestone with dark brown bituminous partings.
965′–970′	Green shaly conglomerate with rounded frosted quartz pebbles.
970′–978′	Bright red quartz–feldspar granite.
	Total depth 978′

Formational summary:	(feet)
Missing	0–195
Whitby, upper member	195–290
Whitby, middle member	290–345
Whitby, lower member	345–385
Lindsay	385–645
Verulam, upper member	645–685
Verulam, lower member	685–850
Bobcaygeon, upper and middle members	850–870
Bobcaygeon, lower member	870–885
Gull River, upper and middle members	885–930
Gull River, lower member	930–965
Shadow Lake	965–970
Precambrian	970–978

Geological log of: D. Smith No. 1.

Location: Lot 11, con. III, Essa tp., Simcoe co.

Completed: 1953. Elevation: 750′.

Total depth: 2000′. Result: dry hole.

Rig: Standard Cable Tool.

Samples examined by: B. A. Liberty, 1953.

Depth	
0′–400′	Drift.
400′–405′	Limestone, dark grey, fine-grained, and grey, medium-grained limestone; much crystalline content, fossil fragments.
405′–420′	Limestone, dark grey and grey, fine-grained; trace medium-grained limestone; moderate amount of crystalline material.
420′–425′	Limestone, dark grey and grey, fine- and medium-grained; moderate amount of crystalline material; fossil fragments.
425′–435′	Limestone, dark grey, fine-grained, with some mottled grey, medium-grained limestone; moderate amount of crystalline material, fossil fragments.
435′–440′	Limestone, dark grey, fine-grained and grey, medium-grained limestone; moderate amount of crystalline material.
440′–445′	Same as 435′–440′; bentonite present.
445′–450′	Limestone, grey, fine-grained with some mottled blue and white medium-grained limestone; fossil fragments.
450′–455′	Limestone, grey, fine-grained, some crystalline content; fossil fragments, bentonite present.
455′–460′	Limestone, grey, medium-grained, with dark grey, fine-grained limestone; trace grey clastic limestone; some crystalline content; fossil fragments.
460′–465′	Limestone, dark grey, fine-grained, and grey, medium-grained limestone; much crystalline content; fossil fragments, ostracods, and brachiopods.

Depth	
465′–480′	Limestone, dark grey, fine-grained, some grey, medium-grained limestone; much crystalline content.
480′–485′	Limestone, grey, medium-grained, some dark grey, fine-grained limestone; moderate amount of crystalline material; fossil fragments.
485′–490′	Limestone, dark grey, fine-grained, and light grey, medium-grained limestone; some crystalline material; fossil fragments.
490′–495′	Limestone, dark grey and grey, fine-grained, with some mottled blue and white, medium-grained limestone; some crystalline material; fossil fragments.
495′–505′	Limestone, dark grey and grey, fine-grained, trace of brown, sublithographic limestone and mottled blue and grey, medium-grained limestone.
505′–510′	Limestone, dark grey, grey, light grey, fine-grained; fossil fragments.
510′–515′	Limestone, grey, fine-grained; trace of brown, sublithographic limestone; fossil fragments.
515′–520′	Limestone, grey, fine-grained, some dark grey, fine-grained limestone; fossil fragments, crinoid columnals, *Zygospira* sp.
520′–530′	Limestone, dark grey, grey and brown, fine-grained; minor amount of sublithographic limestone; ostracods.
530′–540′	Limestone, dark grey and brown, sublithographic, and some fine-grained grey limestone; bentonite.
540′–545′	Limestone, dark grey, fine-grained, minor amount of sublithographic limestone; fossil fragments, ostracods.
545′–550′	Limestone, dark grey and brown sublithographic, and fine-grained; conglomerate; fossil fragments.
550′–560′	Limestone, dark grey and brown sublithographic, and fine-grained; green unidentified mineral present; fossil fragments.
560′–570′	Limestone, dark grey, brownish grey, sublithographic to lithographic, some grey, fine-grained limestone, some crystalline content; bentonite.
570′–575′	Limestone, dark grey and brown, fine-grained and sublithographic, some crystalline content, trace of bentonite.
575′–580′	Limestone, dark grey and grey, fine- and medium-grained; much crystalline content.
580′–585′	Limestone, dark grey, fine-grained, some medium-grained limestone; fossil fragments.
585′–590′	Limestone, dark grey and grey, fine- and medium-grained.
590′–595′	Limestone, dark grey and grey, fine- and medium-grained.
595′–600′	Limestone, dark grey, grey, brown, and cream lithographic, some fine- and medium-grained limestone; traces of calcite and pyrite; fossil fragments.
600′–605′	Limestone, cream coloured, lithographic; pyrite; bentonite.
605′–610′	Limestone, dark grey, sublithographic and lithographic; fossil fragments.
610′–615′	Limestone, dark grey and grey, sublithographic; some grey, fine-grained limestone.
615′–620′	Limestone, dark grey, sublithographic and grey, fine-grained; fossil fragments.
620′–625′	Limestone, dark grey, fine-grained, some dark brownish grey sublithographic limestone; fossil fragments.
625′–630′	Limestone, dark grey, fine-grained; some sublithographic limestone, some thinly laminated shale; fossil fragments.
630′–635′	Limestone, dark grey, fine-grained and sublithographic; fossil fragments.
635′–640′	Limestone, dark grey and grey, fine-grained; some brown sublithographic limestone; fossil fragments.
640′–645′	Limestone, dark grey, fine-grained, some mottled blue and grey, medium-grained limestone; fossil fragments.
645′–650′	Limestone, dark grey, fine-grained, and grey, sublithographic limestone; fossil fragments.

Depth	
650′–655′	Limestone, dark grey, fine-grained; some cream, lithographic limestone; some blue and grey mottled, medium-grained limestone.
655′–660′	Limestone, dark grey, fine-grained; minor amount of grey, sublithographic limestone; minor amount thinly laminated limestone; pyrite.
660′–665′	Limestone, dark grey, fine-grained; some thinly laminated limestone; fossil fragments.
665′–′670	Limestone, dark grey and grey, fine-grained and sublithographic; fossil fragments, bryozoa and brachiopods.
670′–680′	Limestone, dark grey, fine-grained and sublithographic; pyrite traces; fossil fragments, *Rafinesquina* sp., trilobite and brachiopod fragments.
680′–690′	Limestone, grey and dark grey, fine-grained, and some brown, sublithographic limestone; minor amount of mottled blue and grey limestone; conglomerate; fossil fragments.
690′–695′	Limestone, grey and dark grey, fine-grained; some mottled blue and grey limestone; fossil fragments.
695′–700′	Limestone, grey, fine-grained; some mottled blue and grey, medium-grained limestone; conglomerate present; fossil fragments, brachiopods.
700′–705′	Limestone, grey, fine-grained; some pink feldspar, quartz, biotite.
705′–2000′	Pink feldspar, biotite quartz; pyrite; traces of greenish grey fine-grained limestone, probably cavings, in uppermost few feet.
	Total depth 2000′

Formational summary:	(feet)
Drift	0–400
Verulam, lower member	400–525
Bobcaygeon, upper and middle members	525–575
Bobcaygeon, lower member	575–595
Gull River, upper and middle members	595–665
Gull River, lower member	665–702
Precambrian	702–2000

Geological log of: H. Coakwell No. 1; Markham well.

Location: Lot 4, con. IX, Markham tp., York co.

Completed: February 1949. Elevation: 536.3′ (inst.).

Total depth: 1010′. Result: non-commercial gas well.

Rig: Standard Cable Tool.

Samples examined by: M. J. Quantz, 1949.

