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Ontario Geological Survey

Open File Report 5770

Paleozoic Geology of the Ottawa-St.Laurence Lowland, Southern Ontario

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ONTARIO GEOLOGICAL SURVEY

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Paleozoic Geology of the Ottawa-St. Lawrence Lowland, Southern Ontario

By

D.A. Williams

1991

Ontario Geological Survey

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V.G. Milne, Director
Ontario Geological Survey

FOREWORD

During the years 1981, 1982 and 1983 remapping of the Paleozoic strata in eastern Ontario was undertaken by the Ontario Geological Survey. As a result of this work a considerable amount of new information was established for the Paleozoic rock unit, which led to a number of important changes being made to the stratigraphic nomenclature used in eastern Ontario. This new information is released in this report, which will be the major reference work for the Paleozoic strata in eastern Ontario for some time to come.

V. G. Milne Director OGS

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PALEOZOIC GEOLOGY OF THE
OTTAWA-ST. LAWRENCE LOWLAND
SOUTHERN ONTARIO

BY: D.A. WILLIAMS[1]

1991

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Manuscript approved for publication by O.L. White, Former Section Chief, Engineering and Terrain Geology Section, Ontario Geological Survey, July 25, 1990.

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ABSTRACT

This report describes the Paleozoic stratigraphy, igneous intrusions, structural geology, and economic geology of the Ottawa-St. Lawrence Lowland of southern Ontario.

The sedimentary sequence which unconformably overlies the Precambrian basement has a maximum thickness of approximately 1200 metres, and is subdivided (in ascending order) as follows: Potsdam Group (Covey Hill and Nepean Formations); Beekmantown Group (March and Oxford Formations); Rockcliffe Formation; Ottawa Group (Shadow Lake, Gull River, Bobcaygeon, Verulam, and Lindsay Formations); Billings Formation; Carlsbad Formation; and Queenston Formation. The feldspathic conglomerates and sandstones of the Covey Hill Formation (Upper Cambrian and/or older) were deposited in a terrestrial environment, and overlying units in an intracontinental shelf environment. The Nepean Formation (Upper Cambrian to Lower Ordovician) consists of interbedded quartz sandstone and conglomerate; the March Formation (Lower Ordovician) of interbedded quartz sandstone and dolostone; and the Oxford Formation (Lower Ordovician) of dolostone. The Lower-Middle Ordovician contact is disconformable. The Rockcliffe Formation (Middle Ordovician) consists of interbedded quartz sandstone, shale, limestone, and silty dolostone; the Ottawa Group (Middle to Upper Ordovician) of limestone with interbeds of silty dolostone, shale, and quartz sandstone;

the Billings Formation (Upper Ordovician) of shale; the Carlsbad Formation (Upper Ordovician) of interbedded shale, siltstone, and limestone; and the Queenston Formation (Upper Ordovician) of red to green siltstone and shale.

Carbonatite dikes of probable Cretaceous age intrude Paleozoic rocks at two localities (in the Blackburn quarries, 10 km east of central Ottawa; and along the southern bank of the Ottawa River, between the Carillon Dam and the Ontario-Quebec Border). The dikes strike easterly and are up to 40 cm thick. They consist mainly of dolomite, and are characterized by calcite, phlogopite, and apatite phenocrysts and a variety of rounded xenocrysts derived mainly from Precambrian rocks.

Joint sets in the Paleozoic rocks strike at approximately 015°, 055°, 100°, and 145°. The 100° joint direction is the most dominant, and the 055° orientation is the least dominant. Steeply dipping normal faults and fault zones strike from southeast to northeast, and have vertical displacements which exceed 1000 metres in places. Fault traces are normally gently curved, but may be distinctly curved in the vicinity of fault junctions. The vertical displacement at a fault junction is approximately equal to the sum of the displacements along each set of faults which branches from the junction. Bedding in the Paleozoic rocks is normally close to horizontal, but within many fault zones the beds dip steeply toward the downthrown block. Steeply plunging slickensides are common on fault planes, but gently plunging slickensides also occur. The faults form part of a major tectonic zone, the Ottawa Valley rift zone. The rift zone, a component of the St. Lawrence rift system, trends east-southeast and resulted from crustal extension. Its axis is well defined to the east of Ottawa, where fault blocks containing outcrops of the uppermost units of the Paleozoic sedimentary sequence exist. Faults and joint sets of the Ottawa-St. Lawrence Lowland have orientations which correspond to the trends of other rift zones (Timiskaming Valley, Champlain Valley, and Southern Great Lakes) occurring in adjacent areas, as well as to the trend of the Ottawa Valley rift zone. This indicates that the complex fault pattern of the Ottawa-St. Lawrence Lowland may have resulted from the successive formation of faults striking parallel to each rift zone. Contemporary high horizontal compressive stresses have resulted in the formation of buckles (also called "pop-ups") at localities near Fallowfield (15 km southwest of central Ottawa), South Mountain (50 km southeast of Ottawa), Burritts Rapids (50 km south of Ottawa), and Cornwall. The epicentre of a 1944 earthquake of magnitude 5.7 was located near Cornwall.

Large quantities of crushed stone, used mainly as aggregate, are produced from the quarries of the Ottawa-St. Lawrence Lowland. The principal raw materials are the carbonate rocks of the Beekmantown Group, Rockcliffe Formation, and Ottawa Group. Dimension stone has been quarried extensively in the past, and is being produced at present from massive limestone of the Bobcaygeon Formation by Karnuk Marble Industries Incorporated, Cornwall. Siltstone and shale of the Queenston Formation are extracted by Canada Brick from the Russell quarry, 30 km southeast of Ottawa, for use in the manufacture of brick and tile. Quartz sandstone of the Nepean Formation has high potential for the production of silica sand. The Oxford Formation has high potential for the production of gypsum. Hematite-siderite-calcite veins occurring within Paleozoic strata have little apparent potential, but chalcopyrite-thucolite mineralization occurring in the March Formation may have some potential. Calcite-fluorite-barite-celestite-galena-sphalerite mineralization has high resource potential, and exploration should be directed at fault junctions. Hydrocarbons (oil shale, petroleum, and natural gas) occur in the Lindsay and Billings Formations, but have very little apparent potential. The quality and quantity of water occurring in Paleozoic bedrock decrease from the base of the sequence upwards; the best aquifers are the Nepean, March, and Oxford Formations.

INTRODUCTION

Current Program

Mapping of the Paleozoic geology of the Ottawa-St. Lawrence Lowland was conducted during 1981 to 1983 (Carson 1982a, Williams and Wolf 1982, Williams and Rae 1983). The study area encompasses the region bounded to the north by the Ottawa River, to the east by the Ontario-Quebec border, to the south by latitude 44°30′N and the St. Lawrence River, and to the west by longitude 76°30′W (Figure 1). The National Topographic Series (NTS) map areas involved are shown in Figure 2. A series of 1:50 000 Paleozoic geology preliminary maps (Carson 1982b-d; Williams, Rae and Wolf 1984; Williams, Wolf and Rae 1984; Williams and Wolf 1984a-c; Williams, Rae and Wolf 1985a-c; Williams, Wolf and Carson 1985a-c) has been published. Figure 3 is a compilation of these maps, and includes data collected since they were published. Classifications used during the course of the project are indicated in Tables 1 to 4.

Although the Paleozoic geology of the region has been the subject of many previous studies, the current program was undertaken for several reasons:

1. It was apparent that the many surface exposures and drillcores now available but not in existence at the time of previous studies would enable much more accurate determination of the extent of areas within which particular

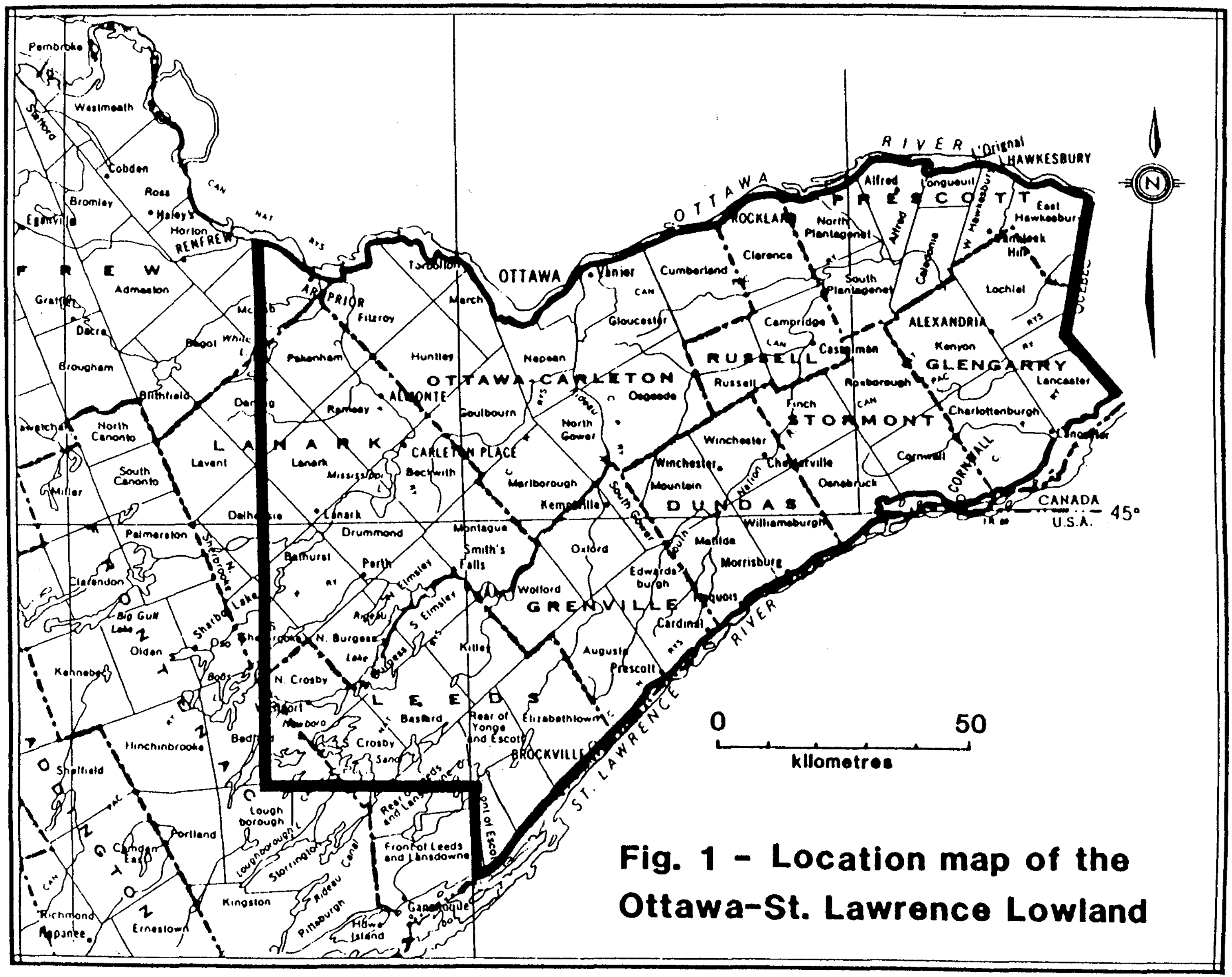

Fig. 1 - Location map of the Ottawa-St. Lawrence Lowland

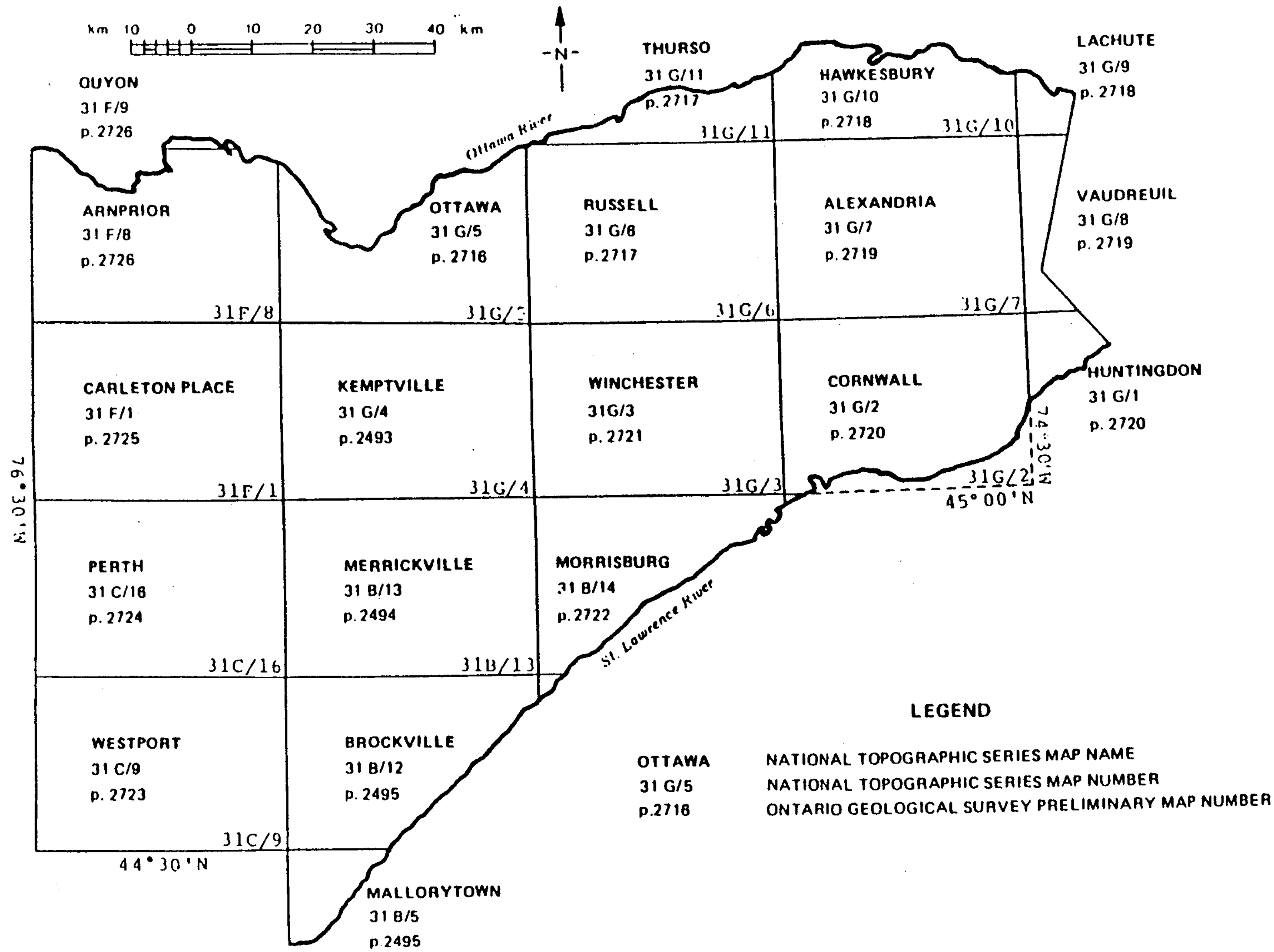

Figure 2. Index map of the Ottawa-St. Lawrence Lowland.

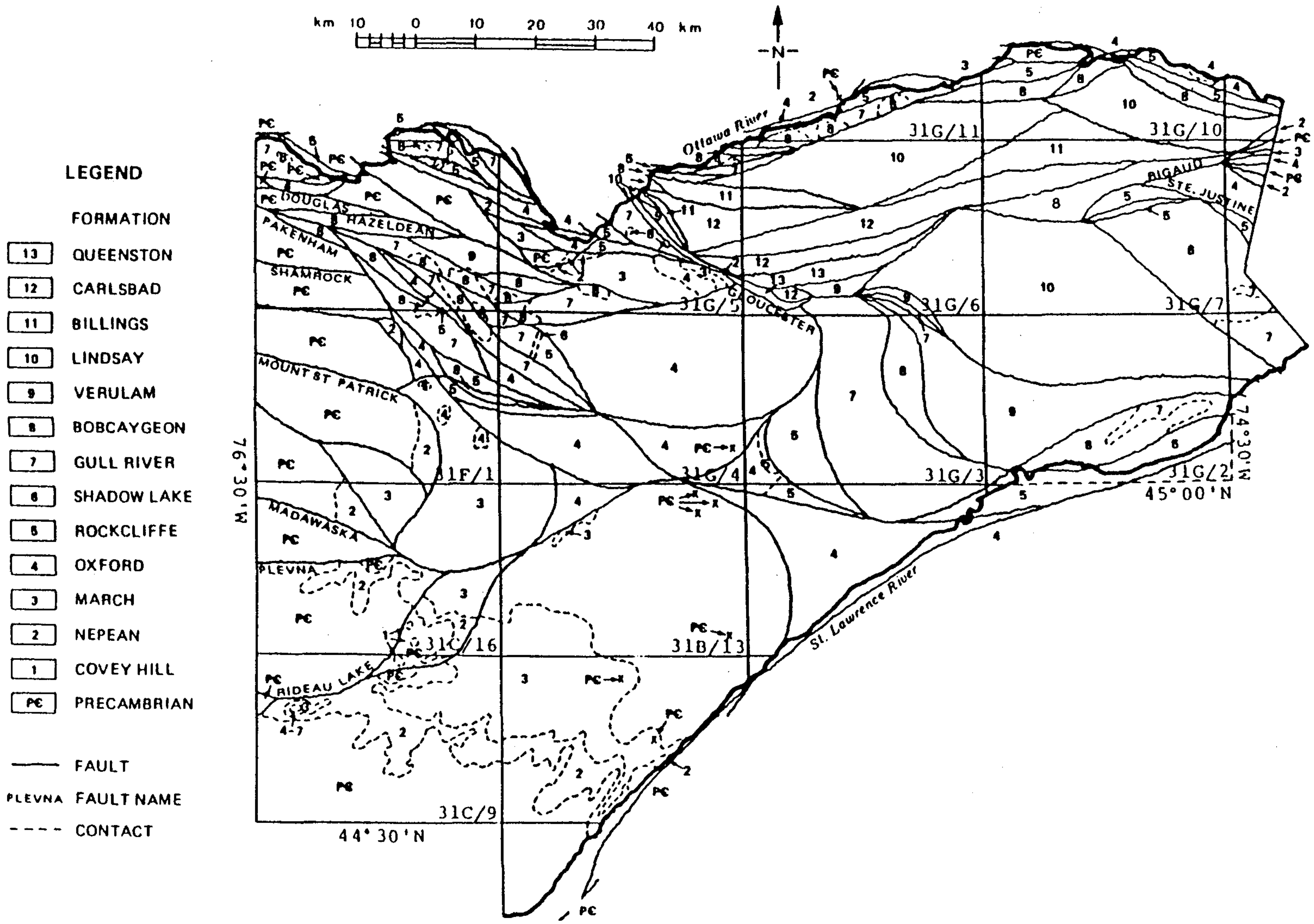

Figure 3 Generalized Paleozoic geology of the Ottawa - St. Lawrence Lowland.

stratigraphic units outcrop and subcrop beneath drift cover. As well as recent roadcuts and quarries being available for examination, excavation during 1982 to a depth of up to 4 metres for the natural gas pipeline of Trans Canada Pipelines Limited resulted in the exposure of bedrock along much of the pipeline route through the Arnprior (31F/8), Ottawa (31G/5), Kemptville (31G/4) and Winchester (31G/3) map areas. Several drillholes were used to provide reference sections, the principal one being the Geological Survey of Canada (GSC) Russell well (Figure 4);

2. Understanding of the stratigraphy of the Cambrian-Ordovician sequence (Tables 5 and 6) had been hindered by the use of a combination of both lithostratigraphic and biostratigraphic terminology. The need for an entirely lithostratigraphic nomenclature was apparent;

3. The structural geology is complex in places (Figure 5), and a modern analysis had not been done; such an analysis depends heavily on the knowledge of surface and subsurface stratigraphy; and

4. The bedrock resources are of considerable economic importance, and their development would be assisted by an updated evaluation.

The southern part of the Lowland contains the least stratigraphic diversity and is the least affected by faults. Thus, there was little revision to the earlier studies. However, the northern portion of the Lowland (especially the Ottawa area) proved to be more structurally complex than

NAME	CaO/MgO RATIO
Limestone	> 27:1
Dolomitic Limestone	4:1 - 27:1
Calcitic Dolostone	1.8:1 - 4:1
Dolostone	1.4:1 - 1.8:1

TABLE 1. Chemical classification of carbonate rocks (after Hewitt and Vos 1972)

CRYSTALLINITY	CRYSTAL SIZE
Coarsely crystalline	> 5 mm
Medium crystalline	1 mm - 5 mm
Finely crystalline	0.2 mm - 1 mm
Sublithographic	0.05 mm - 0.2 mm
Lithographic	< 0.05 mm

TABLE 2. Crystal size classification of carbonate rocks (after Hewitt and Vos 1972)

GRANULARITY	GRAIN SIZE
Boulder	> 256 mm
Cobble	64-256 mm
Pebble	4-64 mm
Granule	2-4 mm
Very coarse grained sand	1-2 mm
Coarse grained sand	0.5 -1 mm
Medium grained sand	0.25 -0.5 mm
Fine grained sand	0.125-0.25 mm
Very fine grained sand	0.063-0.125 mm
Silt	0.004-0.063 mm
Clay	<0.004 mm

TABLE 3. Grain size classification of terrigenous rocks (after Hewitt and Vos 1972)

TERM	BED THICKNESS
Massive bedded	> 1 m
Thickly bedded	30 cm - 1 m
Medium bedded	10 cm - 30 cm
Thinly bedded	3 cm - 10 cm
Very thinly bedded	1 cm - 3 cm
Thickly laminated	0.3 cm - 1 cm
Thinly laminated	<0.3 cm

TABLE 4. Classification of bed and lamination thickness (after Hewitt and Vos 1972)

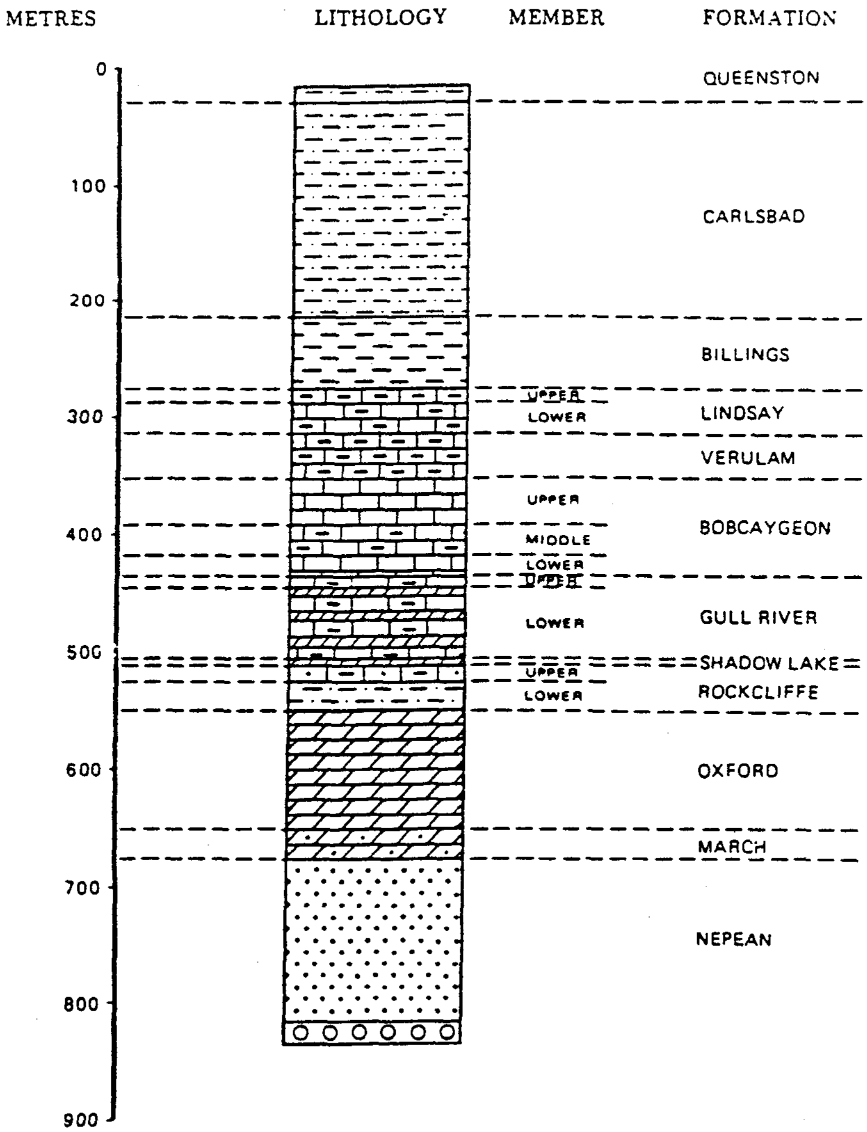

Figure 4. **Stratigraphy of the Geological Survey of Canada Russell well.**

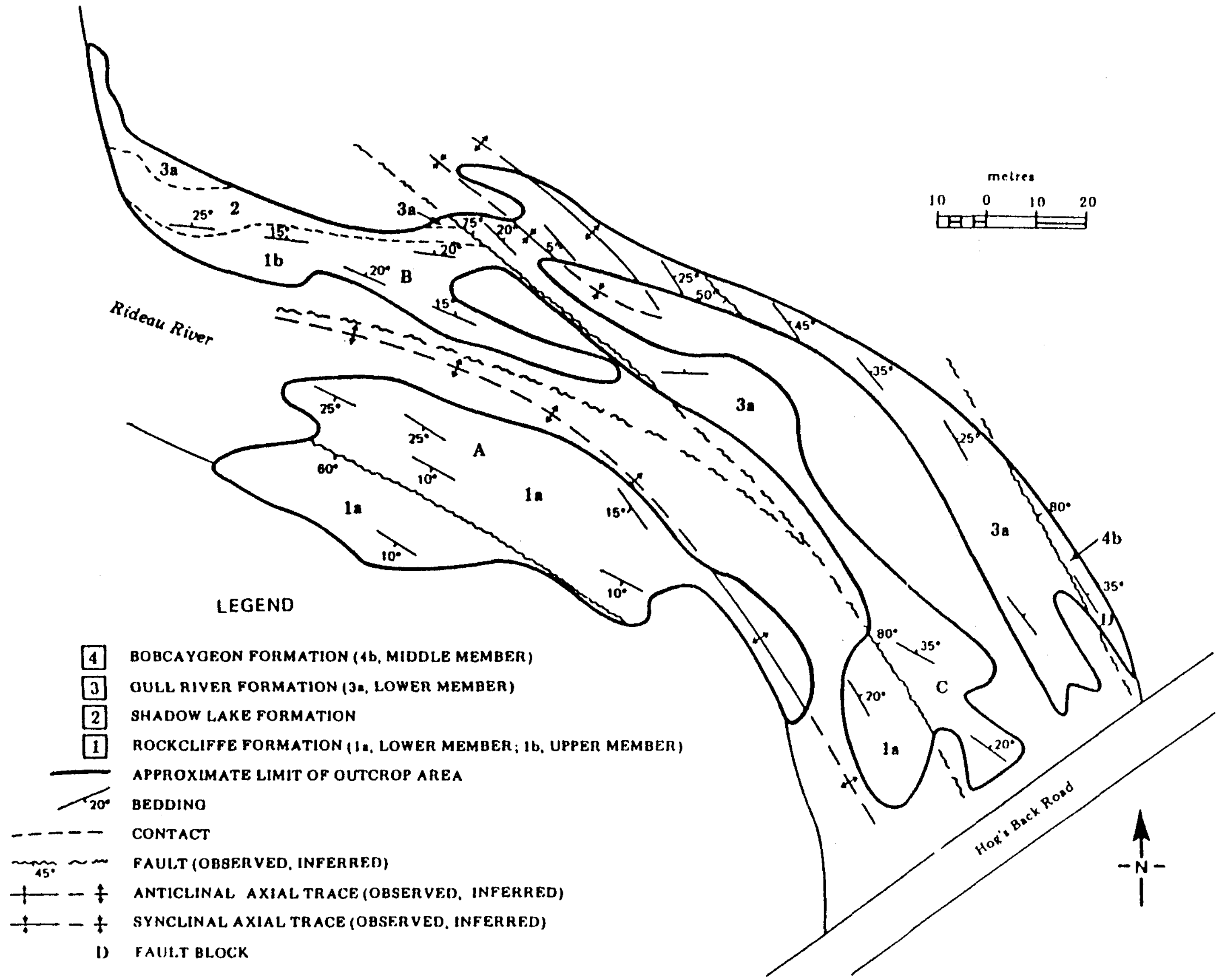

Figure 5. **Bedrock geology of the vicinity of Prince of Wales Falls, Hog's Back Park, Ottawa.**

NORTH AMERICAN SERIES	NORTH AMERICAN STAGES		MIDCONTINENT CONODONT FAUNAL ZONES	BRITISH SERIES
Cincinnatian (Upper Ordovician)	Gamachian		13	Ashghillian
	?			
	Richmondian		12	
	Maysvillian			
			11	
	Edenian			Caradocian
Champlainian (Middle Ordovician)	Shermanian	Trentonian	10	
			9	
	Kirkfieldian			
	Rocklandian		8	
	Blackriveran		7	
	?		6	
	Chazyan			Llandeilian
			5	Llanvirnian
	?		4	
	Whiterockian		3	
			2	
			1	Arenigian
Canadian (Lower Ordovician)			E	
			D	
			C	Tremadocian
			B	
			A	

TABLE 5. Ordovician Chronostratigraphy (after Barnes et al. 1981).

Note 1: Inclusion of a restricted Cobourgian (latest Trentonian) stage between the Shermanian and Edenian stages has been advocated by Walters et al. (1982).

Note 2: Replacement of the Canadian stage by the Ibexian stage has been advocated by Ross et al. (1982).

PERIOD	SERIES	STAGE	SOUTHEASTERN ONTARIO – THIS STUDY: GROUP	FORMATION	MEMBER	WILSON 1946a: FORMATION	"FAUNAL ZONE"	SOUTH CENTRAL ONTARIO – LIBERTY 1969, RUSSELL AND TELFORD 1983: GROUP	FORMATION	MEMBER	NORTH CENTRAL NEW YORK – FISHER 1977, CAMERON AND MANGION 1977: GROUP	FORMATION	SOUTHERN QUEBEC – CLARK 1972a, 1972b, GLOBENSKY 1982a, 1982b: GROUP	FORMATION	MEMBER
ORDOVICIAN	CINCINNATIAN	Richmondian		Queenston		Queenston			Queenston				Queenston	Becancour River	
				Carlsbad		Russell			Georgian Bay	Upper			Lorraine	Nicolet River	
						Carlsbad				Lower					
		Maysvillian		Billings		Billings			Blue Mountain				Utica	Lachine	
			Ottawa	Lindsay	Upper (Eastview)	Eastview		Simcoe	Lindsay	Upper (Collingwood)			Trenton	Tetreauville	
		Edenian			Lower	Ottawa	"Cobourg"			Lower	Trenton	Hillier			
	CHAMPLAINIAN	Shermanian		Verulam			"Sherman Fall"		Verulam	Upper		Sl... / Denley		Montreal	
										Lower		Sugar River			
		Kirkfieldian		Bobcaygeon	Upper		"Hull"		Bobcaygeon	Upper		Kings Falls		Deschambault	
		Rocklandian			Middle		"Rockland"			Middle		Napanee		Mile End / Ouareau	
		Blackriveran			Lower		"Leray"		Gull River	Lower	Black River	Selby	Black River	Leray	
				Gull River	Upper		"Lowville"			Upper / Middle		Watertown / Lowville		Lowville	
					Lower					Lower					
				Shadow Lake			"Pamelia"	Basal	Shadow Lake			Pamelia		Pamelia	
		Chazyan		Rockcliffe	Upper	St. Martin		?			Chazy	St. Martin	Chazy	Laval	St. Martin
					Lower	Rockcliffe						Rockcliffe			Ste. Therese
		Whiterockian	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////	//////////
	CANADIAN		Beekmantown	Oxford		Oxford		?			Beekmantown	Ogdensburg	Beekmantown	Beauharnois	
				March		March						Theresa		Theresa	
			Potsdam	Nepean		Nepean		Basal	Mount Simon		Potsdam	Keeseville	Potsdam	Cairnside	
CAMBRIAN				Covey Hill					Jacobsville			Ausable		Covey Hill	

TABLE 6. Cambrian-Ordovician stratigraphic units of southeastern Ontario, and their equivalents in adjacent areas.

previously considered, and extensive alterations were made to the geological maps.