Depth	
0′–203′	Drift.
203′–233′	Shale, medium grey to dark brownish grey, finely micaceous, silty, grading into lighter grey, very calcareous, finely micaceous siltstone.
233′–245′	Shale, dark brownish grey, finely micaceous, slightly calcareous, and medium grey, hard, calcareous, silty to sandy.
245′–250′	Shale grading into lighter grey limy siltstone as above.
250′–280′	Shale, dark (pale brown streak) to medium (grey streak) grey, hard, finely micaceous, slightly calcareous.
280′–365′	Shale, dark grey, brown streak, hard, silty, slightly calcareous, widely scattered pyrite in upper section.
365′–375′	Shale, dark brownish grey, brown streak, hard, silty, calcareous, grading into dark brown, dense, shaly, pyritic limestone; some fossil evidence.

Depth		
375′–390′	Limestone,	pale greyish buff or brown to brownish grey, dense, very shaly, fossiliferous.
390′–460′	Limestone,	buff to greyish brown, dense, very shaly, slightly fossiliferous becoming more so with depth; trace of fragmental brown limestone throughout. 400′–405′ Grey dense limestone.
460′–510′	Limestone,	medium brownish grey to greyish brown, dense, very shaly, grading into limy shale with increasing depth, slightly fossiliferous with trace of fossiliferous fragmental brown limestone. 460′–465′ Limestone, brown, fragmental, as above. 480′–485′ Limestone, brown, fragmental, as above.
510′–530′	Limestone	as above grading into medium grey limy shale, also brown, coarsely crystalline, fragmental, fossiliferous, dolomitic (50–50%).
530′–535′	Limestone,	medium brownish grey grading into limy shale, and brown, fragmental, as above; metabentonite, pale brownish grey, pyritic.
535′–550′	Limestone,	brown to greyish brown, dense, or finely to coarsely crystalline, fragmental, fossiliferous, shaly in varying amounts.
550′–575′	Limestone	as above, speckled; shale, medium brownish or greenish grey, very limy, pyritic, rough appearance.
575′–590′	Limestone	as above; metabentonite, greenish.
590′–600′	Limestone,	brown, in part dense, very shaly, and in part fragmental; fossiliferous, medium to finely crystalline, shaly; shale, dark brownish grey, calcareous.
600′–605′	Limestone,	medium greyish brown, dense, shaly, in part fragmental; fossil evidence.
605′–610′	Limestone	as above grading into limy shale.
610′–640′	Limestone,	shades of greyish brown to dark brownish grey, coarsely to finely crystalline to dense, in part fragmental, fossiliferous, and in part very shaly, grading into limy dark grey shale as above. 625′–630′ Brown, finely crystalline, translucent limestone.
640′–665′	Limestone	and shale as above, intergrading.
665′–675′	Limestone	as above, coarsely to finely crystalline; a little shale grading into dense limestone as above.
675′–700′	Limestone,	greyish buff to greyish brown to dark brownish grey, dense, shaly to very shaly, some fossil evidence.
700′–715′	Limestone	as above, predominantly dark brownish grey, very shaly; and trace of fragmental fossiliferous limestone.
715′–755′	Limestone,	shades of greyish brown to dark brownish grey, coarsely to finely crystalline to dense, in part fragmental, fossiliferous, and in part very shaly, grading into dark grey limy shale.
755′–765′	Limestone	as above, fragmental to dense, very shaly, with trace of interbedded limy shale.
765′–770′	Limestone	and limy shale as above.
770′–810′	Limestone,	fragmental to dense, very shaly, as above.
810′–825′	Limestone,	predominantly dark brownish grey, dense, very shaly.
825′–845′	Limestone,	brown to shades of greyish brown, fragmental, fossiliferous, coarsely to finely crystalline or dense. 840′–845′ Dark grey limy shale and dark greenish metabentonite.
845′–855′	Limestone,	brown, finely crystalline to dense, shaly; blue chert.
855′–870′	Limestone	as above.
870′–875′	Limestone	as above with small amount of associated bituminous material; a fragment of brown translucent chert in sample.
875′–895′	Limestone,	buff, dense.

Depth	
895′–900′	Limestone, buff to brown, dolomitic, medium- to finely crystalline, shaly, slightly silty, some fragments exhibit oolitic structure.
900′–905′	Limestone, buff, dense, dolomitic, slightly shaly in part shaly, slightly silty.
905′–910′	Limestone, brown, finely crystalline to dense, dolomitic.
910′–915′	Limestone, buff to brown as above, silty, dolomitic.
915′–925′	Limestone, buff, finely crystalline to dense, dolomitic.
925′–935′	Limestone, brown, dolomitic, shaly, finely crystalline, in part lighter brown, dense.
935′–945′	Limestone, dolomitic, pale buff to light greyish, silty, finely crystalline, sugary-textured.
945′–950′	Dolomite, pale grey, finely crystalline, sugary-textured with scattered clean quartz pebbles, silty.
950′–955′	Shale, bright green, sandy, hard, with large pebbles scattered throughout.
955′–960′	Shale, bright green as above, also brick red; quartz pebbles.
960′–1010′	Pinkish granite and feldspar fragments.
	Total depth 1010′

Formational summary:	(feet)
Drift	0–203
Georgian Bay	203–250
Whitby	250–375
Lindsay	375–610
Verulam, upper member	610–640
Verulam, lower member	640–825
Bobcaygeon, upper and middle members	825–845
Bobcaygeon, lower member	845–870
Gull River, upper and middle members	870–898
Gull River, lower member	898–950
Shadow Lake	950–960
Precambrian	960–1010

Geological log of: Canadian National Exhibition No. 1.

Location: Middle of east side of Automotive Bldg., near Prince's Gate, Toronto, York co.

Completed: September, 1948.

Total depth: 1,000′.

Elevation: 255′ (est.).

Result: dry hole.

Rig: Rotary.

Samples examined by: M. J. Quantz, 1948.

Depth	
0′– 40′	Missing.
40′– 80′	Shale, grey, slightly calcareous, silty to sandy, grading into calcareous, shaly siltstone to very calcareous, fine-grained sandstone.
80′–110′	Shale, grey, silty, calcareous; sandstone, grey, fine-grained, calcareous; scattered fossil evidence throughout.
110′–140′	Shale and sandstone as above.
140′–150′	Shale and sandstone as above; limestone, brown, dense, silty to sandy, shaly, fossiliferous.
150′–180′	Shale and sandstone as above, fossiliferous.