Physiography

The physiography of the Ottawa-St. Lawrence Lowland (Figure 6) has been described by Chapman and Putnam (1951, 1966, 1984). All or part of ten physiographic regions occur within the study area. Two are characterized by exposed Precambrian bedrock, one by exposed Paleozoic bedrock, two by glacial deposits, and five by postglacial sediments. Surfical deposits of the Lowland include till (which occurs as till plains, drumlinized in places); ice-contact stratified drift; marine (Champlain Sea) sediments; alluvial sand and silt; and organic bog deposits. The surficial geology of various parts of the study area has been described by Terasmae (1965), Henderson (1970, 1973), Gwyn and Lohse (1973), Gwyn and Girard (1975), Gwyn and Thibault (1975), Richard (1976a-d, 1982a-e, 1983a-b, 1984), and Sharpe (1979).

Precambrian rock of the Algonquin highlands outcrops in the western part of the Arnprior (31F/8), Carleton Place (31F/1), Perth (31C/16), and Westport (31C/9) map areas. The Leeds knobs and flats in the Mallorytown (31B/5) and southern part of the Brockville (31B/12) and Westport (31C/9) map areas are characterized by less prominent Precambrian exposures. The Smith's Falls limestone plain,

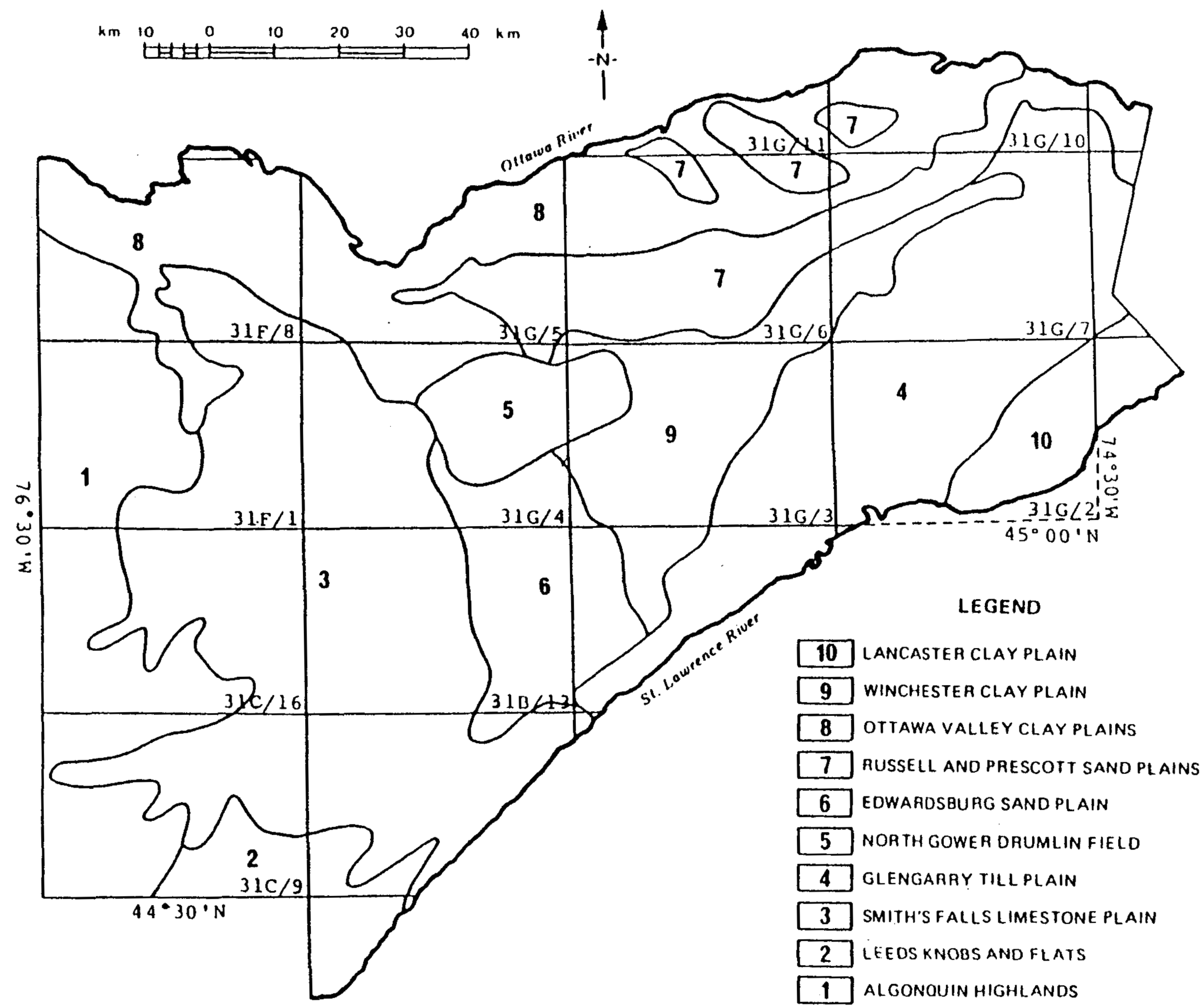

Figure 6. Physiographic units of the Ottawa–St. Lawrence Lowland (after Chapman and Putnam 1984).

in which Paleozoic rock outcrops, occurs to the east of the Algonquin highlands and is up to 50 km wide.

The area to the northeast of the Smith's Falls limestone plain is characterized by surficial deposits with a maximum thickness of about 50 metres. Bedrock cliffs occur along the Ottawa River, and areas of bedrock pavement are relatively common within 10 km of the river. Further south, scattered bedrock exposures occur in river valleys and some areas of bedrock pavement exist. The physiographic regions, from northwest to southeast across the Lowland, are as follows: the Ottawa Valley clay plains, with individual clay plains being separated by portions of the Russell and Prescott sand plains; the Edwardsburg sand plain (to the southwest) and the Winchester clay plain (to the northeast); the Glengarry till plain; and the Lancaster clay plain. Drumlins of the North Gower drumlin field occur in the Ottawa Valley and Winchester clay plains.

The Ottawa River forms the northern boundary of the Ontario portion of the Lowland and flows generally eastward. The St. Lawrence River forms the southeastern boundary and flows generally northeastward. Only a few non-linear segments of the Ottawa River do not follow fault traces, and the St. Lawrence River follows a fault trace along all but the extreme northeastern part of its course through Ontario.

The other major waterways of the Lowland are (from west to east) the Madawaska River, the Mississippi River (including Mississippi Lake), the Rideau River and Canal (including the Rideau Lakes), and the South Nation River. The Madawaska and Mississippi Rivers empty into the Ottawa River at Arnprior and Fitzroy Harbour (Arnprior map area, 31F/8), respectively. Both are characterized by fault-controlled linear segments. The Rideau River empties into the Ottawa River at Rideau Falls (Ottawa map area, 31G/5), and the Rideau Lakes (Perth map area, 31C/16, and Westport map area, 31C/9) occupy a fault-controlled topographic low. The South Nation River empties into the Ottawa River at Wendover (Thurso map area, 31G/11), and has a few fault-controlled linear segments.

Acknowledgments

Mapping of the Paleozoic geology of the Ottawa-St. Lawrence Lowland was part of the Southeastern Ontario Geological Survey (SOGS) which was funded equally by the (then) Canada Department of Regional Economic Expansion (DREE) and the Ontario Ministry of Natural Resources under the minerals program of the Eastern Ontario Subsidiary Agreement. The project was conducted under the supervision of Dr. P.G. Telford and M.D. Johnson (Engineering and Terrain Geology Section, Ontario Geological Survey). The manuscript was reviewed by R.R. Wolf, who was a senior assistant during the 1981 and 1982 field seasons. A.M. Rae was a senior assistant during the 1982 and 1983 field seasons. The figures were drafted by B. Aikman. The help of D.M. Carson and Dr. D.J. Russell (Engineering and Terrain Geology Section, Ontario Geological Survey), C.A. Rogers (Ontario Ministry of Transportation), Dr. B.V. Sanford (Geological Survey of Canada), and personnel of the Ontario Ministry of Northern Development and Mines (Southern Region) and the Ontario Ministry of Natural Resources (Eastern Region) is gratefully acknowledged. Final editing, formatting and compilation of the report was completed by Zenia Jaremko of the Ontario Geological Survey. The co-operation of quarry owners, landowners, and municipal and federal officials is greatly appreciated.

PREVIOUS WORK

A voluminous literature describing the Paleozoic geology of the Ottawa-St. Lawrence Lowland is available. Early studies were summarized by Wilson (1946a, p. 1-4), who also included in her report (p. 49-62) a comprehensive bibliography which should be consulted for the older reference material.

The exploration work of Sir William Logan began in 1841 and culminated in the publication of Geology of Canada (Logan 1863) and the accompanying Atlas (Logan 1865). Large parts of these publications were concerned with the Lowland, and incorporated data acquired by Alexander Murray (whose study of the Lowland was published in 1852) and Elkanah Billings (who was appointed Paleontologist to the GSC in

1856). Geological mapping in the Lowland, particularly in the Ottawa area, was continued by R.W. Ells and N.J. Giroux (Ells 1902). The Brockville and Mallorytown areas (31B/12 and 31B/5) were mapped by J.F. Wright (1923). Portions of the Arnprior and Quyon areas (31F/8 and 31F/9) were studied by M.E. Wilson (1924). Detailed geological mapping of the Lowland was carried on from 1925 to 1941 by A.E. Wilson and culminated in the publication of her report in 1946. It was preceded by a series of maps covering individual areas of the Lowland (A.E. Wilson 1938a-b, 1940a-b, 1941a-c, 1942). The westernmost part of the Lowland was not included in A.E. Wilson's report, and maps were subsequently published as follows: Perth map area, 31C/16 (M.E. Wilson and Dugas 1961); Brockville and Mallorytown map areas, 31B/12 and 31B/5 (Wynne-Edwards 1963); Westport map area, 31C/9 (M.E. Wilson, Brownell and Wynne-Edwards 1967); Carleton Place map area, 31F/1 (A.E. Wilson, Reinhardt and Liberty 1973); and Arnprior and Quyon map areas, 31F/8 and 31F/9 (A.E. Wilson, Livingstone, Hill and Kirwan 1973). Except for the Brockville-Mallorytown area, the mapping of the Paleozoic geology of these areas preceded publication by many years and was conducted as follows: A.E. Wilson, 1925-41 (Carleton Place and Arnprior-Quyon); G.M. Brownell, 1927-28 (Westport); and M.E. Wilson, 1928-29 (Perth and Westport).

Detailed studies of the quarries of the Ottawa-St. Lawrence Lowland have been published periodically, and include those by Miller (1904), Parks (1912), Frechette

(1918), Picher (1920), Keele and Cole (1922), Goudge (1938), Hewitt (1960, 1963, 1964a-b), Hewitt and Vos (1972), Rogers (1980), and Derry et al. (1989). R. R. Wolf was responsible for the provision of geological data for that part of the latter report which deals with the Ottawa-St. Lawrence Lowland.

Field guides by A. E. Wilson (1956a), Baird (1968), Bolton and Liberty (1972), and Williams and Telford (1986, 1987) are available. Billings (1976) described many geological sites located within the Regional Municipality of Ottawa-Carleton, and recommended that action be taken to preserve the most important ones. Belanger and Harrison (1980) compiled maps of bedrock and surficial geology, geotechnical characteristics of bedrock units, thickness of surficial deposits, and topography of the bedrock surface for use in regional planning.

The Paleozoic geology of areas in Ontario adjacent to the Ottawa-St. Lawrence Lowland has been mapped by Carson (1982e) and Russell and Williams (1985a-f). Adjoining areas in Quebec have been mapped by A. E. Wilson (1946a), Sabourin (1965), and Globensky (1981, 1982a-b), and in New York State by Cushing et al. (1910), Cushing (1916) and Dietrich (1957).

The studies referred to above incorporate much information concerning stratigraphy, which is also the subject of many other publications. General stratigraphic studies include those by Ami (1902), A. E. Wilson (1937), and Liberty (1967). More specific studies include those by Ells

(1894, Potsdam and Beekmantown Groups), Raymond (1911 and 1914, Rockcliffe Formation and Ottawa Group), Foerste (1916, Billings, Carlsbad, and Queenston Formations), A. E. Wilson (1932a, Ottawa Group), Kay (1942 and 1968b, Ottawa Group), Vollrath (1962, Rockcliffe Formation and Ottawa Group), Barnes (1967 and 1968, Ottawa Group), Forsyth (1968, Potsdam Group), Sinclair (1968, Ottawa Group), Sawford (1972, Ottawa Group), Greggs and Bond (1972 and 1977, Potsdam Group), Bond and Greggs (1973 and 1976, Beekmantown Group), Griffen (1973, Potsdam Group), Waterfall (1973, Potsdam Group), Bond (1974, Potsdam and Beekmantown Groups), Giles (1976, Beekmantown Group), Brand and Rust (1977a and 1977b, Potsdam Group), Ferry (1977, Potsdam Group), Whitfield (1977, Beekmantown Group), Beauchamp (1979, Potsdam and Beekmantown Groups), Cass (1979, Beekmantown Group), Dorr (1984, Potsdam Group), Wolf and Dalrymple (1984 and 1985, Potsdam Group), and Steele-Petrovich (1986, 1989, and 1990, Ottawa Group).

General studies dealing primarily with biostratigraphy and paleontology include those by Ami (1901 and 1904, Ordovician), Raymond (1905 and 1921, Middle Ordovician), A. E. Wilson (1921, 1932b, and 1948, Middle Ordovician), Foerste (1924, Upper Ordovician), and Steele and Sinclair (1971, Middle Ordovician). More specific studies include those by Burling (1917, Lower Ordovician trace fossils), A. E. Wilson (1946b, Middle Ordovician echinoderms) (1946c, Middle Ordovician brachiopods) (1947, Middle Ordovician trilobites) (1951, Middle Ordovician gastropods and conularids) (1956b, Middle Ordovician pelecypods) (1961, Middle Ordovician cephalopods), Fritz (1957, Middle Ordovician bryozoa), Barnes (1964, Middle Ordovician conodonts), Schopf (1966, Trentonian conodonts), Greggs and Bond (1971, Lower Ordovician conodonts), Uyeno (1974, Trentonian conodonts), Yochelson and Copeland (1974, Lower Ordovician gastropods), Hofmann (1979, Chazyan trace fossils), Ludvigsen (1979, Lower Ordovician trilobites), Tuffnell and Ludvigsen (1984, Upper Ordovician trilobites), and Copeland et al. (1989, Chazyan ostracodes and conodonts).

The most contentious aspect of the stratigraphy of the Lowland has been the subdivision of the sequence of Middle and Upper Ordovician limestone (Tables 5, 6 and 7). A. E. Wilson (1946a) subdivided her Ottawa Formation into both, lithostratigraphic phases (lower, middle and upper) and biostratigraphic faunal zones (Pamelia, Lowville, Leray, Rockland, Hull, Sherman Fall, and Cobourg, from base to top). The latter terms had all been in previous use and were derived from localities in southeastern Ontario (Rockland), south-central Ontario (Cobourg), southern Quebec (Hull), and north-central New York State (Pamelia, Lowville, Leray, and Sherman Fall).

Attempts have been made to use the names of A. E. Wilson's (1946a) faunal zones in a lithostratigraphic sense, and many of these attempts have caused confusion. For example, beds exposed in the Rockland quarry (Thurso map

SOUTHEASTERN ONTARIO								NORTH-CENTRAL NEW YORK					
WILSON 1946a		WILLIAMS AND WOLF 1982		THIS STUDY				KAY 1968a		WALKER 1973		CAMERON AND MANGION 1977	
FORMATION	PHASE	FORMATION	UNIT	GROUP	FORMATION	MEMBER		GROUP	FORMATION	GROUP	FORMATION	GROUP	FORMATION
Eastview		Eastview			Lindsay	Upper (Eastview)							
			F			Lower			Hillier				
	Upper								Steuhen				
			E		Verulam				Denley				
									Sugar River				
Ottawa	Middle	Ottawa	D	Ottawa		Upper		Trenton	Kings Falls			Trenton	Kings Falls
						Middle			Napanee				Napanee
			C		Bobcaygeon	Lower	B		Selby		Chaumont		Selby
							A		Watertown				Watertown
						Upper							
	Lower		B		Gull River	Lower		Black River	Gull River	Black River	Lowville	Black River	Lowville
			A		Shadow Lake				Pamelia		Pamelia		Pamelia

TABLE 7. Lithostratigraphy of the Ottawa Group of Ontario and the Black River and Trenton Groups of adjacent New York State.

area, 31G/11; AQ TH-1 in Appendix 1) were assigned by Barnes (1967, p. 211; 1968, p. 170) to the uppermost part of the Lowville Formation, but were assigned by Kay (1968b, p. 167) to the overlying Watertown Limestone. Although Sinclair (1968) supported Barnes' interpretation, the lithostratigraphic-biostratigraphic problem prevented a satisfactory resolution of the issue.

Liberty (1967) applied a lithostratigraphic nomenclature previously in use in south-central Ontario to southeastern Ontario. The use of a modified version of Liberty's proposal is considered here to be preferable to using A.E. Wilson's (1946a) faunal zones in a lithostratigraphic sense. Liberty's (1967) subdivision of the Middle and Upper Ordovician limestones of southeastern Ontario consists of the Gull River, Bobcaygeon, Verulam, and Lindsay Formations. Liberty (1967) equated the Gull River-Bobcaygeon and Bobcaygeon-Verulam contacts with the Lowville-Leray and Rockland-Hull contacts, respectively (Tables 6 and 7). The former is accepted but the latter is not, since the base of Verulam Formation lithology (very thinly to medium bedded limestone with shale interbeds) coincides with the top (and not the base) of the Hull faunal zone. Liberty (1967) placed the lower contact of the Lindsay Formation within the Cobourg faunal zone, and the upper contact of the Lindsay Formation at the upper contact of A.E. Wilson's (1937) Eastview Formation (Tables 6 and 7); both placements are accepted in this report.

The studies by Kay (1942) and A.E. Wilson (1946a) referred to above incorporate much structural information, and other studies which deal primarily with structural geology include those by Ells (1898), Kindle and Burling (1915), M.E. Wilson (1921), Kumarapeli and Saull (1966), Norris (1967), and Sanford et al. (1984).

A.E. Wilson (1946a) recognized that a large number of faults exist in the Ottawa-St. Lawrence Lowland, and Kay (1942) mapped many faults in an area extending westward from the western part of the Lowland. Kumarapeli and Saull (1966) recognized that the Lowland is located within a rift zone which is one of a series of zones constituting an extensive rift system. The actual extent and geometric continuity of faulting in the Lowland was not realized before the current project began.

STRATIGRAPHY

Precambrian

The Paleozoic sequence of the Ottawa-St. Lawrence Lowland unconformably overlies a Precambrian basement consisting of highly deformed metasedimentary and metavolcanic rocks (including gneiss, amphibolite, quartzite, and marble) which have been intruded by felsic to mafic plutons (Figure 7). The dominant foliation strikes generally northeast, dips at moderate to steep angles, and

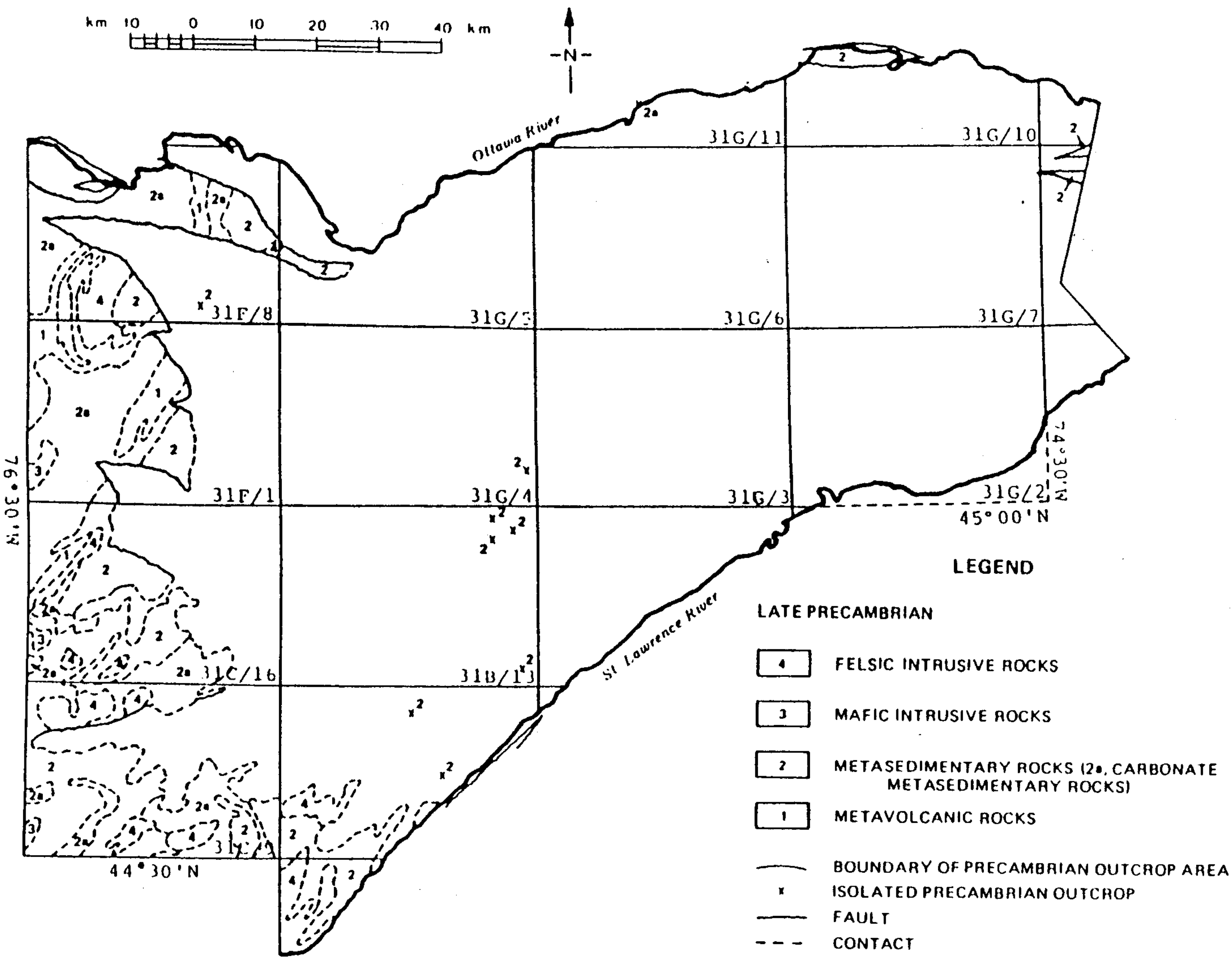

Figure 7. **Generalized Precambrian geology of the Ottawa-St. Lawrence Lowland and surrounding areas.**

is parallel to lithological contacts. Precambrian outcrop areas, part of the Central Metasedimentary Belt of the Grenville Province of the Canadian Shield, border the Lowland and occur as inliers.

Rocks of the Algonquin highlands outcrop in the western part of the Arnprior (31F/8), Carleton Place (31F/1), Perth (31C/16), and Westport (31C/9) map areas (A. E. Wilson, Livingstone, Hill, and Kirwan 1973; A. E. Wilson, Reinhardt, and Liberty 1973; M. E. Wilson and Dugas 1961; M. E. Wilson et al. 1967; Wynne-Edwards 1967; Kingston et al. 1985). Precambrian rocks of the Leeds knobs and flats form the Frontenac Axis, a southeasterly trending feature separating the Lowland from the Paleozoic outcrop area of south-central Ontario. It extends across the Mallorytown (31B/5) and southern part of the Brockville (31B/12) and Westport (31C/9) map areas (Wynne-Edwards 1963, 1967; M. E. Wilson et al. 1967; Currie and Ermanovics 1971; Kingston et al. 1985). Rocks of the Laurentian highlands outcrop to the north of the Lowland in the Gatineau region of Quebec. A continuation of the Gatineau Precambrian outcrop area into Ontario extends southeastward through the Arnprior (31F/8) and Ottawa (31G/5) map areas (A. E. Wilson, Livingstone, Hill, and Kirwan 1973; Kirwan 1962). Other continuations exist in the Thurso (31G/11) and Hawkesbury (31G/10) map areas (Figure 7).

Precambrian inliers occur adjacent to the Algonquin highlands and the Leeds knobs and flats. Inliers are also present in the Kemptville (31G/4) and Merrickville (31B/13) map areas, where they consist of resistant quartzite which formed prominent islands in the Upper Cambrian and Lower Ordovician seas. Precambrian rocks are inferred to subcrop beneath surficial deposits in the Ontario portion of the Lachute (31G/9) and Vaudreuil (31G/8) map areas by extrapolation from the Quebec portion of the map areas (Globensky 1982a, 1982b).

Precambrian-Paleozoic Boundary

A major unconformity separates the sequence of Paleozoic rocks and the underlying Precambrian basement (Plate 1). Adjacent to the main Precambrian-Paleozoic contact (Figure 7), the Paleozoic rock commonly forms an escarpment of up to 25 metres relief. The Precambrian rock occurring immediately beneath the unconformity is commonly altered, and the thickness of the altered material exceeds 10 metres in places. Bernius (1981) reported that an alteration zone 17 metres thick was intersected in holes drilled at the Canada Centre for Mineral and Energy Technology complex in Nepean. The altered rock may represent a preserved regolith formed prior to deposition of the Paleozoic units, or it may be the result of subsequent groundwater leaching.

The Precambrian surface was characterized by considerable (at least 100 metres) relief during deposition of the Paleozoic sequence. This is indicated by the large amount of indentation of the main contact; the common occurrence of relatively steep bedding dips in Paleozoic rock adjacent to contacts with Precambrian rock; and the existence of many Paleozoic outliers in the Algonquin highlands and Leeds knobs and flats close to the main contact. The effect of Precambrian topography on Paleozoic deposition patterns is illustrated by the absence of part or all of the lower units (Covey Hill, Nepean, and March Formations) in the vicinity of prominent Precambrian topographic highs. Such a topographic high may have existed in the location of the Frontenac Axis during deposition of the Potsdam Group (Wolf and Dalrymple 1985, p. 117). A belt of resistant quartzite occurring in the Precambrian basement has resulted in a zone of Precambrian inliers which trends northeast through the Brockville (31B/12), Merrickville (31B/13), and Kemptville (31G/4) map areas (Figure 7). Outcrops of the March and Oxford Formations adjacent to the inliers are characterized by quartzite clasts. Terrigenous clastics derived from Precambrian topographic highs constitute a large part of the Paleozoic sequence from the basal Covey Hill Formation up to the lower member of the Gull River Formation, inclusive (see the following formation descriptions).

At many localities where outcrop areas of Precambrian and Paleozoic rock are separated by a fault (Figure 7), there is evidence that structural features in the Paleozoic

Plate 1. Precambrian-Paleozoic contact, Charleston Lake Provincial Park (Westport map area, 31C/9; UTM 418500E, 4929280N). The basal Paleozoic unit is conglomerate of the Nepean Formation. Photo RW-2-10 (1982).

sequence reflect those in the Precambrian basement. Most of the movement along the Rideau Lake fault (Figure 3) predated Paleozoic deposition, since the intensity of deformation is much greater in the Precambrian rock (Wynne-Edwards 1967, p. 87-88).

The Precambrian-Paleozoic unconformity is observable at many localities. A good example is the Butternut Bay roadcut (Brockville map area, 31B/12; S BR-2 in Appendix 1). Here, sandy dolostones of the March Formation contain cobbles and boulders adjacent to the steeply dipping contact with Precambrian rock. The contact between the Precambrian and the overlying Nepean Formation can be seen in the Westport map area (31C/9) in the Highway 15 roadcut 2 km north of Morton (UTM 404120E, 4934250N); in the Highway 15 roadcut at Elgin (UTM 402810E, 4939780N); and in Charleston Lake Provincial Park (UTM 418500E, 4929280N) (Plate 1).

Potsdam Group (Covey Hill and Nepean Formations)

The sequence of Hadrynian, Cambrian, and Lower Ordovician sandstones and conglomerates which unconformably overlies the Precambrian was named the Potsdam Sandstone by Emmons (1838). The type locality is Potsdam Township in north-central New York State. A dolomitic upper unit was removed from the Potsdam Formation by Cushing (1908), and referred to as the Theresa Formation. The presence of additional mappable units within the Potsdam Formation led

Clark (1966) to refer to it as the Potsdam Group. The latter has been subdivided into formations (Table 6) on the basis of a lower quartzo-feldspathic unit and an upper quartzose unit. The term "Covey Hill Formation" was first applied to Ontario by Williams and Wolf (1982, p. 133) to refer to the lower unit, which includes the very poorly sorted feldspathic conglomerate and sandstone of Wilson and Dugas (1961). The upper unit in southeastern Ontario is the Nepean Formation (Wilson 1937). In north-central New York State the equivalent units are the Ausable Formation and the overlying Keeseville Formation (Fisher 1977 - see Table 6). The Ausable Formation includes the Allen's Falls feldspathic conglomerate and sandstone of Krynine (1948) and the Nicholville conglomerate of Postel _et al._ (1959). In southern Quebec the Covey Hill Formation is overlain by the Cairnside Formation (Globensky 1982a - see Table 6).

Covey Hill Formation

Definition. The Covey Hill Formation (Plate 2) was defined in southern Quebec (Clark 1966, p. 4-18), where it consists of interbedded non-calcareous feldspathic conglomerate and sandstone. This term was extended into Ontario by Williams and Wolf (1982, p. 133). The unconformable lower contact of the Covey Hill Formation is the top of the Precambrian basement, and the unconformable upper contact with the Nepean Formation is the upper limit of common occurrence of

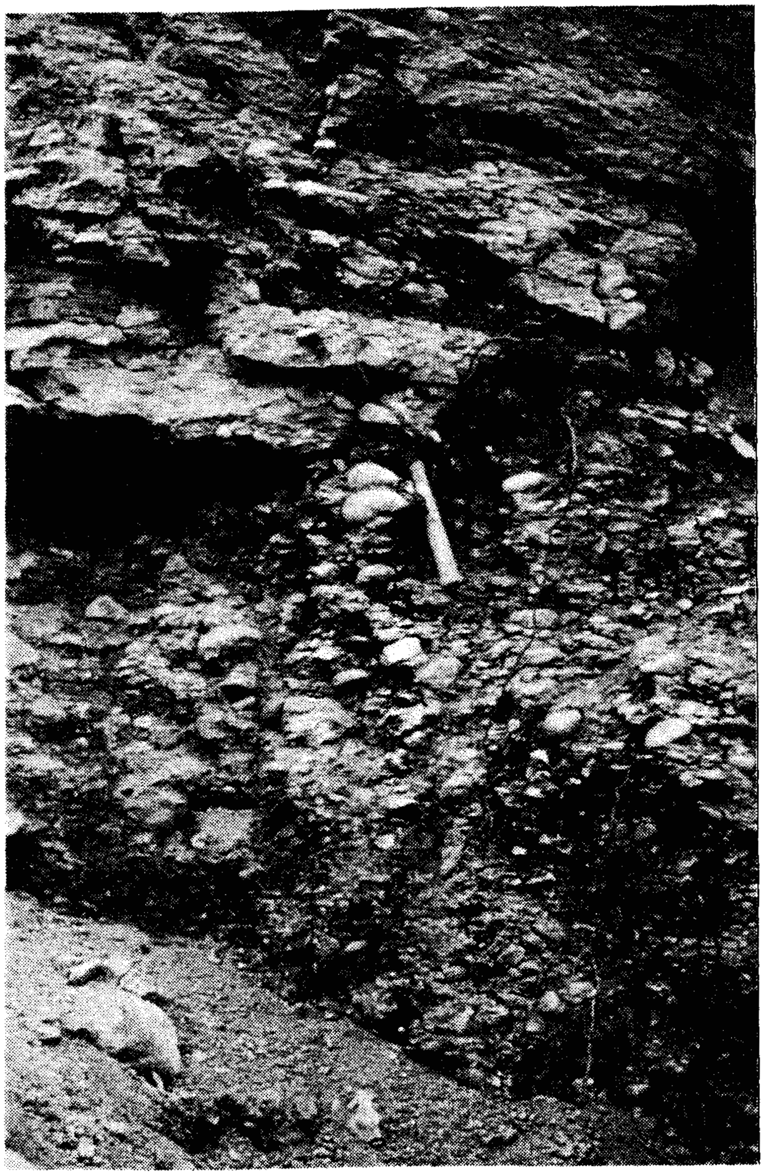

Plate 2. Covey Hill Formation, Mill Pond Quarry (Perth map area, 31C/16; LQ PE-3 in Appendix 1). Photo RW-3-34 (1982).

feldspar. The contacts can be seen in the GSC Lebreton drillhole (Ottawa map area, 31G/5; DH OT-5 in Appendix 2).