Depth	
180′–210′	Shale, grey, calcareous, silty, finely micaceous; lesser amounts of sandstone as above.
210′–220′	Shale, grey, slightly calcareous, silty.
220′–230′	Shale, calcareous, as above; sandstone, grey, fine-grained, calcareous.
230′–250′	Shale, grey, silty to sandy, calcareous, hard, grading into fine-grained sandstone.
250′–260′	Shale, grey, silty, hard, calcareous.
260′–280′	Shale grading into sandstone as above.
280′–300′	Shale as above, silty to sandy.
300′–310′	Missing.
310′–340′	Shale, grey, hard, silty to sandy, calcareous.
340′–370′	Shale as above, silty.
370′–390′	Shale as above, silty to sandy. 380′–390′ Trace of fine-grained calcareous grey standstone.
390′–440′	Shale as above, silty.
440′–490′	Shale as above, silty, varying from calcareous to slightly so.
490′–550′	Shale, dark brownish grey, calcareous, brown streak.
550′–560′	Shale, dark brown, hard, very calcareous, grading into dense shaly limestone; scattered fossil evidence.
560′–580′	Limestone, brown, finely crystalline to dense, slightly dolomitic, very shaly, scattered fossil evidence.
580′–610′	Missing.
610′–630′	Limestone, brown, finely crystalline to dense, very shaly, scattered fossil evidence.
630′–650′	Limestone as above; shale, dark brownish grey, calcareous.
650′–660′	Limestone as above to coarser, fossiliferous, fragmental.
660′–690′	Limestone, brown, shaly, coarsely crystalline, fossiliferous, fragmental; a little shale, dark brownish grey, calcareous, to 670′. 680′–690′ Shale as above.
690′–700′	Missing.
700′–710′	Limestone as above.
710′–720′	Limestone, brown, shaly, medium- to coarsely crystalline, slightly silty, in part slightly dolomitic, fossiliferous, fragmental.
720′–730′	Missing.
730′–740′	Limestone as above.
740′–760′	Limestone as above, also darker brown, dense, very shaly, grading into limy shale.
760′–770′	Limestone as above; shale, dark brownish grey, calcareous.
770′–780′	Limestone, grey-buff, dense, dolomitic, very shaly, grading into calcareous shale, scattered fossils; shale, dark grey, hard, calcareous; metabentonite, greenish grey with brown mica flakes.
780′–790′	Limestone as above with scattered fossil fragments grading into shale as above.
790′–800′	Shale, dark grey, slightly calcareous, to greenish grey, very calcareous; some limestone as above.
800′–820′	Shale, dark grey to greenish, hard, very calcareous; limestone, brown, medium- to finely crystalline, in part coarse, shaly, some fossil evidence.
820′–830′	Shale and limestone as above; metabentonite, greenish grey with brown mica flakes.
830′–840′	Shale as above; limestone as above becoming coarser and more fossiliferous.
840′–870′	Missing.
870′–900′	Limestone, brown, fine- to coarsely crystalline, and dolomitic, shaly, some fossil evidence; shale, dark grey, hard, calcareous, grading into dense, shaly, brownish grey limestone.
900′–910′	Limestone, brown, fine- to coarsely crystalline, slightly shaly; shale, dark grey, calcareous.

Depth	
910′–930′	Missing.
930′–940′	Limestone and shale as above.
940′–960′	Missing.
960′–970′	Limestone as above, fine- to medium-crystalline; shale as above.
970′–980′	Missing.
980′–1000′	Limestone and shale as above.

Total depth 1000′

Formational summary:	(feet)
Missing	0– 30
Georgian Bay	30– 280
Whitby, upper member	280– 440
Whitby, middle member	440– 550
Whitby, lower member	550– 560
Lindsay	560– 690
Verulam, upper member	690– 720
Verulam, lower member	720– 895
Bobcaygeon	895–1000

APPENDIX D

Faunal Lists for Gull River, Bobcaygeon, Verulam, Lindsay, and Whitby Formations

(unless otherwise noted all fauna listed were collected and identified by B. A. Liberty)

1. Faunal List for Gull River Formation, Lower, Middle, and Upper Members

Coboconk village vicinity

	L	M	U
	Members		
Stromatoporoidea:			
Cryptophragmus sp.	x		
C. cf. *gracilis* (Ulrich)	x		
Stromatocerium rugosum Hall			x
Anthozoa:			
Lambeophyllum profundum (Conrad)			x
Tetradium cellulosum (Hall)	x		
T. fibratum Safford			x
T. halysitoides Raymond			x
T. cf. *syringoporoides* Ulrich			x
Brachiopoda:			
Öpikina minnesotensis (Winchell)	x		x
Rafinesquina sp.	x		x
R. cf. *trentonensis* (Conrad)	x		x
Strophomena sp.	x		x
S. cf. *minuta* Wilson	x		
Zygospira recurvirostris (Hall)			x
Pelecypoda:			
Ctenodonta cf. *gibberula* Salter			x
Gastropoda:			
Helicotoma sp.			x
H. planulata Salter			x
Holopea cf. *concinnula* Ulrich and Scofield	x		
Hormotoma sp.	x		x
H. gracilis (Hall)			x
Liospira sp.			x
Lophospira concinnula Ulrich and Scofield	x		
L. milleri (Hall)	x		
L. perangulata (Hall)	x		
Raphistomina lapicida (Salter)			x
Trochonema sp.			x

	Members L	M	U
Trilobita:			
Bathyurus cf. *extans* (Hall)			x
B. johnstoni Raymond			x
B. superbus Raymond	x		
Bumastus sp.			x
B. indeterminatus (Walcott)	x		
Calliops callicephalus (Hall)			x
Ostracoda:			
Eoleperditia fabulites (Conrad)			x
Isochilina sp.			x
Leperditia amygdalina Jones			x

2. Faunal List for Bobcaygeon Formation, Lower Member

C_2: upper submember, from Silver Lake East road-cut, lot 1, cons. 2 and 3, Galway tp.

C_1: B upper faunal zone / A lower faunal zone — lower submember, from vicinity of Coboconk village.

	Submembers C_{1A}	C_{1B}	C_2
Porifera:			
Receptaculites occidentalis Salter		x	
Stromatoporoidea:			
Solenopora 'compacta' (Billings)		x	x
Stromatocerium rugosum Hall	x	x	
S. cf. *rugosum* Hall			x
Anthozoa:			
Calapoecia canadensis Billings		x	
Foerstephyllum halli (Nicholson)	x	x	
Lambeophyllum profundum (Conrad)	x	x	
L. cf. *profundum* (Conrad)			x
Lichenaria sp.	x	x	x
L. coboconkensis Okulitch	x	x	x
Tetradium cellulosum (Hall)	x	x	
T. fibratum Safford	x		
Echinodermata:			
Glyptocrinus sp.		x	
Ottawacrinus typus W. R. Billings		x	
Bryozoa:			
Escharopora subrecta (Ulrich)			x
Graptodictya proava (Eichwald)		x	
Hallopora multitabulata (Ulrich)		x	
Nicholsonella sp.		x	x
Prasopora grandis (Ulrich)			x

	Submembers C_{1A}	C_{1B}	C_2
Brachiopoda:			
Camerella panderi Billings			x
Dinorthis cf. *meedsi germana* (Winchell and Schuchert)			x
Hesperorthis tricenaria (Conrad)		x	x
Öpikina sp.			x
Ö. clara Okulitch	x	x	
Ö. minnesotensis (Winchell)		x	
Parastrophina hemiplicata (Hall)			x
Paucicrura rogata (Sardeson)			x
Rafinesquina sp.			x
Rafinesquina alternata plana Wilson			x
Rafinesquina trentonensis (Conrad)	x	x	
Rhynchotrema increbescens (Hall)	x	x	x
Sowerbyella cf. *curdsvillensis* (Foerste)			x
S. sericea (Sowerby)			x
Strophomena sp.			x
S. incurvata (Shepard)	x	x	
S. cf. *incurvata* (Shepard)			x
Triplecia cuspidata (Hall)		x	x
Zygospira recurvirostris (Hall)	x	x	x
Pelecypoda:			
Ctenodonta sp.		x	
C. cf. *logani* Salter		x	
Whitella sp.			x
Gastropoda:			
Helicotoma planulata Salter	x	x	
Hormotoma gracilis (Hall)	x	x	
Liospira sp.	x	x	
Lophospira sp.	x	x	
Maclurites logani (Salter)		x	
Trochonema cf. *umbilicatum* (Hall)		x	
Cephalopoda:			
Actinoceras bigsbyi Bronn	x	x	
Trilobita:			
Bathyurus sp.	x	x	
Ceraurus dentatus Raymond and Barton		x	
C. pleurexanthemus Green	x	x	
C. cf. *pleurexanthemus* Green			x
Encrinurus sp.			x
Isotelus gigas DeKay		x	
I. cf. *iowensis* (Owen)			x
Ostracoda:			
Eoleperditia fabulites (Conrad)		x	
Leperditia sp.			x

3. Faunal List for Bobcaygeon Formation,
Middle and Upper Members
Middle: Little Bob quarry, lot 13, con. XIX, Harvey tp.
Upper: Kirkfield quarry, lots 31–32, con. IX, Eldon tp.
+2 to +36 feet only (with respect to quarry floor, in northwest corner).