The Covey Hill Formation includes the very poorly sorted feldspathic conglomerate and sandstone of Wilson and Dugas (1961) and the basal unit of Williams and Rae (1983, p. 108). As noted above, the Covey Hill Formation is equivalent to the Ausable Formation of adjacent New York State (Fisher 1977 - see Table 6).

<u>Distribution</u>. The Covey Hill Formation outcrops sporadically along the margin of the Ottawa-St. Lawrence Lowland in the Westport (31C/9) and Perth (31C/16) map areas (Figure 8). It subcrops beneath overlying formations in the same map areas, but does not occur in the vicinity of prominent Precambrian topographic highs.

A good exposure of the Covey Hill Formation which is used herein as the principal reference section is the Mill Pond quarry (LQ PE-3, Perth map area, 31C/16) (Plate 2), described in Appendix 1. As indicated in Appendix 2, the formation was intersected in the GSC Lebreton drillhole (DH OT-5, Ottawa map area, 31G/5).

<u>Lithology</u>. The Covey Hill Formation consists of interbedded non-calcareous feldspathic conglomerate and sandstone. Conglomerate predominates, and sandstone interbeds are up to approximately 3 metres thick. The sandstones and the matrix of the conglomerates consist of fine to coarse quartz sand

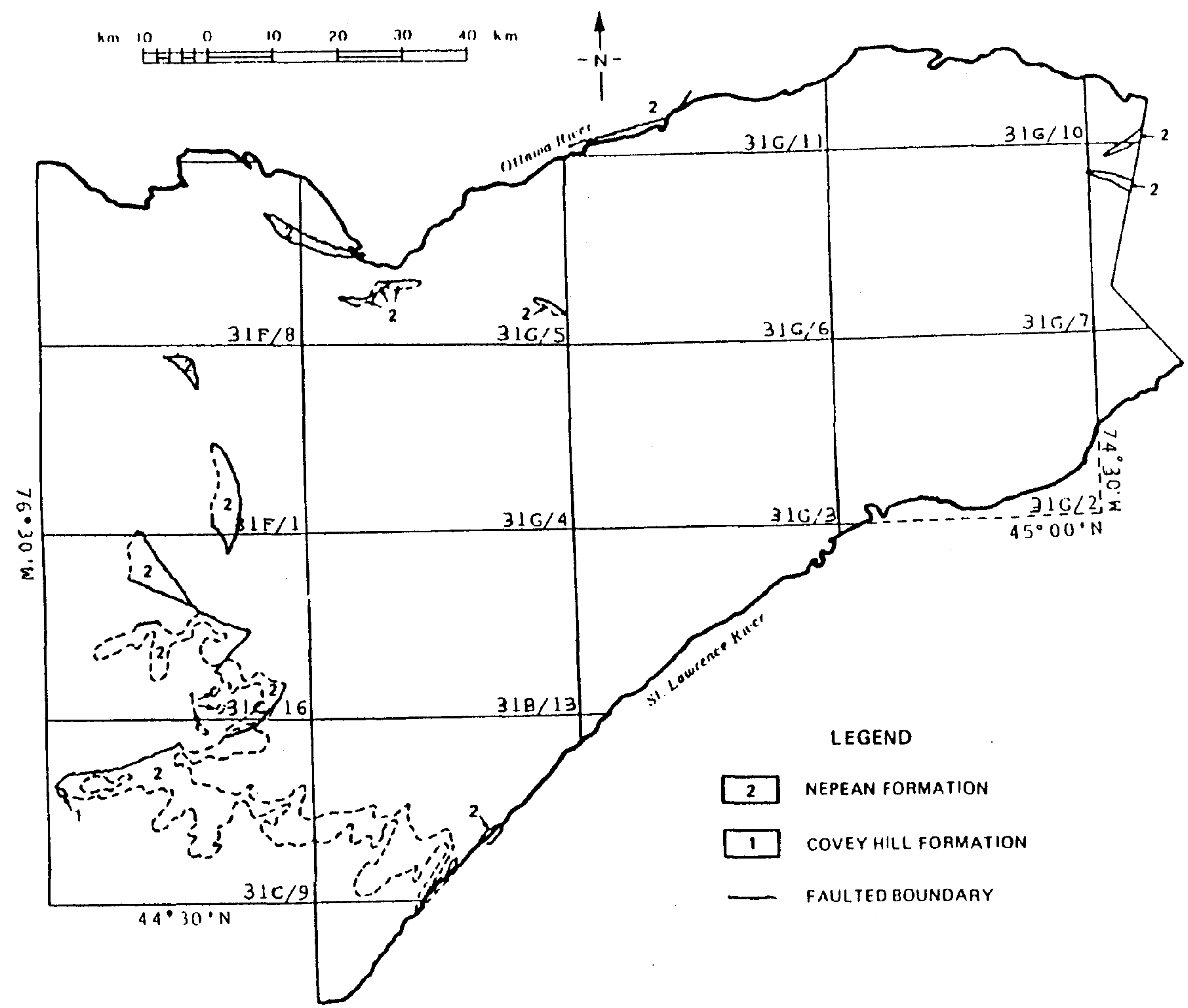

Figure 8. Distribution of the Potsdam Group of the Ottawa-St. Lawrence Lowland.

and angular feldspar grains. The subangular to subrounded quartz grains contain variable amounts of hematite coating which enhance laminae within the beds. The conglomerates contain pebble- to boulder-size subangular to well rounded clasts derived from a variety of Precambrian rock types (typically quartzite, marble, granite, and gneiss). The conglomerates are poorly stratified to massive, and range in colour from light grey to dark grey to reddish brown. The sandstones are thinly to thickly bedded and fairly well to poorly sorted, commonly containing scattered pebbles and cobbles, and range in colour from light grey to reddish brown to green. Crossbeds up to 1 metre thick occur in cosets up to 4 metres thick.

Wolf and Dalrymple (1984, 1985) inferred an alluvial fan-braided fluvial depositional environment for the Covey Hill Formation along the western margin of the Ottawa-St. Lawrence Lowland.

Thickness. The Covey Hill Formation ranges in thickness from zero to at least 13.0 metres. Except for the eastern Perth (31C/16) and Westport (31C/9) map areas, the thickness is greater than zero only locally. The lack of a significant thickness of the Covey Hill Formation in holes drilled in the eastern part of the Ontario portion of the Ottawa-St. Lawrence Lowland suggests that Clark's (1972a, p. 12) figure of 516.3 metres in the Quonto-International (St. Vincent) well, drilled near Montreal, includes a considerable thickness of beds overlying the Covey Hill Formation.

Measured thicknesses (in metres) for the exposed sections and drillhole intersections of Appendices 1 and 2 are listed in Table 8 (the "+" symbol indicates that the entire thickness of the formation does not occur in the exposure or drillhole).

Exposure	Thickness	Drillhole	Thickness	Drillhole	Thickness	Drillhole	Thickness
S BR-2	0.00	GDH BR-2	0.0	DH MO-1	0.0	GDH PE-3	0.0
LQ PE-3	13.00+	GDH BR-6	0.0	GDH OT-1	0.0	GDH WE-1	0.0
		GDH CA-1	0.0	DH OT-5	8.8	GDH WE-2	0.0
		GDH CA-2	0.0	GDH PE-1	0.0	GDH WE-3	0.0
		GDH ME-2	0.0	GDH PE-2	0.0		

TABLE 8. Thickness (in metres) of the Covey Hill Formation of the Ottawa-St. Lawrence Lowland.

Age. The Covey Hill Formation is unfossiliferous. Based on the presence of the inarticulate brachiopod *Lingulepis acuminata* in overlying strata, Clark (1972a, p. 33) assigned an Upper Cambrian and/or older age to the formation.

Nepean Formation

Definition. The Nepean Formation (Plates 1, 3 and 4) as originally proposed by Wilson (1937) consisted of interbedded quartz sandstone and conglomerate. It was named for Nepean Township (now the City of Nepean) in the Ottawa map area (31G/5). The Queensway roadcut (S OT-3 of Appendix 1) in Nepean was proposed as a principal reference section by Greggs and Bond (1972, 1977) and as the type section by Brand and Rust (1977a, 1977b). Disagreement (Brand and Rust 1977a; Greggs and Bond 1977) concerning the stratigraphy of the Queensway roadcut developed because Greggs and Bond (1972) described the section at a part of the roadcut where the upper contact of the Nepean Formation is not exposed (Brand and Rust 1977b, p. 2761).

Although Wilson (1946a, p. 10) placed the lower contact of the Nepean Formation at the top of the Precambrian basement, the recognition now of the Covey Hill Formation underlying the Nepean Formation requires redefinition of the lower contact. Thus, the base of the Nepean Formation is defined here as the first appearance of quartz arenite. Where the Covey Hill Formation is absent, and the Nepean Formation rests directly on the Precambrian basement, the basal beds often are conglomeratic and consist of quartzite clasts in a quartzose matrix (Plates 1 and 3). Wilson (1946a, p. 10) placed the conformable upper contact of the Nepean Formation at the base of the lowest dolomitic or calcareous bed, but calcareous sandstone beds occur within the Nepean Formation and the upper contact is defined better as the base of the lowest dolomitic bed.

The occurrence of the Nepean Formation in Ontario is not restricted to the Ottawa-St. Lawrence Lowland, since it outcrops across and to the west of the Frontenac Axis. As noted above, the Nepean Formation is equivalent to the Keeseville Formation of adjacent New York State (Fisher 1977

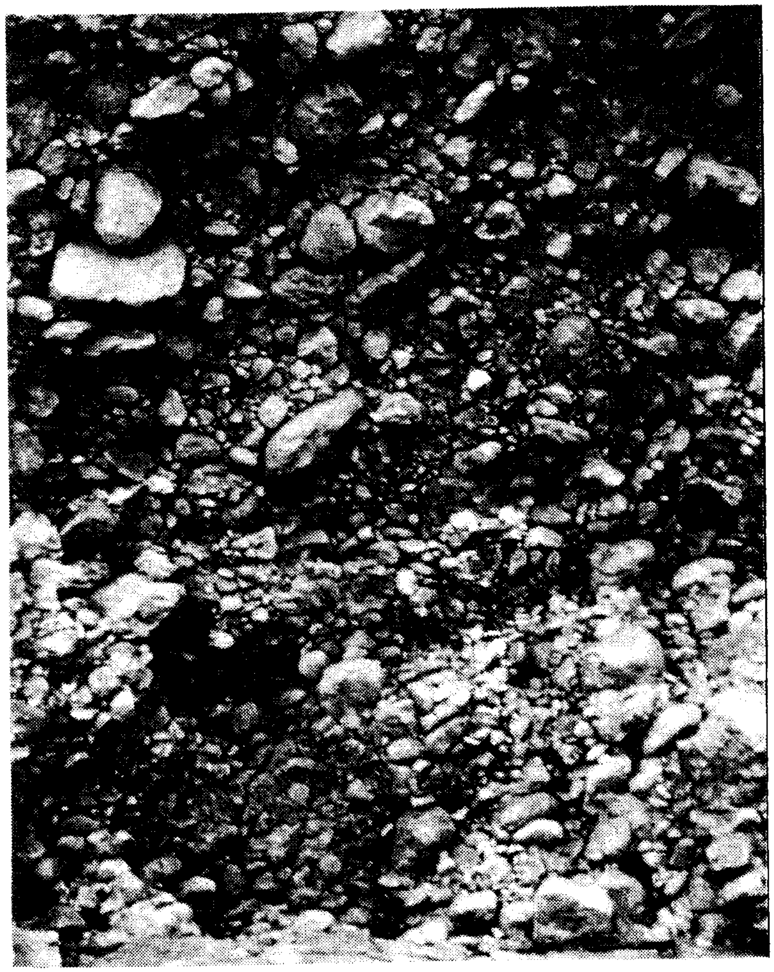

Plate 3. Nepean Formation, Charleston Lake Provincial Park (Westport map area, 31C/9; UTM 418500E, 4929280N). The exposure consists of conglomerate, with a lens of quartz sandstone. Photo RW-2-14 (1982).

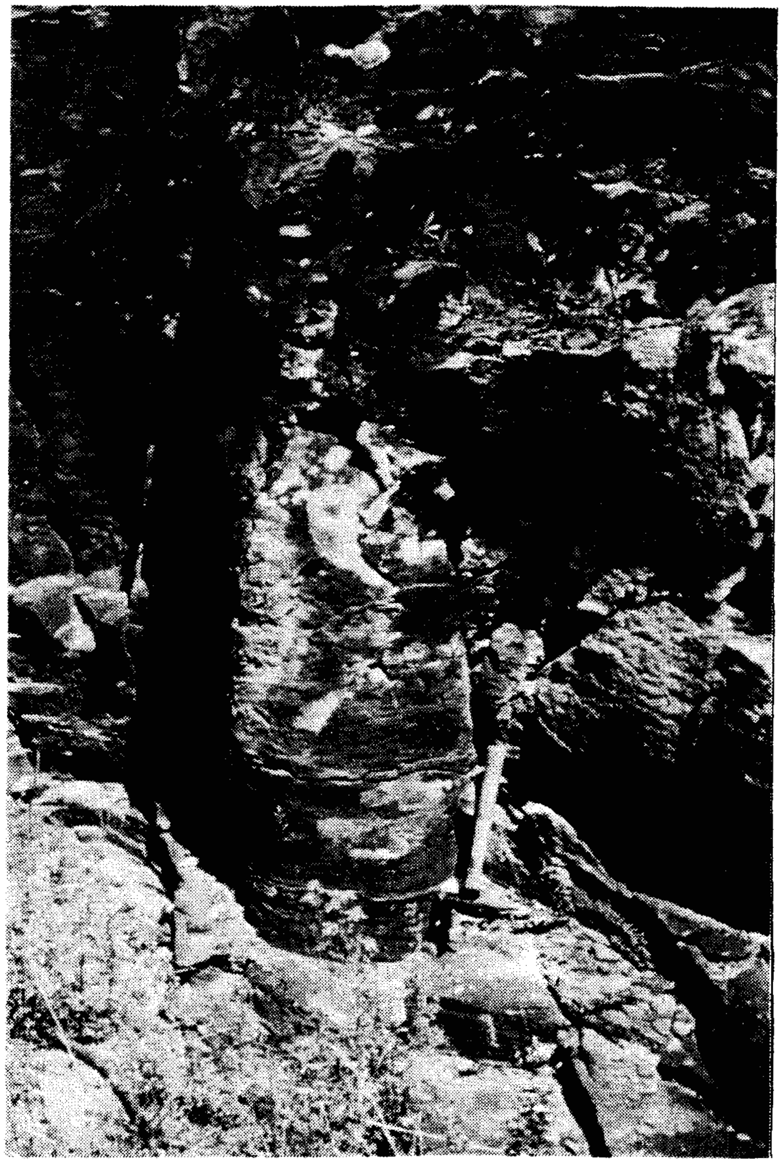

Plate 4. Cylindrical structure in quartz sandstone of the Nepean Formation, Highway 15 roadcut 2 km north of Morton (Westport map area, 31C/9; UTM 404120E, 4934250N). Photo RW-4-14 (1982).

- see Table 6). It is also equivalent to the Cairnside Formation of adjacent Quebec, introduced by Globensky (1982a, p. 8; 1982b, p. 7-8) to replace Clark's (1966, p. 19-29) Cairnside Member of the Chateauguay Formation.

Distribution. The Nepean Formation outcrops sporadically along the margins of the Ottawa-St. Lawrence Lowland in the Mallorytown (31B/5), Brockville (31B/12), Westport (31C/9), Perth (31C/16), Carleton Place (31F/1), Arnprior (31F/8), Ottawa (31G/5), and Thurso (31G/11) map areas (Figure 8). It generally subcrops beneath overlying formations throughout the Lowland, but does not occur in the vicinity of prominent Precambrian topographic highs.

Many of the exposed sections of the Nepean Formation are described in Appendix 1, which includes references to other published section descriptions. The Queensway roadcut (S OT-3, Ottawa map area, 31G/5) exposes the upper contact and is accepted here as the type section of the Nepean Formation, in accord with Brand and Rust (1977a, 1977b). Other good exposures which are used herein as reference sections are the Hayes Corners roadcut (S BR-1, Brockville map area, 31B/12); the Carleton Place (Metcalf) quarry (AQ CA-1, Carleton Place map area, 31F/1); the Browns Bay roadcut (S MA-1, Mallorytown map area, 31B/5); and the Philipsville roadcut (S WE-1, Westport map area, 31C/9). The upper contact of the Nepean Formation is exposed in both the Browns Bay and Philipsville roadcuts. As indicated in

Appendix 2, many drillholes have intersected the formation; references to drillhole descriptions are included in Appendix 2.

Lithology. The Nepean Formation consists of quartz sandstone, with some conglomerate interbeds up to approximately 3 metres thick and rare shaly partings. Conglomerate beds are confined to the lower part of the formation. The sandstones and the matrix of the conglomerates consist of fine to coarse quartz sand grains. Fine grained sandstone predominates in the upper part of the formation. The subrounded to well rounded quartz grains have variable amounts of hematite coating which enhance laminae within the beds. The two most common cements are quartz, which renders the rock more resistant to weathering; and calcite, which results in a more friable rock. The lower part of the formation is non-calcareous, and the upper part becomes increasingly calcareous towards the top.

The sandstones are thinly bedded to massive (beds up to 2 metres thick fill channels) and usually are well sorted, rarely containing any quartz pebbles and cobbles. The sandstones range in colour from white to light grey, brown, reddish brown, and green; and weather white to light grey and brown to reddish brown. Numerous small brown-weathering spots are the result of diffusion into the surrounding pore spaces of iron derived from detrital pyrite, magnetite, or ilmenite grains. Cross bedding, ripple marks, and burrows are common. Chaotic structures in an outcrop located at Eagleson Corners (Ottawa map area, 31G/5; UTM 431470E, 5016620N) were probably caused by slumping prior to consolidation (Waterfall 1973).

Conglomerates of the Nepean Formation contain pebble-to cobble-size subangular to well rounded clasts derived mainly from Precambrian quartzite. The conglomerates are generally massive, and range in colour from light grey to dark grey to reddish brown.

Unique cylindrical structures ("pillars") occurring in southeastern Ontario and adjacent New York State have been described by Hawley and Hart (1934) and Dietrich (1953). The cylinders are characterized by abrupt termination of stratification at their contacts, and by concentric reddish brown colour banding subparallel to the contacts. The cylinders have vertical axes, and vertical and horizontal dimensions of up to 5 metres. Dietrich (1953) concluded that the cylinders resulted from movement of sand into cavities in the underlying Precambrian marble. Sandstone pillars have been reported from the Perth map area (31C/16) by Wilson and Dugas (1961), and were observed at several localities in the Westport map area (31C/9). Excellent examples are present in the Highway 15 roadcut 2 km north of Morton (UTM 404120E, 4934250N) (Plate 4).

The chemical composition of the Nepean Formation was approximated by averaging the drillcore analyses reported by Powell and Klugman (1979, Appendix 2), and is as follows:

96.6% SiO_2, 0.2% Fe_2O_3, 1.1% Al_2O_3, 1.8% CaO, and 0.1% MgO. Loss on ignition was not determined.

Wolf and Dalrymple (1984, 1985) identified three marine and two terrestrial facies within the Nepean Formation. The marine facies are dominant in the Ottawa-St. Lawrence Lowland, and the terrestrial facies in the Gananoque map area (31C/8) to the southwest. The most common marine facies consists of crossbedded sandstone with discrete vertical burrows, alternating with intensely bioturbated sandstone, in cycles up to 3 metres thick. Deposition in a lower intertidal to subtidal environment was suggested. Two minor, associated facies indicate deposition in wave- and storm-dominated environments, respectively. The most common terrestrial facies consists of sandstone units with large-scale crossbeds (interpreted as a coastal dune complex) separated by conglomerate layers and lenses (interpreted as stream gravels). A minor associated facies of trough cross bedded sandstone suggests a fluvial channel deposit.

Thickness. The Nepean Formation is considerably thicker (up to at least 309.4 metres) in the eastern part of the Ontario portion of the Ottawa-St. Lawrence Lowland than in the western part. This suggests that Clark's (1972a, p. 12, 30) figure of only 44.2 metres for the equivalent Cairnside Formation in the Mallet (Ste. Therese) well, drilled near Montreal, excludes a considerable thickness of underlying beds that probably should be referred to the Cairnside

Formation. Reduced thicknesses occur in the southern part of the Ottawa-St. Lawrence Lowland in the vicinity of prominent Precambrian topographic highs, as exemplified by the absence of the Nepean Formation in the Butternut Bay roadcut (Brockville map area, 31B/12; S BR-2 in Appendix 1).

Measured thicknesses from this study for the exposed sections and drillhole intersections are listed in Appendices 1 and 2 and Table 9 (the "+" symbol indicates that the entire thickness of the formation does not occur in the exposure or drillhole). Measurements reported in other publications for the exposed sections, and for other sections no longer exposed (AQ OT-5, AQ OT-6, and AQ PE-4), are included in Appendix 1. Bernius (1981) reported a thickness of approximately 45.5 metres for the Nepean Formation, as intersected in holes drilled at the Canada Centre for Mineral and Energy Technology complex in Nepean.

Exposure	Thickness	Drillhole	Thickness	Drillhole	Thickness	Drillhole	Thickness
S BR-1	10.47+	DH AL-1	258.8+	DH MO-1	45.3	GDH WE-3	12.2+
S BR-2	0.00	DH AL-3	309.4+	DH MO-2	19.8+	GDH WE-4	10.5+
AQ CA-1	3.75+	GDH AR-1	9.1+	GDH OT-1	9.1+		
AQ CA-2	0.75+	GDH BR-1	6.8+	GDH OT-3	6.4+		
S MA-1	7.70+	GDH BR-2	26.7+	DH OT-5	60.4		
AQ OT-7	1.75+	GDH BR-6	3.4	GDH PE-1	4.0+		
S OT-3	6.35+	GDH CA-1	31.1	GDH PE-2	13.7+		
AQ PE-1	2.00+	GDH CA-2	20.1+	GDH PE-3	36.9		
AQ PE-3	1.30+	GDH CA-3	1.2+	DH RU-24	159.3+		
LQ WE-1	2.00+	GDH CA-4	5.1+	GDH VA-1	9.1+		
LQ WE-5	2.50+	GDH HA-1	10.9+	GDH WE-1	20.3+		
S WE-1	3.10+	GDH ME-2	0.0	GDH WE-2	22.6+		

TABLE 9. Thickness (in metres) of the Nepean Formation of the Ottawa-St Lawrence Lowland.

Age. The Nepean Formation contains the inarticulate brachiopod *Lingulepis acuminata* (Wilson 1946a, p. 12), rare pelecypods and gastropods (Wolf and Dalrymple 1985, p. 115), and various trace fossils: *Climactichnites* (ladder-like trails), *Protichnites* (arthropod crawling traces), *Arenicolites* (u-shaped burrows), *Diplocraterion* (u-shaped burrows), *Skolithos* (vertical and inclined burrows), and *Monocraterion* (vertical burrows) (Wolf and Dalrymple 1984, 1985). In the Brockville map area (31B/12) the Nepean Formation has not yielded any conodonts, but overlying strata of the March Formation contain an Upper Tremadocian (Lower Ordovician) conodont fauna (Greggs and Bond 1971; Bond and Greggs 1973). In the Ottawa map area (31G/5) the upper part of the Nepean Formation contains a younger Lower Arenigian (Lower Ordovician) conodont fauna (Brand and Rust 1977a). An Upper Cambrian to Lower Ordovician age is therefore indicated for the Nepean Formation, with the age of the upper contact becoming younger northward.

At Ausable Chasm in northeastern New York State, the equivalent Keeseville Formation has yielded Middle Cambrian trilobites (Fisher 1968, p. 16).

Beekmantown Group (March and Oxford Formations)

The sequence of Lower Ordovician dolostone was named the Beekmantown Group by Clarke and Schuchert (1899). It was named for the village of Beekmantown in northeastern New

York State, where it outcrops, The Beekmantown Group has been subdivided into two formations (Table 6): the lower, a sandy unit which was removed from the Potsdam Group by Cushing (1908) and referred to by him as the Theresa Formation; and the upper, a less sandy unit which was referred to by Cushing (1916) as the Ogdensburg Formation. In southeastern Ontario the lower unit was named the March Formation, and the upper unit the Oxford Formation, by Wilson (1937) (Table 6). In southern Quebec the Theresa Formation is overlain by the Beauharnois Formation (Globensky 1982a, 1982b) (Figure 6). Because of the different lithological parameters used to distinguish the Theresa and Ogdensburg Formations, and the March and Oxford Formations, the upper contact of the Theresa Formation is stratigraphically lower than the upper contact of the March Formation. Cushing's (1916) definition of the Theresa-Ogdensburg contact is very difficult to apply in practice (Selleck 1984, p. 119), but Wilson's (1946a, p. 13-14) definition of the March-Oxford contact (the top of the highest occurrence of sand in any quantity, or the top of the uppermost sandy bed) is relatively easy to apply.

March Formation

Definition. The Lower Ordovician March Formation (Plate 5) as originally proposed by Wilson (1937) consisted of interbedded quartz sandstone and dolostone. The sandstone

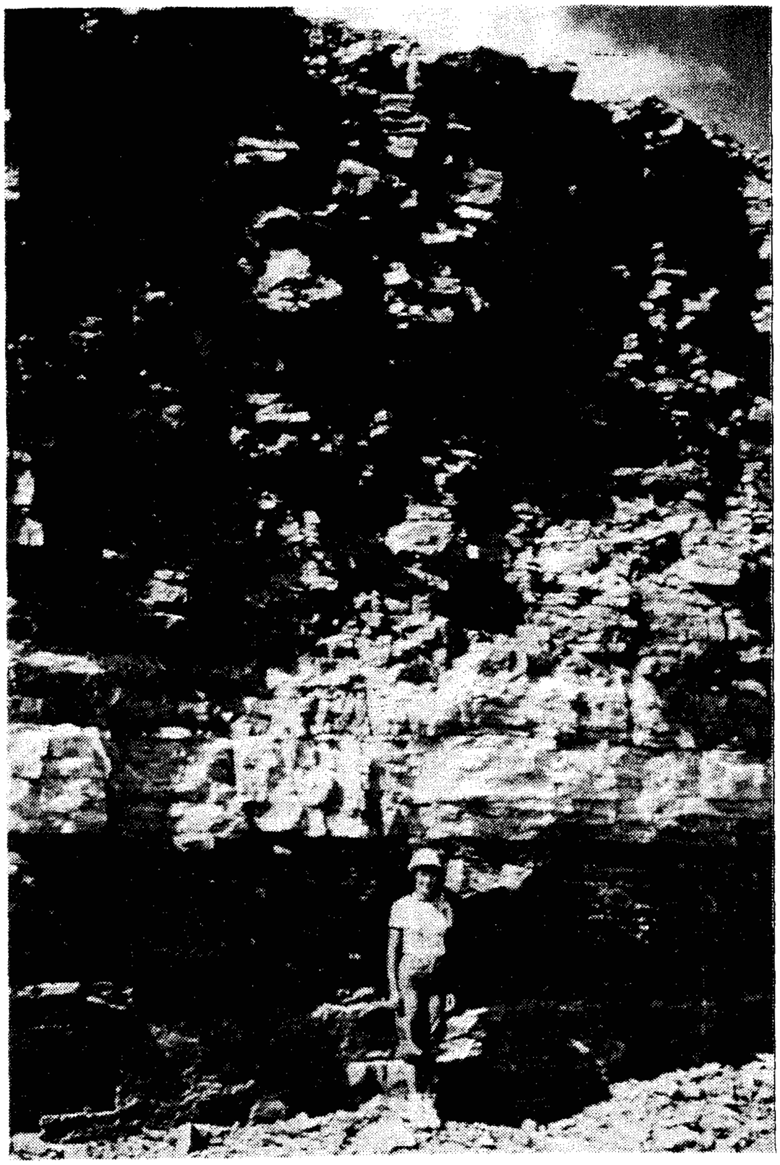

Plate 5. March Formation, Carleton Place (Duffy) quarry (Carleton Place map area, 31F/1; LQ CA-4 in Appendix 1). The prominent light coloured bed is quartz sandstone. Photo RW-4-21 (1982).

beds are commonly dolomitic, and the dolostone beds are commonly sandy. The formation was named for March Township in the Ottawa map area (31G/5), where it outcrops. Wilson (1946a, p. 12-13) placed the conformable lower contact at the base of the lowest dolomitic bed and the conformable upper contact at the top of the highest occurrence of sand in any quantity. Wilson's (1946a) intention was for the formation to represent a transition between quartz sandstone of the underlying Nepean Formation and dolostone of the overlying Oxford Formation. Bond and Greggs (1973, p. 1142) included intervals of sandy dolostone in the overlying Oxford Formation, thus reducing the effectiveness of considering the March Formation as a transition zone. In addition, the redefinitions by Bond and Greggs (1973) resulted in the March-Oxford formational contact being less distinctive as it was marked only by the difference between dolomitic sandstone and sandy dolostone (Rogers 1980, p. 9). As the use of this parameter is not feasible, the top of the March Formation is recommended to be placed at the upper limit of the common occurrence of quartz sand.

As noted above, the March Formation is equivalent to the Theresa Formation and lowermost Ogdensburg Formation of adjacent New York State and to the Theresa Formation and lowermost Beauharnois Formation of adjacent Quebec (Table 6). Distinctive bluish grey, dolomitic quartz sandstone occurring in the lower part of the Theresa Formation in New

York State is very similar to that present in the lower part of the March Formation in adjacent Ontario.

Distribution. The March Formation outcrops sporadically along the margins of the Ottawa-St. Lawrence Lowland in the Mallorytown (31B/5), Brockville (31B/12), Merrickville (31B/13), Westport (31C/9), Perth (31C/16), Carleton Place (31F/1), Arnprior (31F/8), Ottawa (31G/5), Thurso (31G/11), and Hawkesbury (31G/10) map areas (Figure 9). It generally subcrops beneath overlying formations throughout the Lowland, but usually does not occur in the vicinity of prominent Precambrian topographic highs.

Many of the exposed sections of the March Formation are described in Appendix 1, which includes references to other published section descriptions. Good exposures which are used herein as the principal reference sections are the Brockville (Permanent) quarry (LQ BR-3, Brockville map area, 31B/12) and the South Gloucester (Armbro) quarry (LQ OT-7, Ottawa map area, 31G/5). The upper contact of the March Formation is exposed in both quarries. Another good exposure of the March Formation is the Smith's Falls (Shirley) quarry (LQ PE-1, Perth map area, 31C/16). As indicated in Appendix 2, many drillholes have intersected the formation; references to drillhole descriptions are included in Appendix 2.