	Members	
	M	U
Porifera:		
Pasceolus globosus Billings		x
Receptaculites sp.	x	x
R. occidentalis Salter	x	
Stromatoporoidea:		
Solenopora 'compacta' (Billings)	x	
Stromatocerium sp.	x	
Anthozoa:		
Calapoecia canadensis Billings	x	
Columnaria magnifica Okulitch	x	
Foerstephyllum halli (Nicholson)	x	
Lambeophyllum profundum (Conrad)	x	x
Lichenaria typa Winchell and Schuchert	x	
Lindströmia whiteavesi Foerste	x	
Streptelasma corniculum Hall	x	x
Tetradium cellulosum (Hall)	x	
Echinodermata:		
Astroporites ottawaensis Lambe		x
Cleiocrinus sp.		x
Cremacrinus rugosus (W. R. Billings)		x
Cupulocrinus humilis (Billings)		x
C. jewetti (Billings)		x
Cyclocystoides halli Billings		x
Edrioaster bigsbyi (Billings)		x
Glyptocrinus sp.		x
Glyptocystites grandis Sinclair		x
Hemicystites billingsi (Chapman)		x
Hybocystites sp.		x
Lichenocrinus sp.		x
Ottawacrinus sp.		x
O. typus W. R. Billings		x
Pleurocystites squamosus Billings		x
Bryozoa:		
Batostoma winchelli (Ulrich)		x
Dekayella trentonensis (Ulrich)		x
Escharopora subrecta (Ulrich)		x
Favositella laxata (Ulrich)		x
F. sp.		x
Hallopora multitabulata (Ulrich)		x
Hemiphragma ottawaense (Foord)		x
Homotrypa minnesotensis Ulrich		x

	Members M	Members U
Bryozoa (Cont.):		
H. subramosa Ulrich		x
Mesotrypa quebecensis (Ami)		x
Nicholsonella sp.	x	x
N. laminata Ulrich	x	
N. cf. *ponderosa* Ulrich	x	
N. wilsoni Fritz		x
Pachydictya acuta (Hall)		x
P. foliata Ulrich	x	x
Prasopora cf. *grandis* (Ulrich)		x
P. insularis Ulrich		x
P. simulatrix Ulrich		x
P. simulatrix orientalis Ulrich	x	
Rhinidictya sp.		x
R. mutabilis (Ulrich)	x	
Stictoporella cribrosa Ulrich		x
Brachiopoda:		
Camerella panderi Billings	x	
C. volborthi Billings	x	
Dinorthis iphigenia (Billings)		x
D. meedsi germana (Winchell and Schuchert)		x
D. cf. *meedsi plana* Wilson		x
D. pectinella (Emmons)		x
D. pectinella sweeneyi (N. H. Winchell)		x
Doleroides pervetus ottawanus Wilson		x
Drepanorhyncha cf. *ottawaensis* (Billings)	x	
Ectenoglossa cf. *philomela* (Billings)	x	
Hesperorthis tricenaria (Conrad)	x	x
Lingula briseis Billings		x
Microtrypa? cf. *plana* Wilson		x
Öpikina ampla Wilson	x	x
Ö. gloucesterensis Wilson		x
Ö. ovalis Wilson		x
Ö. cf. *ovalis* Wilson	x	
Ö. platys Wilson	x	x
Ö. rugosa (Wilson)	x	x
Ö. rugosa avita (Wilson)	x	
Ö. septata borealis Wilson	x	
Ö. wagneri (Okulitch)		x
Paucicrura rogata (Sardeson)	x	x
Platystrophia amoena McEwan		x
P. cf. *amoena longicardinalis* McEwan		x
P. trentonensis McEwan		x
P. uxoris Sinclair		x
Plectorthis ottawaensis Wilson		x
P. cf. *plicatella* (Hall)		x
P. plicatella trentonensis Foerste		x
Pseudolingula cf. *eva* (Billings)		x
P. rectilateralis major (Ruedemann)		x
Rafinesquina sp.	x	x
R. alternata alata Wilson	x	
R. cf. *alternata alata* Wilson	x	x
R. alternata intermedia Wilson	x	x
R. alternata plana Wilson	x	x
R. alternata platys Wilson		x
R. alternata semiquadrata Wilson	x	x

	Members M	U
Brachiopoda (Cont.):		
R. alternata transversa Wilson	x	
R. carlottina Wilson		x
R. cf. *deerensis* Salmon		x
R. cf. *lennoxensis* Salmon	x	
R. okulitchi Wilson		x
R. cf. *patula* Wilson		x
R. cf. *praecursor* Raymond		x
R. trentonensis (Conrad)	x	x
Resserella resupinata (Raymond)	x	x
R. whittakeri (Raymond)		x
Rhynchotrema increbescens (Hall)	x	x
R. intermedia Wilson		x
Skenidioides? *merope* (Billings)	x	x
Sowerbyella curdsvillensis (Foerste)		x
S. cf. *curdsvillensis* (Foerste)	x	
S. sericea (Sowerby)	x	x
S. punctostriata (Mather)		x
S. subovalis Wilson		x
Strophomena dignata Fenton	x	x
S. extensa Wilson		x
S. incurvata (Shepard)	x	
S. cf. *filitexta crenulata* Wilson		x
S. magna Wilson	x	x
S.? *millionensis affinis* Wilson	x	
S. planumbona (Hall)	x	
S. planumbona praecipita Wilson	x	
Trematis cf. *ottawaensis* Billings		x
Triplecia cuspidata (Hall)	x	
Zygospira deflecta (Hall)		x
Z. recurvirostris (Hall)	x	x
Pelecypoda:		
Ambonychia sp.		x
A. orbicularis (Emmons)	x	
Ctenodonta gibberula Salter	x	
C. nasuta robusta Ulrich	x	
C. cf. *nasuta robusta* Ulrich		x
Cyrtodonta obtusa (Hall)		x
Whitella subtruncata (Hall)	x	
Gastropoda:		
Bucania halli Ulrich and Scofield	x	
Cyclonema cf. *cushingi* Ruedemann	x	
C. cf. *montrealense* Billings		x
cf. *Daidia cerithioides* (Salter)	x	
Eccyliomphalus sp.		x
E. cf. *ottawaensis* (Billings)	x	
Eotomaria larvata (Salter)		x
E. cf. *larvata* (Salter)	x	
Helicotoma cf. *planulata* Salter	x	
Holopea sp.		x

	Members M	U
Gastropoda (Cont.):		
Hormotoma bellicincta (Hall)	x	
H. gracilis (Hall)	x	x
H. salteri canadensis Ulrich and Scofield	x	x
H. simplex Wilson	x	x
H. simplex paquettensis Wilson	x	
H. trentonensis (Hall)	x	x
H. trentonensis crassa Wilson	x	
Liospira cf. *progne* (Billings)		x
Lophospira medialis Ulrich and Scofield	x	
L. perangulata (Hall)	x	
L. procris (Billings)	x	
L. serrulata (Salter)	x	
Maclurites logani (Salter)	x	
Phragmolites compressus Conrad	x	x
Pterotheca sp.	x	
Raphistomina aperta (Salter)		x
R. distincta Wilson		x
R. lapicida (Salter)		x
Salpingostoma cf. *billingsi* Wilson		x
Sinuites cancellatus (Hall)	x	x
S. cancellatus angularis Wilson		x
S. cf. *cancellatus liratus* Wilson	x	
Straparollina sp.	x	
S. cf. *asperostriata* Billings		x
Subulites conradi Ulrich and Scofield	x	x
S. regularis Ulrich and Scofield		x
Trochonema umbilicatum Hall	x	
Tropidodiscus? *disculus* (Billings)		x
Cephalopoda:		
Endoceras proteiforme Hall		x
Gonioceras sp.	x	
'Orthoceras' sp.	x	x
'O.' arcuoliratum Hall		x
'Spyroceras' bilineatum (Hall)	x	
Conularida:		
Conularia trentonensis Hall		x
Trilobita:		
Achatella sp.	x	
cf. *Achatella achates* (Billings)	x	
Bathyurus acutus Raymond		x
B. extans (Hall)		x
B. cf. *trispinosus* Wilson	x	
Bumastoides milleri (Billings)		x
Bumastus sp.	x	x
Calliops narrawayi Okulitch		x
C. callicephalus (Hall)	x	
Ceraurus cf. *bispinosus* Raymond and Barton	x	
C. dentatus Raymond and Barton	x	x

Trilobita (Cont.):	Members M	U
C. pleurexanthemus Green	x	x
Chasmops sp.		x
C. bebryx (Billings)		x
Encrinurus cybeleformis Raymond		x
E. trentonensis Walcott		x
Flexicalymene senaria (Conrad)		x
Illaenus cf. *conradi* Billings		x
Isotelus gigas DeKay	x	x
I. iowensis (Owen)	x	x
I. cf. *maximus* Locke	x	
Proetus sp.		x
Pterygometopus sp.		x
Raymondites ingalli (Raymond)	x	x
R. cf. *ingalli* (Raymond)	x	x
R. cf. *spiniger* (Hall)	x	x
Ostracoda:		
Eoleperditia fabulites (Conrad)	x	x
Leperditia sp.	x	x
L. trentonensis Wilson		x

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4. Faunal List for Verulam Formation

L: Lower member, whose collecting localities, in ascending stratigraphic order, are:

K: Kirkfield quarry (36–43 feet), lots 31–32, con. IX, Eldon tp.
S9: Ancona Point, lot 12, con. V, Verulam tp.
S8: Cedar Glen, lot 11, con. III, Verulam tp.
S1: Sturgeon Heights Cottage section, lot 9, con. XI, Fenelon tp.
S2: Sturgeon Heights Culvert section, lot 9, con. XI, Fenelon tp.
S5: Eldon Hill No. 3 section, lot 19, con. VIII, Eldon tp.
S7: Zion South section, lot 10, con. IV, Fenelon tp.

U: Upper member, whose collecting localities, in ascending stratigraphic order, are:

S7: Zion South section, lot 10, con. IV, Fenelon tp.
S4: Eldon Hill No. 5 Spring section, lot 21, con. VII, Eldon tp.
S3: Cobourg Hill No. 1, west railway-cut, lot 16, con. VII, Eldon tp.
S6: Cobourg Hill No. 1, west railway-cut, lot 15, cons. VII–VIII, Eldon tp.

G: General collection.

	Lower member							Upper member				G
	K	S						S				
		9	8	1	2	5	7	7	4	3	6	
Markings:												
Licrophycus minor Billings										x		
Porifera:												
Ischadites sp.												x
Graptozoa:												
Diplograptus cf. *amplexicaulis pertenuis* Ruedemann			x									
D. sp.				x								
Climacograptus sp.							x					
Anthozoa:												
Streptelasma sp.					x							
S. corniculum Hall			x			x					x	
Tetradium cellulosum (Hall)									x			
Enchinodermata:												
Amygdalocystites florealis Billings						x						
Isorophusella incondita (Raymond)				x								
Palaeocrinus pulchellus Billings						x						
Pleurocystites sp.										x	x	
Porocrinus conicus Billings						x						
Reteocrinus sp.											x	
Bryozoa:												
Batostoma sp.	x											
B. cf. *superbum* (Foord)			x									
B. winchelli (Ulrich)							x					
Corynotrypa inflata (Hall)					x					x		
Dekayella trentonensis (Ulrich)				x			x			x	x	
D. cf. *trentonensis* (Ulrich)								x				
cf. *D. trentonensis* (Ulrich)									x			
Dekayia sp.										x		
Dekayia typica Fritz										x		
D. cf. *typica* Fritz				x		x						
Dianulites sp.									x			
Eridotrypa aedilis (Eichwald)	x	x	x	x			x		x	x		
Escharopora sp.							x					
E. cf. *subrecta* (Ulrich)							x					
Favositella laxata (Ulrich)						x						
Hallopora ampla (Ulrich)		x			x	x			x			
H. cf. *ampla* (Ulrich)			x									
H. dumalis magna Fritz				x		x						
H. cf. *dumalis* (Ulrich)							x					
H. multitabulata (Ulrich)	x	x			x					x		
Hemiphragma cf. *shermanense* Fritz				x								
Homotrypa minnesotensis Ulrich	x											
H. cf. *minnesotensis* Ulrich		x										
cf. *H. minnesotensis* Ulrich							x					
H. similis Foord						x						
Mesotrypa angularis parvatrypa Fritz	x	x		x						x		

	Lower member							Upper member				G
	K	S						S				
		9	8	1	2	5	7	7	4	3	6	
Bryozoa (Cont.):												
M. cf. *infida* (Ulrich)				x								
M. quebecensis (Ami)	x						x					
cf. *M. spinosa* Ulrich					x							
M. whiteavesi (Nicholson)	x					x	x					
Pachydictya acuta (Hall)				x	x						x	
P. foliata Ulrich											x	
Prasopora grandis (Ulrich)	x											
P. insularis Ulrich	x											
P. simulatrix Ulrich	x	x	x	x			x					
P. cf. *simulatrix* Ulrich					x							
P. simulatrix orientalis Ulrich	x	x					x	x				
Prasoporina selwyni (Nicholson)						x	x	x	x	x		
P. semioculata Fritz		x	x				x					
Rhinidictya mutabilis (Ulrich)						x		x				
Stictoporella sp.					x			x				
Brachiopoda:												
Catazyga sp.				x								
Camerella sp.				x								
Dinobolus sp.				x	x	x						
D. canadensis (Billings)										x		
D. cf. *canadensis* (Billings)						x						
Dinorthis browni Wilson				x								
D. cf. *browni* Wilson			x									
D. cf. *calderi* Wilson				x							x	
D. iphigenia (Billings)				x		x						
D. cf. *iphigenia* (Billings)		x									x	
D. iphigenia media Wilson											x	
D. cf. *meedsi plana* Wilson			x									
D. cf. *ottawaensis* Wilson											x	
D. pectinella (Emmons)	x	x	x		x	x					x	
D. cf. *pectinella* (Emmons)										x		
D. pectinella sweeneyi (N. H. Winchell)				x	x					x	x	
D. cf. *pectinella sweeneyi* (N. H. Winchell)			x			x						
Doleroides sp.					x							
D. cf. *gibbosus* (Billings)					x							
D. pervetus ottawanus Wilson					x	x						
D. cf. *pervetus ottawanus* Wilson			x									
Glyptorthis cf. *bellarugosa* (Conrad)					x							
Hesperorthis tricenaria (Conrad)				x	x							
H. cf. *tricenaria* (Conrad)						x						
Lingula sp.	x	x	x		x		x		x			
L. cf. *briseis* Billings					x							
L. cf. *elongata* Hall				x								
L. cf. *friabilis* Sinclair					x							
L. huronensis Billings				x								
L. narrawayi Wilson							x					
L. obtusa Hall					x							
L. placibilis Sinclair										x		
L. prolixa Sinclair				x								