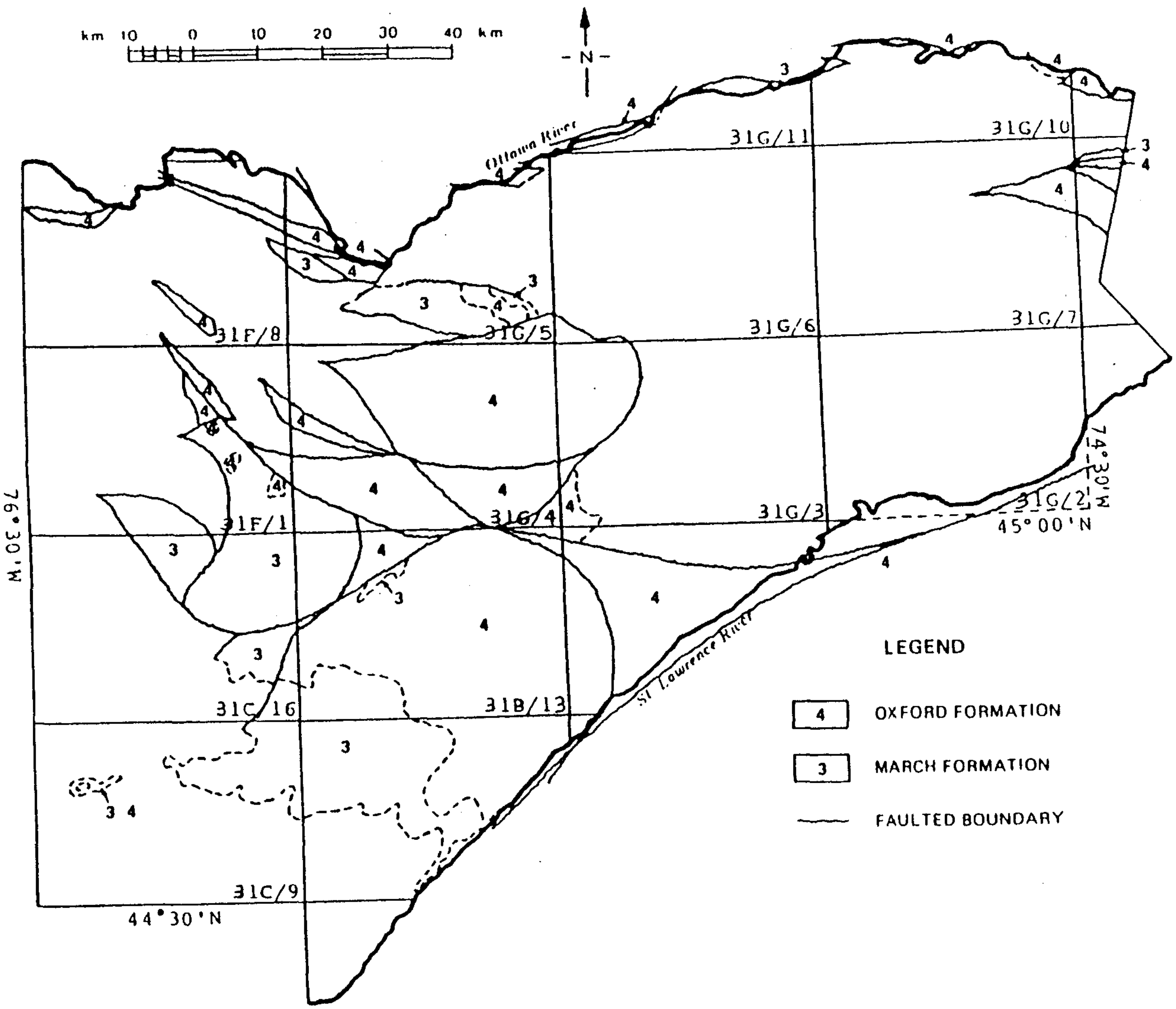

Figure 9. **Distribution of the Beekmantown Group of the Ottawa-St. Lawrence Lowland.**

Lithology. The March Formation consists of interbedded quartz sandstone, dolomitic quartz sandstone, sandy dolostone, and dolostone. Quartz sandstone units have a maximum thickness in excess of 10 metres, while unit thicknesses of other lithologies range up to several metres. Shaly partings occur throughout the formation, and glauconitic partings are present in the dolostones and sandy dolostones. Boulders and cobbles of quartzite occur in the Butternut Bay roadcut (Brockville map area, 31B/12; S BR-2 in Appendix 1), adjacent to the steeply dipping contact with a prominent Precambrian topographic high.

Quartz sandstones of the March Formation are lithologically similar to those of the underlying Nepean Formation. They are thinly to thickly bedded, fine to coarse grained, and well sorted. The sandstones range in colour from white to light grey, brown, reddish brown, and green; and weather white to light grey and brown to reddish brown. Small brown-weathering spots are common, and are the result of diffusion into the surrounding pore spaces of iron derived from detrital pyrite, magnetite, or ilmenite grains. The quartz grains are subrounded to well rounded. Two types of cement are common: quartz, which renders the rock more resistant to weathering; and calcite, which results in a more friable rock. Crossbedding, ripple marks, and burrows are common.

The dolomitic quartz sandstones and sandy dolostones are light to medium brownish to bluish grey in colour, and weather brownish grey to buff to reddish brown. They are thinly to thickly bedded and contain finely to medium crystalline carbonate and well rounded, fine to coarse grained quartz sand. Some dolomitic sandstone beds are calcareous, and some sandy dolostone beds are calcitic. Burrows and calcite-filled vugs are common.

Dolostones of the March Formation are lithologically similar to those of the overlying Oxford Formation. They are light to medium brownish to greenish grey in colour, and weather light grey to buff to reddish brown. They are thinly to thickly bedded, sublithographic to medium crystalline, and calcitic to non-calcitic. Algally bound laminae and calcite-filled vugs are common.

The chemical composition of the March Formation is approximated by the average of drillcore analyses reported by Powell and Klugman (1979, Appendix 2) for a 30.5-metre section intersected in the Ontario Ministry of Natural Resources (Eastern Region) Lanark E drillhole (Perth map area, 31C/16; GDH PE-3 in Appendix 2), as follows: 41.1% SiO_2, 0.72% Fe_2O_3, 2.77% Al_2O_3, 19.9% CaO, 10.1% MgO, and 26.8% loss on ignition.

The March Formation was deposited in a supratidal to subtidal environment. Supratidal to intertidal deposition and hypersalinity are implied by calcite-filled vugs (originally sulphate nodules) and algal lamination in the dolostones. Intertidal deposition is implied by bipolar crossbedded quartz sandstone containing discrete vertical burrows. Subtidal deposition is indicated by highly bioturbated dolomitic quartz sandstone (Bond and Greggs 1973, p. 1147-1150). A similar environment was inferred for the Theresa Formation of adjacent New York State by Selleck (1984).

Thickness. The thickness of the March Formation shows a general southeastward increase, ranging from 6.6 metres in the Carleton Place map area (31F/1) to 63.7 metres in the Alexandria map area (31G/7). A continued southeastward increase in adjacent Quebec is indicated by a thickness of 73.8 metres for the partially equivalent Theresa Formation in the Mallet (Ste. Therese) well, drilled near Montreal (Clark 1972a, p. 12, 30). Reduced thicknesses occur in the southern part of the Ottawa-St. Lawrence Lowland in the vicinity of prominent Precambrian topographic highs, as exemplified by the absence of the March Formation in the Ontario Ministry of Transportation and Communications Merrickville 7 drillhole (Merrickville map area, 31B/13; GDH ME-2 in Appendix 2).

Measured thicknesses (in metres) for the exposed sections and drillhole intersections of Appendices 1 and 2 are listed in Table 10 (the "+" symbol indicates that the entire thickness of the formation does not occur in the exposure or drillhole). In addition, the thickness of the March Formation at South Gloucester (Ottawa map area, 31G/5) is 16.2 metres (equal to the sum of the intersection in GDH

OT-3 and the section in LQ OT-7, less 8.4 metres overlap); and the thickness at Brockville (Brockville map area, 31B/12) is 24.9+ metres (equal to the sum of the intersection in GDH BR-4 and the section in LQ BR-3, less 7.6 metres overlap). Measurements reported in other publications for the exposed sections of Table 10, and for LQ BR-4 which is no longer exposed, are included in Appendix 1. Bernius (1981) reported a thickness of approximately 8.5 metres for the March Formation, as intersected in holes drilled at the Canada Centre for Mineral and Energy Technology complex in Nepean.

Exposure	Thickness	Exposure	Thickness	Drillhole	Thickness	Drillhole	Thickness
LQ BR-1	6.45+	LQ OT-10	1.70+	DH AL-1	63.1	DH MO-2	33.5
LQ BR-3	12.10+	S OT-1	6.03+	DH AL-3	63.7	DH MO-3	31.7+
LQ BR-5	4.50+	S OT-2	0.57+	GDH BR-1	9.4+	GDH OT-3	9.4+
LQ BR-6	4.50+	S OT-3	0.35+	GDH BR-3	1.2+	GDH OT-4	14.3+
AQ BR-1	1.90+	LQ PE-1	11.00+	GDH BR-4	20.4+	GDH OT-5	6.0+
S BR-2	6.40+	LQ PE-4	5.15+	GDH BR-5	13.4+	GDH OT-6	7.6+
S BR-3	8.70+	AQ PE-2	2.50+	GDH BR-6	5.8+	DH OT-5	17.6
S BR-4	4.50+	LQ WE-2	3.65+	GDH CA-1	6.9	DH OT-9	5.2+
LQ CA-4	4.30+	LQ WE-3	3.80+	GDH CA-3	9.2+	GDH PE-3	34.4+
S MA-1	4.70+	LQ WE-4	8.30+	GDH CA-4	6.6	DH RU-24	20.1
LQ ME-3	3.40+	S WE-1	3.55+	GDH HA-1	26.3	DH RU-26	3.0+
LQ OT-7	15.19+			GDH ME-2	0.0	GDH WE-4	8.9
LQ OT-8	4.60+			DH MO-1	35.3	DH WI-2	16.7+

TABLE 10. Thickness (in metres) of the March Formation of the Ottawa-St. Lawrence Lowland.

Age. The March Formation contains the same marine trace fossil assemblage as the underlying Nepean Formation, except for the absence of Climactichnites and Protichnites. Some dolostone beds contain stromatolites, and some dolostone and sandy dolostone beds contain numerous gastropods. In the Brockville map area (31B/12), a change in conodont faunas probably indicating the Tremadocian-Arenigian boundary was recognized by Greggs and Bond (1971) and Bond and Greggs (1973). This boundary occurs at the upper contact of their March Formation, that is, within the upper part of the March Formation of this study. In the Ottawa map area (31G/5), the upper part of the underlying Nepean Formation contains a Lower Arenigian conodont fauna (Brand and Rust 1977a). A Lower Ordovician age is therefore indicated for the March Formation, with the age of both lower and upper contacts becoming younger northward.

Oxford Formation

Definition. The Lower Ordovician Oxford Formation (Plate 6) as originally proposed by Wilson (1937) consisted of dolostone with subordinate shaly and sandy interbeds. It was named for outcrops in Oxford Township, in the Merrickville (31B/13) and Kemptville (31G/4) map areas. Wilson's (1946a, p. 14) definition of the conformable lower contact with the March Formation, the top of the uppermost sandy bed, is modified here as the upper limit of common occurrence of quartz sand. The disconformable upper contact with the Rockcliffe Formation is at the base of the overlying sequence of quartz sandstone and shale.

As noted above, the Oxford Formation is equivalent to all but the lowest part of the Ogendsburg Formation of New

Plate 6. Oxford Formation, Trans Canada Pipelines Limited excavation, Hallville (Winchester map area, 31G/3; UTM 462860E, 4992510N). Photo DW-3-10 (1982).

York State and to all but the lowest part of the Beauharnois Formation of Quebec (Table 6).

Distribution. As indicated in Figure 9, the Oxford Formation outcrops sporadically in all map areas of the Ontario portion of the Ottawa-St. Lawrence Lowland except Mallorytown (31B/5), where only units stratigraphically below the Oxford Formation outcrop; and Huntingdon (31G/1), where only units stratigraphically above the Oxford Formation are interpreted to subcrop beneath surficial deposits. The formation subcrops beneath overlying bedrock formations in the central and northern parts of the Lowland.

Many of the exposed sections of the Oxford Formation are described in Appendix 1, which includes references to other published section descriptions. Good exposures which are used herein as reference sections are the Brockville (Permanent) quarry (LQ BR-3, Brockville map area, 31B/12); the South Gloucester (Armbro) quarry (LQ OT-7, Ottawa map area, 31G/5); the Iroquois (Fetterly) quarry (LQ MO-3, Morrisburg map area, 31B/14); and the Cumberland quarry (AQ TH-2, Thurso map area, 31G/11). The principal reference sections for the lower part of the Oxford Formation (including the lower contact) are the Brockville (Permanent) quarry and the South Gloucester (Armbro) quarry. The principal reference section for the upper part of the formation (including the upper contact) is the Cumberland quarry. As indicated in Appendix 2, many drillholes have intersected the formation; references to drillhole descriptions are included in Appendix 2.

Lithology. The Oxford Formation consists mainly of dolostone. Shaly interbeds up to 30 cm thick occur, and are commonly glauconitic. Fine to coarse grained well rounded quartz sand occurs in some beds in minor amounts as floating grains, and fine to medium grained quartz sandstone occurs as interbeds up to 30 cm thick. Bond and Greggs (1976, p. 22) divided the formation into lower quartzose and upper non-quartzose units. Steeply dipping sandy to conglomeratic dolostone characterizes exposures adjacent to prominent Precambrian topographic highs (consisting of quartzite) which occur in the Merrickville (31B/13) and Kemptville (31G/4) map areas.

Dolostones of the Oxford Formation are light to medium brownish to greenish grey in colour, and weather light grey to buff and reddish brown. They are thinly to thickly bedded, sublithographic to medium crystalline, and calcitic to non-calcitic. Algally bound laminae and calcite-filled vugs are common, and quartz-filled vugs are also present. Pyrite occurs in some calcite-filled vugs, and also in some of the thin interbeds. Intraclastic beds occur, and are commonly oolitic. The dolostones are also characterized by desiccation cracks, conchoidal fractures, stylolites, burrows, and soft-sediment deformation structures (load casts and flame structures). Nodules of white chert occur locally.

The chemical composition of the Oxford Formation is approximated by the average of analyses reported by Hewitt (1960, p. 20-22) for a 23.8 metre section exposed in the Iroquois (Fetterly) quarry (Morrisburg map area, 31B/14; LQ MO-3 in Appendix 1), as follows: 9.34% SiO_2, 1.00% Fe_2O_3, 4.94% Al_2O_3, 26.48% CaO, 17.29% MgO, and 39.79% CO_2.

A supratidal to intertidal hypersaline depositional environment is inferred from the occurrence of calcite-filled vugs (originally sulphate nodules) and algal lamination in the Oxford Formation. This was also inferred for the Ogdensburg Formation of adjacent New York State by Harris and Friedman (1982) on the basis of the presence of five lithofacies: mottled quartzose feldspathic dolostone (supratidal); algal-laminated dolostone (upper intertidal to supratidal); interbedded fossiliferous and mottled dolostone (upper intertidal); current-laminated dolostone (upper intertidal); and silicified oosparite (lower intertidal). Only the first three lithofacies are common.

Thickness. The Oxford Formation is considerably thicker (up to 197.5 metres) in the eastern part of the Ontario portion of the Ottawa-St. Lawrence Lowland than in the western part. A continued eastward increase in adjacent Quebec is indicated by a thickness of 248.1 metres for the partially equivalent Beauharnois Formation in the Mallet (Ste. Therese) well, drilled near Montreal (Clark 1972a, p. 12).

Measured thicknesses (in metres) for the exposed sections and drill hole intersections of Appendices 1 and 2 are listed in Table 11 (the "+" symbol indicates that the entire thickness of the formation does not occur in the exposure or drillhole). Measurements reported in other publications for the exposed sections of Table 11 are included in Appendix 1.

Exposure	Thickness	Exposure	Thickness
LQ BR-2	6.00+	S ME-1	4.05+
LQ BR-3	8.00+	LQ MO-2	0.30+
LQ BR-4	5.60+	LQ MO-3	27.62+
AQ BR-2	7.00+	AQ MO-1	2.80+
AQ BR-3	2.00+	LQ OT-6	1.50+
AQ BR-4	10.10+	LQ OT-7	12.11+
S BR-5	8.15+	LQ OT-8	7.55+
LQ CA-3	1.70+	LQ OT-9	8.80+
LQ CA-4	4.50+	LQ OT-10	5.05+
LQ KE-2	8.00+	S OT-2	3.03+
LQ ME-1	5.00+	S OT-9	0.25+
LQ ME-2	10.40+	LQ PE-2	4.10+
LQ ME-4	5.40+	AQ TH-2	10.00+

Drillhole	Thickness	Drillhole	Thickness
DH AL-3	197.5	DH MO-3	108.8+
GDH BR-3	7.9+	GDH OT-4	0.3+
GDH BR-5	4.9+	GDH OT-5	3.1+
GDH CA-1	1.8+	DH OT-5	62.2
GDH CA-4	2.3+	DH OT-9	64.9
GDH HA-1	129.1	DH RU-24	102.1
GDH KE-1	9.1+	DH RU-26	100.6
GDH ME-1	9.1+	GDH WE-4	3.8
GDH ME-2	5.8+	GDH WI-1	9.3+
GDH MO-1	9.1+	DH WI-1	164.6+
GDH MO-2	8.8+	DH WI-2	169.5
DH MO-1	109.4+	DH WI-3	36.3+
DH MO-2	105.5+		

TABLE 11. Thickness (in metres) of the Oxford Formation of the Ottawa-St. Lawrence Lowland.

<u>Age</u>. Some beds of the Oxford Formation contain numerous gastropods (Wilson 1946a, p. 16; Yochelson and Copeland 1974), and stromatolites and algal lamination are common. A small collection of poorly preserved trilobites of late Lower Ordovician age was described by Ludvigsen (1979). Bond and Greggs (1976, p. 23) noted that macrofossils are rare in the upper part of the formation. The Oxford Formation contains a Lower Arenigian (Lower Ordovician) conodont fauna in the Brockville map area (31B/12) (Bond and Greggs 1976, p. 24-25).