	Lower member							Upper member				G
	K	S						S				
		9	8	1	2	5	7	7	4	3	6	
Brachiopoda (Cont.):												
L. progne Billings				x								
L. riciniformis Hall				x								
L. cf. *riciniformis* Hall			x									
L. scutum Sinclair	x											
L. cf. *scutum* Sinclair				x								
L. trentonensis Conrad		x	x	x								
L. cf. *trentonensis* Conrad					x							
cf. *Pseudolingula eva*			x									
Microtrypa altilis Wilson						x						
Öpikina auriculata Wilson							x					
Ö. platys Wilson	x		x				x	x		x	x	
Ö. rugosa (Wilson)				x			x		x	x	x	
Ö. cf. *rugosa* (Wilson)								x				
Ö. rugosa avita (Wilson)				x			x			x	x	
Ö. septata borealis Wilson						x						
Ö. cf. *septata borealis* Wilson											x	
Ö. cf. *sinclairi* Wilson											x	
Ö. tumida Wilson						x						
Ö. cf. *wagneri* (Okulitch)											x	
Parastrophina hemiplicata (Hall)			x	x						x	x	
Paucicrura rogata (Sardeson)	x	x	x	x	x	x	x	x	x	x	x	
Pholidops trentonensis Hall		x	x	x	x					x		
Pionodema sp										x		
Platystrophia amoena McEwan	x											
P. amoena longicardinalis McEwan	x		x									
P. cf. *elegantula* McEwan	x											
P. felis Sinclair	x					x						
P. hermitagensis McEwan			x									
P. cf. *hermitagensis* McEwan											x	
P. preponderosa McEwan	x					x						
P. sera Sinclair				x								
P. trentonensis McEwan	x	x	x									
P. cf. *trentonensis* McEwan				x		x					x	
P. uniplicata McEwan	x											
P. uxoris Sinclair	x					x						
P. cf. *uxoris* Sinclair			x		x							
Plectorthis sp							x					
P. ottawaensis Wilson							x					
P. plicatella (Hall)			x	x								
P. pulchella Wilson			x									
P. cf. *pulchella* Wilson					x							
Pseudolingula rectilateralis (Emmons)				x								
Rafinesquina alternata alata Wilson				x	x						x	
R. alternata intermedia Wilson	x	x	x	x	x	x	x	x	x	x	x	
R. alternata plana Wilson	x	x	x	x	x	x	x	x	x	x	x	
R. alternata platys Wilson							x				x	
R. alternata pota Wilson					x		x					
R. alternata quadrata Wilson				x			x					
R. alternata transversa Wilson			x	x	x	x						
R. calderi Wilson				x			x					
R. camerata (Conrad)				x			x					

	Lower member							Upper member				G
	K	**S**						**S**				
		9	8	1	2	5	7	7	4	3	6	
Brachiopoda (Cont.):												
R. carlottina Wilson	x											
R. cf. *carlottina* Wilson				x					x			
R. cf. *deerensis* Salmon					x							
R. deltoidea (Conrad)			x	x	x	x	x					
R. equipunctata Wilson				x								
R. esmondensis borealis Wilson				x			x		x	x		
R. cf. *esmondensis borealis* Wilson					x							
R. gibbosa Wilson					x	x						
R. normalis Wilson					x							
R. normaloides Wilson				x	x						x	
R. cf. *okulitchi* Wilson						x				x		
R. cf. *orleansensis* Wilson									x			
R. cf. *patula* Wilson									x			
R. praecursor Raymond				x								
R. praedeltoidea Wilson					x	x					x	
R. prestonensis Salmon				x								
R. salmoni Wilson					x							
R. cf. *sardesoni* Salmon?				x								
R. semicircularis Wilson										x		
R. trentonensis (Conrad)	x	x	x	x	x	x	x	x	x	x	x	
Resserella whittakeri (Raymond)										x	x	
Rhynchotrema increbescens (Hall)	x	x	x	x	x	x	x	x	x	x	x	
R. intermedia Wilson			x	x	x	x			x			x
Skenidioides? *merope* (Billings)						x	x			x		
Sowerbyella cf. *curdsvillensis* (Foerste)		x	x	x	x		x		x	x	x	
S. minuta Wilson										x		
S. punctostriata (Mather)	x	x			x	x	x					
S. cf. *punctostriata* (Mather)									x			
S. sericea (Sowerby)	x	x	x	x	x	x	x	x	x	x	x	
S. subovalis Wilson			x	x	x	x	x			x	x	
Strophomena sp			x									
S. billingsi Winchell and Schuchert				x	x							
S. cf. *billingsi* Winchell and Schuchert							x			x		
S. delicatula Fenton							x			x		
S. cf. *dignata* Fenton										x	x	
S. cf. *extensa* Wilson				x								
S. incurvata (Shepard)					x					x		
Trematis ottawaensis Billings						x						
T. cf. *ottawaensis* Billings	x		x		x	x	x					
Valcourea cf. *deflecta* (Conrad)											x	
Vellamo trentonensis (Raymond)										x	x	
V. cf. *trentonensis* (Raymond)							x					
Zygospira deflecta (Hall)		x	x	x	x				x			
Z. recurvirostris (Hall)	x	x	x	x	x		x	x	x	x	x	
Pelecypoda:												
Ambonychia sp	x									x		
A. amygdalina Hall											x	
A. orbicularis (Emmons)					x							
A. cf. *orbicularis* (Emmons)	x					x						
Cleidophorus sp											x	

	Lower member							Upper member				G
	K	S						S				
		9	8	1	2	5	7	7	4	3	6	
Pelecypoda (Cont.):												
Clionychia undata (Emmons)	x											
Ctenodonta albertina Ulrich					x							
C. compressa (Ulrich)										x		
C. cf. *compressa* (Ulrich)				x								
C. cf. *filistriata* Ulrich				x								
C. logani Salter							x					
C. cf. *logani* Salter											x	
C. cf. *madisonensis* Ulrich											x	
C. nasuta (Hall)				x			x	x			x	
C. nitida (Ulrich)					x							
C. scofieldi Ulrich					x							
C. cf. *simulatrix* Ulrich	x											
Cuneamya sp											x	
Cyrtodonta glabella (Ulrich)						x						
C. obesa Ulrich					x							
C. obtusa (Hall)					x	x						
C. subangulata (Hall)	x											
Endodesma cf. *gesneri* (Billings)										x		
E. cf. *orthonotum* (Meek and Worthen)						x						
Matheria rugosa Ulrich											x	
Modiolopsis sp					x							
M. concava Ulrich		x							x			
M. lata Hall						x						
M. cf. *lata* Hall										x		
Orthodesma cf. *canaliculatum* Ulrich							x					
Paramodiola sp											x	
Plethocardia suberecta Ulrich											x	
Saffordia cf. *modesta* (Ulrich)					x							
S. cf. *ventralis* Ulrich											x	
Vanuxemia abrupta Ulrich											x	
V. dixonensis Meek and Worthen											x	
V. media Ulrich											x	
V. terminalis (Ulrich)						x						
V. cf. *terminalis* (Ulrich)				x								
Whitella sp						x						
W. compressa Ulrich											x	
W. cf. *truncata* Ulrich									x			
Gastropoda:												
Bucania halli Ulrich and Scofield	x							x			x	
B. punctifrons (Emmons)										x		
B. cf. *punctifrons* (Emmons)							x					
Carinaropsis acuta Ulrich and Scofield				x								
Cyclonema gracile Ulrich					x					x	x	
C. cf. *montrealense* Billings							x					
Eccyliomphalus ottawaensis (Billings)										x		
Eotomaria sp				x	x	x						
E. dryope (Billings)											x	
E. cf. *dryope* (Billings)						x						
E. dryope plana Wilson										x		
Fusispira angusta Ulrich and Scofield				x								

	Lower member							Upper member				G
	K	S						S				
		9	8	1	2	5	7	7	4	3	6	
Gastropoda (Cont.):												
F. subfusiformis (Hall)				x								
Helicotoma sp.							x	x				
H. planulata Salter				x								
H. spinosa Salter											x	
Holopea nereis Billings					x							
H. paludiniformis Hall					x							
Hormotoma bellicincta (Hall)					x	x	x					
H. gracilis (Hall)	x			x	x	x	x		x	x	x	
H. cf. *major* (Hall)						x						
H. salteri canadensis Ulrich and Scofield				x	x	x	x	x	x	x	x	
H. simplex Wilson					x	x	x				x	
H. simplex paquettensis Wilson					x	x					x	
H. trentonensis (Hall)		x				x				x	x	
H. trentonensis crassa Wilson					x	x						
H. trentonensis plana Wilson					x							
Liospira americana (Billings)					x	x						
L. micula (Hall)			x	x		x					x	
L. cf. *micula* (Hall)					x							
L. progne (Billings)					x					x	x	
L. cf. *progne* (Billings)			x			x						
Lophospira augustina (Billings)							x					
L. perangulata (Hall)				x	x	x	x			x	x	
L. perforata Ulrich and Scofield					x		x					
L. saffordi Ulrich and Scofield					x					x	x	
L. serrulata (Salter)					x		x					
L. ventricosa (Hall)				x	x		x			x		
L. cf. *ventricosa* (Hall)											x	
Omospira alexandra (Billings)					x		x			x		
Raphistomina aperta (Salter)				x								
R. distincta Wilson						x						
R. lapicida (Salter)			x	x	x							
R. rugata Ulrich and Scofield			x									
R. cf. *rugata* Ulrich and Scofield						x						
Salpingostoma expansum (Hall)						x	x					
S. cf. *expansum* (Hall)			x					x				
Sinuites bilobatus (Sowerby)			x									
S. bilobatus corrugatus (Hall)			x	x	x						x	
S. cancellatus (Hall)	x		x	x	x	x	x	x	x	x	x	
S. cancellatus angularis Wilson	x		x	x	x					x	x	
cf. *Straparollina* sp.									x			
Subulites sp.									x			
Subulites elongatus Conrad												x
Trochonema fragile Ulrich and Scofield							x				x	
T. umbilicatum Hall				x	x		x				x	
T. umbilicatum canadense Ulrich and Scofield					x							
T. vagrans Ulrich and Scofield											x	
Tropidodiscus? *disculus* (Billings)		x			x						x	
T.? cf. *disculus* (Billings)				x						x		

	Lower member							Upper member				G
	K	S						S				
		9	8	1	2	5	7	7	4	3	6	
Cephalopoda:												
Endoceras proteiforme Hall				x			x					
E. cf. *proteiforme* Hall	x											
'*Orthoceras*' sp.		x					x					
Conularida:												
Climacoconus sp.	x											
Conularia sp.							x					
C. trentonensis Hall				x	x	x	x				x	
Trilobita:												
Achatella achates (Billings)						x					x	
cf. *Achatella achates* (Billings)							x					
Achatella cf. *billingsi* Sinclair								x				
Bumastoides billingsi (Raymond and Narraway)				x						x		
Bumastus sp.										x		
B. indeterminatus (Walcott)				x								
Calliops callicephalus (Hall)		x		x	x		x					
C. narrawayi Okulitch		x		x								
Calyptaulax sp.									x			
C. alatus Okulitch							x					
C. calderi Wilson							x					
Ceraurinus marginatus Barton						x						
Ceraurus sp.	x											
C. dentatus Raymond and Barton				x	x		x			x		
C. pleurexanthemus Green					x	x	x			x		
cf. *Cryptolithus* sp.				x								
Encrinurus sp.										x		
E. cybeleformis Raymond	x			x								
E. trentonensis Walcott	x			x								
Eobronteus cf. *lunatus* (Billings)					x							
Flexicalymene senaria (Conrad)	x	x	x	x	x	x	x			x	x	
Hemiarges paulianus (Clarke)												x
H. cf. *paulianus* (Clarke)	x						x					
Illaenus americanus Billings			x				x			x	x	
Isotelus sp.			x	x					x	x		
I. gigas DeKay	x	x		x	x	x	x	x				
I. cf. *iowensis* (Owen)				x	x							
I. cf. *maximus* Locke					x		x	x				
Raymondites ingalli (Raymond)					x	x	x					
R. cf. *ingalli* (Raymond)				x						x		
cf. *Sphaerocorphe* sp.				x								
Annelida:												
Staurocephalites sp.				x								

5. Faunal List of Lindsay Formation

Fossils were collected by Dr. J. F. Caley and/or the writer; they were identified by officers of the Geological Survey of Canada

C: Craigleith vicinity, Georgian Bay area

S: Kirkfield vicinity, Lake Simcoe area

	Areas C	Areas S
Graptozoa:		
Desmograptus cancellatus (Hopkinson)	x	
Mastigograptus sp.	x	
Anthozoa:		
Streptelasma corniculum Hall	x	
Echinodermata:		
Cheirocrinus granulosus Parks	x	
C. logani (Billings)	x	
cf. *Dendrocrinus alternatus* (Hall)	x	
cf. *Ectenocrinus* sp.	x	
cf. *Schizocrinus nodosus* Hall	x	x
Bryozoa:		
Batostoma evansi Sproule	x	
B. cf. *humila* Ulrich	x	x
Coeloclema trentonensis (Ulrich)	x	
Diplotrypa neglecta Ulrich	x	
Mesotrypa prolifica Fritz	x	
Monotrypa undulata (Nicholson)	x	
Nematopora cf. *ovalis* Ulrich	x	
Paleschara sp.		x
Prasopora patera Ulrich and Bassler	x	
Rhinidictya neglecta canadensis Ulrich	x	
Brachiopoda:		
Catazyga headi filistriata Sproule	x	x
Cyclospira bisulcata (Emmons)	x	x
'Dalmanella' emacerata (Hall)	x	
Dinorthis sp.	x	
D. iphigenia (Billings)	x	
D. meedsi (Winchell and Schuchert)	x	
D. cf. *pectinella* (Emmons)		x
Glyptorthis bellarugosa (Conrad)	x	x
Hebertella occidentalis (Hall)	x	
Hesperorthis tricenaria Conrad	x	
Lingula cobourgensis Billings	x	x
L. rotunda Parks	x	
Öpikina platys Wilson		x
Ö. rugosa (Wilson)		x
Orbiculoidea lamellosa (Hall)	x	
Paucicrura rogata (Sardeson)	x	x
Parastrophina hemiplicata (Hall)	x	x
Platystrophia cf. *trentonensis* McEwan	x	x
P. amoena McEwan	x	

	Areas C	Areas S
Brachiopoda (Cont.):		
P. elegantula McEwan	x	
P. extensa McEwan	x	
Rafinesquina alternata intermedia Wilson		x
R. alternata plana Wilson		x
R. declivis (James)		x
R. deltoidea (Conrad)	x	x
R. nasuta (Conrad)	x	
R. robusta Wilson	x	
R. cf. *sardesoni* Salmon	x	
Rhynchotrema increbescens (Hall)	x	x
R. intermedia Wilson	x	x
Sowerbyella curdsvillensis (Foerste)	x	
S. minnesotensis (Sardeson)	x	
S. punctostriata (Mather)		x
S. sericea (Sowerby)	x	x
S. subovalis Wilson	x	x
Strophomena billingsi Winchell and Schuchert	x	x
S. incurvata (Shepard)	x	
Triplecia cf. *extans* (Emmons)	x	
Zygospira recurvirostris (Hall)	x	x
Pelecypoda:		
Ambonychia sp.	x	
Ctenodonta alta (Hall)	x	
Vanuxemia sp.		x
Whitella ventricosa (Hall)	x	
Gastropoda:		
Clathrospira subconica (Hall)	x	
Fusispira cf. *angustata* Ulrich and Scofield	x	
F. nobilis Ulrich and Scofield	x	
F. subfusiformis (Hall)	x	x
F. ventricosa Hall	x	
Helicotoma spinosa Salter		x
Hormotoma bellicincta (Hall)	x	
H. cf. *gracilis* (Hall)	x	x
H. cf. *salteri* Ulrich	x	
H. salteri canadensis Ulrich		x
H. simplex Wilson	x	x
H. trentonensis Ulrich and Scofield	x	x
Liospira americana (Billings)	x	
L. micula (Hall)	x	
L. vitruvia (Billings)	x	
Lophospira elevata Ulrich and Scofield	x	
L. medialis Ulrich and Scofield	x	
L. milleri (Hall)	x	
L. perangulata (Hall)		x
Salpingostoma expansum (Hall)	x	
Sinuites bilobatus corrugatus (Hall)		x
S. cancellatus (Hall)	x	x
S. cancellatus angularis Wilson		x
Subulites elongatus Conrad	x	x
Trochonema umbilicatum (Hall)	x	x
Tropidodiscus? sp.		x

	Areas C	S
Cephalopoda:		
Beloitoceras parksi Sproule	x	
Cameroceras trentonensis Conrad	x	
'Cyrtoceras' sp.	x	
Endoceras proteiforme Hall	x	
Ephippiorthoceras sigmoidale Fritz	x	
Geisonoceras amplicameratum (Hall)	x	
Probillingsites primus Fritz	x	x
Sactoceras typicale Parks	x	
'Spyroceras' bilineatum (Hall)	x	
Trocholites ammonius Conrad	x	
Conularida:		
Conularia trentonensis Hall	x	x
Trilobita:		
Acrolichas sp.		x
Ceraurinus confluens Barton	x	
C. marginatus Barton	x	
Ceraurus dentatus Raymond and Barton	x	
C. pleurexanthemus Green	x	x
Flexicalymene senaria (Conrad)	x	
F. meeki (Foerste)	x	
Illaenus americanus Billings	x	x
Isotelus gigas DeKay	x	x
I. cf. *maximus* Locke	x	
Pseudogygites canadensis (Chapman)	x	x

6. Faunal List for Whitby Formation, Lower Member

Fossils were collected by Dr. J. F. Caley and/or the author; they were identified by officers of the Geological Survey of Canada

C: Craigleith vicinity, Georgian Bay area

O: Oshawa Creek, Lake Ontario area

	Areas C	O
Graptozoa:		
Climacograptus aequalis Parks	x	
C. prolificus Parks	x	
C. typicalis Hall	x	x
Diplograptus sp.	x	
Glossograptus quadrimucronatus (Hall)	x	x
Lasiograptus eucharis (Hall)	x	
Leptograptus flaccidus (Hall)	x	
Phycograptus cf. *laevis* (Hall)	x	
Echinodermata:		
Glyptocrinus sp.	x	
Lichenocrinus sp.	x	
Schizocrinus cf. *nodosus* Hall	x	
Bryozoa:		
Paleschara sp.	x	x

	Areas C	O
Brachiopoda:		
'Dalmanella' emacerata (Hall)	x	x
'D'. rugostriata Parks and Dyer	x	
Lingula cobourgensis Billings	x	x
L. curta Conrad	x	
L. obtusa Hall	x	
L. philomela Billings	x	
L. progne Billings	x	x
Leptaena 'rhomboidalis' (Wilckens)	x	
Leptobolus insignis Hall	x	x
Paucicrura rogata (Sardeson)	x	x
Rafinesquina camerata (Conrad)	x	
R. cf. *sardesoni* Salmon	x	
R. trentonensis (Conrad)	x	
Sowerbyella minnesotensis (Sardeson)	x	
S. sericea (Sowerby)	x	x
Strophomena incurvata (Shepard)	x	
Zygospira modesta (Hall)	x	x
Pelecypoda:		
Ctenodonta elongata Parks	x	
C. georgina Parks	x	
C. cf. *levata* (Hall)	x	
C. pulchella (Hall)		x
C. cf. *pulchella* (Hall)	x	
cf. *Goniophora carinata* (Hall)	x	
Modiolopsis brevis Parks	x	
M. cf. *oweni* Ulrich	x	
cf. *Rhytimya compressa* Ulrich	x	
Gastropoda:		
Eccyliomphalus sp.		x
Trochonema cf. *umbilicatum* (Hall)		x
Pleurotomaria sp.	x	
Cephalopoda:		
Endoceras proteiforme Hall	x	
Geisonoceras tenuistriatum (Hall)	x	x
'Spyroceras' bilineatum (Hall)	x	
Annelida:		
Serpulites serratus Parks	x	
S. isolatus Parks	x	
Conularida:		
Conularia trentonensis latior Ruedemann	x	
Trilobita:		
Ceraurus dentatus Raymond and Barton	x	
Flexicalymene meeki (Foerste)	x	
Homotelus stegops (Green)	x	
Illaenus americanus Billings	x	
Isotelus platycephalus (Stokes)	x	
Pseudogygites canadensis (Chapman)	x	x
Triarthrus canadensis Smith	x	
T. eatoni (Hall)	x	x
T. cf. *huguensis* Foerste	x	
Ostracoda:		
Primitiella ulrichi (Jones)	x	

7. Faunal List for Whitby Formation, Middle Member

P: Pickering
R: Rouge River } Lake Ontario area
W: Whitby

	Localities P	R	W
Graptozoa:			
Climacograptus typicalis Hall	x		x
Glossograptus quadrimucronatus (Hall)			x
Brachiopoda:			
Leptobolus insignis Hall	x	x	x
Lingula sp.			x
Pelecypoda:			
cf. *Prolobella corrugata* Ruedemann			x
Cephalopoda:			
cf. *Cycloceras persculptum* Ruedemann	x	x	x
Geisonoceras tenuistriatum (Hall)	x	x	x
'Orthoceras' cf. *transversum* Miller	x		x
Trilobita:			
Triarthrus canadensis Smith	x	x	x
T. spinosus rougensis Parks	x	x	
Ostracoda:			
Primitiella ulrichi (Jones)		x	x

8. Faunal List for Whitby Formation, Upper Member

Camperdown vicinity on Nottawasaga Bay, Ontario.

Fossils were collected by Dr. J. F. Caley and the author; they were identified by officers of the Geological Survey of Canada.

Graptozoa:

Climacograptus prolificus Parks
C. rougensis Parks
Diplograptus montis Parks
D. cf. *vespertinus* Ruedemann
Glossograptus quadrimucronatus (Hall)
Leptograptus flaccidus (Hall)
Mastigograptus tenuiramosus (Walcott)

Bryozoa:

Aspidopora sp.
Paleschara beani (James)
Spatiopora delicatula Parks

Brachiopoda:

'Dalmanella' fultonensis lorrainensis (Ruedemann)
Leptaena cf. *moniquensis* Foerste
Leptobolus insignis Hall
Lingula cf. *curta* Conrad
Pholidops cincinnatiensis Hall
Sowerbyella cf. *rugosa clarkesvillensis* (Foerste)

Pelecypoda:

Cleidophorus neglectus Hall
C. planulatus (Conrad)
Ctenodonta filistriata Ulrich
Lyrodesma conradi Ulrich

Gastropoda:

Archinacella cf. *subcarinata* (Ruedemann)
Liospira cf. *micula* (Hall)
Tetranota cf. *rugosa* Ruedemann

Cephalopoda:

cf. *Cycloceras persculptum* Ruedemann
Geisonoceras tenuistriatum (Hall)
cf. *Protokionoceras oneidaense* (Walcott)

Annelida:

Cornulites cf. *progressus* Ruedemann
Protoscolex sp.

Trilobita:

Cryptolithus bellulus (Ulrich)
C. lorrainensis Ruedemann
C. cf. *recurvus* Ulrich
C. tessellatus Green
Flexicalymene meeki (Foerste)
Homotelus stegops (Green)
Triarthrus huguensis Foerste
T. spinosus rougensis Parks

Ostracoda:

Aparchites minutissimus (Hall)

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