Rockcliffe Formation

Definition. The sequence of Middle Ordovician limestone, sandstone, and shale which overlies the Beekmantown Group was named the Chazy Limestone by Emmons (1842). The type locality is Chazy Township in northeastern New York State. Raymond (1905) referred to the Chazy Group of the Ottawa Valley as the Aylmer Formation. Wilson (1937) introduced the Rockcliffe Formation (Plates 7 and 8) to refer to the lower part of Raymond's (1905) Aylmer Formation, and the St. Martin Formation to refer to the upper part. The Rockcliffe Formation as originally proposed by Wilson (1937) consisted of interbedded quartz sandstone and shale. It was named for Rockcliffe Park in the Ottawa map area 31G/5, where it outcrops. The disconformable lower contact with the Oxford Formation is the top of the underlying dolostone sequence. Wilson (1937, p. 48-49; 1946a, p. 17) observed the lower contact of the Rockcliffe Formation in an exposure at Skead Road, herein the Rothwell Heights roadcut (Ottawa map area, 31G/5; S OT-9 in Appendix 1). The St. Martin Formation as originally proposed by Wilson (1937) consisted of interbedded quartz sandstone, shale, limestone, and silty dolostone. It was named for Cap St. Martin, near Montreal. The strata referred to by Wilson (1937) as the St. Martin Formation were included within the Rockcliffe Formation by Poole et al. (1970, p. 250) and Williams and Wolf (1982). This is in accord with Clark's (1972a, p. 6) assignment of

Plate 7. Rockcliffe Formation (lower member), Canadian Forces Base Rockcliffe (Ottawa map area, 31G/5; UTM 450240E, 5033700N). Photo RW-2-37 (1982).

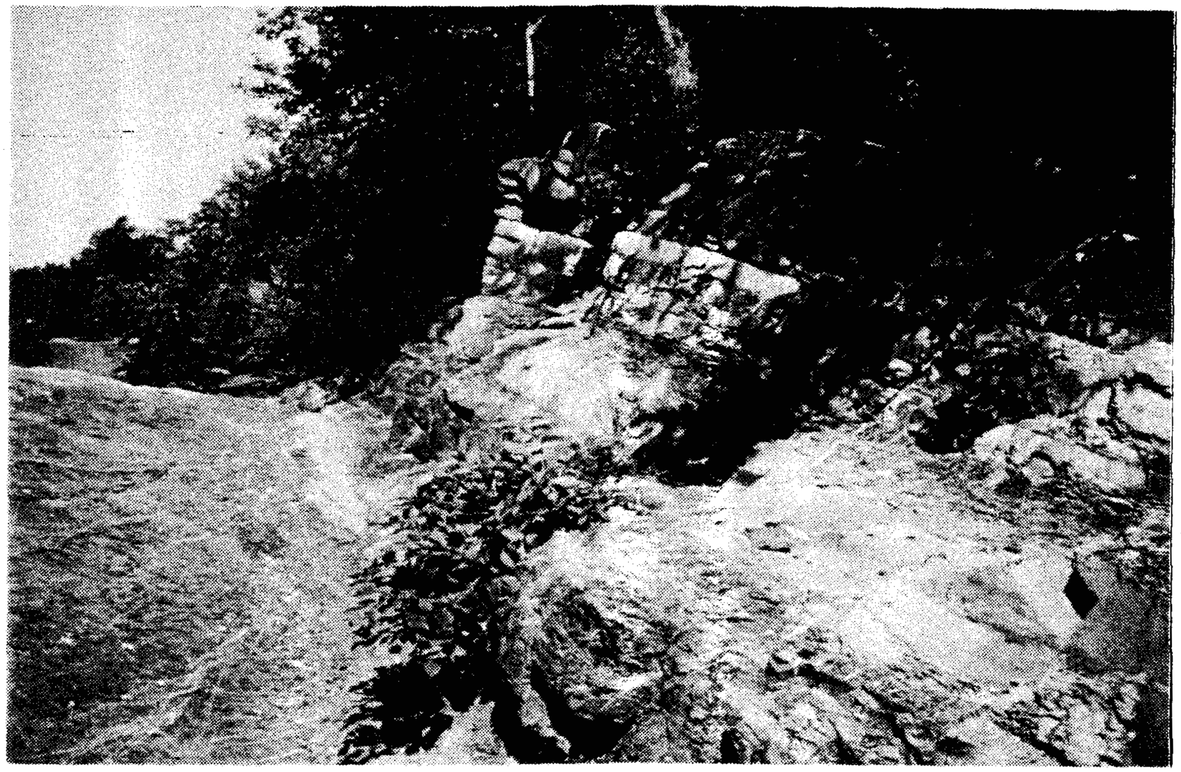

Plate 8. Shadow Lake Formation overlying the Rockcliffe Formation, Prince of Wales Falls, Hog's Back Park, Ottawa (Ottawa map area, 31G/5; S OT-5a in Appendix 1).

the lithology occurring at Cap St. Martin (medium to coarsely crystalline limestone) to member status within the Laval Formation of the Chazy Group. The disconformable upper contact of the Rockcliffe Formation with the Ottawa Group therefore requires redefinition; it is redefined here as the upper limit of occurrence of shale interbeds greater than 10 cm thick.

The Rockcliffe Formation can be subdivided into lower and upper (St. Martin) members; interbedded quartz sandstone and shale occur in both members, the upper member being distinguished by the additional presence of limestone and silty dolostone interbeds. The contact between the members coincides with the base of Wilson's (1937) St. Martin Formation. The lithology constituting Clark's (1972a, p. 63) St. Martin Member (medium to coarsely crystalline limestone) occurs as beds within Wilson's (1937) St. Martin Formation, herein the upper (St. Martin) member (Table 6).

The redefined Rockcliffe Formation is therefore equivalent to the Laval Formation of adjacent Quebec, the lower member being equivalent to the Ste. Therese Member and the upper member to the rest of the Laval Formation including Clark's (1972a) St. Martin Member (Table 6).

<u>Distribution</u>. The Rockcliffe Formation outcrops sporadically and subcrops beneath younger bedrock formations in the central and northern parts of the Ottawa-St. Lawrence Lowland (Figure 10). In the southern part of the Lowland,

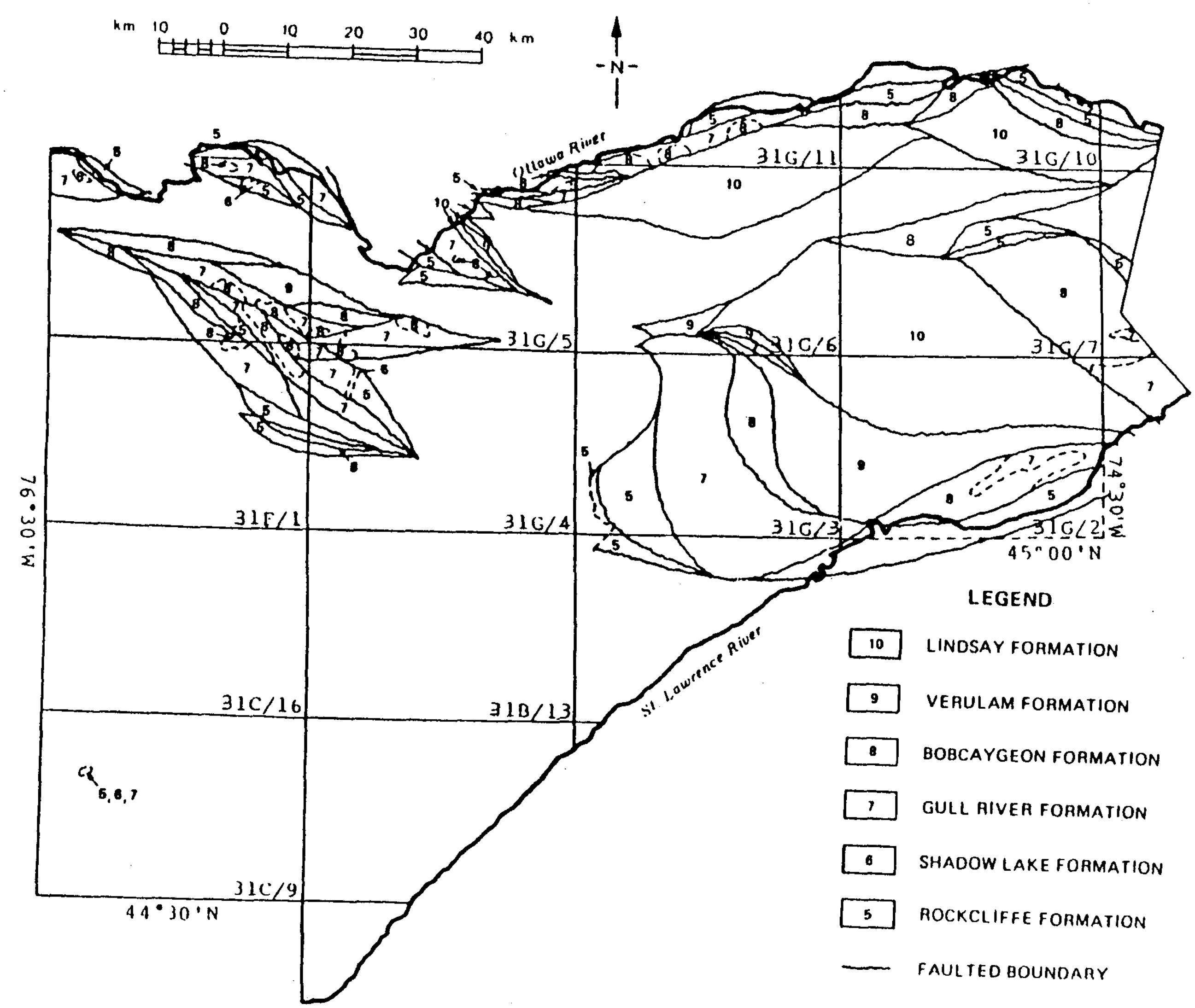

Figure 10. **Distribution of the Rockcliffe Formation and Ottawa Group of the Ottawa-St. Lawrence Lowland.**

only units stratigraphically below the Rockcliffe Formation outcrop in the Mallorytown (31B/5), Brockville (31B/12), and Merrickville (31B/13) map areas.

Many of the exposed sections of the Rockcliffe Formation are described in Appendix 1, which includes references to other published section descriptions. Good exposures which are used herein as reference sections are the Hawkesbury quarry (LQ HA-2, Hawkesbury map area, 31G/10); the escarpment at Canadian Forces Base Rockcliffe (S OT-10, Ottawa map area, 31G/5); and the Cumberland quarry (AQ TH-2, Thurso map area, 31G/11). The principal reference section for the lower member of the Rockcliffe Formation (including the lower contact) is the Cumberland quarry. The principal reference sections for the upper member of the formation (including the lower contact) are the Hawkesbury quarry and the escarpment at CFB Rockcliffe. As indicated in Appendix 2, many drill holes have intersected the formation; references to drillhole descriptions are included in Appendix 2.

<u>Lithology</u>. The Rockcliffe Formation consists mainly of interbedded quartz sandstone and shale, with interbedded shaly bioclastic limestone and shale predominating in the upper member of the formation in the eastern part of the Ontario portion of the Lowland.

The quartz sandstones are light grey to light greenish grey in colour, greenish grey weathering, very thinly to thickly bedded, calcareous to non-calcareous, and generally fine grained. Coarse to very coarse grained interbeds up to one metre thick are present, as are dark green shaly partings. Crossbedding, desiccation cracks, ripple marks, flute casts, and burrows are common.

The shales are dark grey to dark green to maroon. The maroon colour was noted only in the Arnprior (31F/8) and Carleton Place (31F/1) map areas, in the northwestern part of the Lowland. Shale units are up to 2.5 metres thick, and commonly contain thin interbeds of fine grained quartz sandstone.

A basal quartz-pebble conglomerate occurs locally; it is very thinly to medium bedded, and fresh and weathered surfaces are medium grey. In the Rothwell Heights roadcut (Ottawa map area, 31G/5; S OT-9 in Appendix 1), the conglomerate is 65 cm thick. No basal conglomerate occurs in the Dunrobin quarry (Ottawa map area, 31G/5; LQ OT-6 in Appendix 1). The basal unit in the Dames and Moore drill hole RH4 (Winchester map area, 31G/3; DH WI-2 in Appendix 2) is a medium to coarse grained quartz sandstone 4.6 metres thick (Bond and Greggs 1976, p. 22).

The shaly bioclastic limestones of the upper member of the Rockcliffe Formation are sublithographic to finely crystalline. Some beds are sandy. In the eastern part of the Ontario portion of the Lowland, the upper member is also characterized by interbeds up to 4.5 metres thick of medium to coarsely crystalline fossiliferous limestone (equivalent to Clark's (1972a, p. 63) St. Martin Member). The latter are medium to massive bedded and medium grey in colour, weather brownish grey, and commonly contain crossbedding and stylolites. Interbeds up to 70 cm thick of calcitic to non-calcitic silty dolostone with conchoidal fractures also occur in the upper member. These dolostones are finely crystalline and light to medium grey in colour, and weather buff to reddish brown.

The Rockcliffe Formation was deposited in a supratidal to subtidal intracontinental shelf environment. Periodic exposure is indicated by desiccation cracks, and an eastward increase in water depth is suggested by the geographic distribution of trace fossil facies (Hofmann 1979, p. 29-30). The terrigenous clastics were derived from Precambrian topographic highs, suggesting uplift in areas to the west.

Thickness. The Rockcliffe Formation is considerably thicker (up to 124.9 metres) in the eastern part of the Ontario portion of the Lowland than in the western part. The equivalent Laval Formation is 126.2 metres thick in the Oil Selections (L'Assomption) well, drilled near Montreal (Clark 1972a, p. 12). The maximum thickness noted for the lower member of the Rockcliffe Formation in Ontario is 59.0 metres (Hawkesbury map area, 31G/10). The thickness of the upper member increases eastward from 7.0 metres in the Ottawa map area (31G/5) to 105.5 metres of equivalent section in the Oil Selections (L'Assomption) well (Clark 1972a, p. 12, 64).

Measured thicknesses (in metres) of the lower and upper members for the exposed sections and drillhole intersections of Appendices 1 and 2 are listed in Table 12 (the "+" symbol indicates that the entire thickness of the member does not occur in the exposure or drill hole). Measurements reported in other publications for the exposed sections of Table 12 are included in Appendix 1.

LOWER MEMBER				UPPER MEMBER			
Exposure	Thickness	Drillhole	Thickness	Exposure	Thickness	Drillhole	Thickness
LQ CA-2	4.60+	GDH AL-1	9.1+	LA HA-2	4.50+	DH AL-3	58.9+
LQ HA-2	5.00+	DH AL-2	12.2+	S OT-5a	9.20+	DH AL-4	67.2+
AQ MO-2	1.50+	DH AL-3	53.9	S OT-10	10.10+	GDH HA-1	65.9
LQ OT-6	3.50+	GDH HA-1	59.0			DH OT-5	7.0
S OT-7	6.30+	GDH MO-2	3.4+			DH OT-11	12.4
S OT-9	3.55+	DH OT-5	45.1			DH RU-24	12.7
S OT-10	10.30+	DH OT-11	29.7+			GDH WE-4	1.5
AQ TH-2	10.00+	DH RU-24	35.2			DH WI-1	24.3
		GDH WE-4	0.0			DH WI-3	9.5+
		DH WI-1	35.1				
		DH WI-2	31.7+				
		DH WI-3	35.6				

TABLE 12. Thickness (in metres) of the Rockcliffe Formation of the Ottawa-St. Lawrence Lowland.

Age. Crinoids, bryozoa, and brachiopods (Raymond 1911; Wilson 1946a, p. 20-21) are abundant in the limestone beds of the upper member of the Rockcliffe Formation. Trace fossils produced mainly by worms and trilobites are common in the terrigenous beds; crawling traces and feeding burrows are most prevalent, and resting traces, dwelling burrows, and borings also occur (Hofmann 1979). The shelly fossils indicate a Chazyan age for the Rockcliffe Formation (Barnes et al. 1981). Since the underlying Oxford Formation is of Lower Ordovician age (see above), early Middle Ordovician (Whiterockian) strata either were not deposited or were eroded prior to deposition of the Rockcliffe Formation (Table 6).

Ottawa Group (Shadow Lake, Gull River, Bobcaygeon, Verulam, and Lindsay Formations)

The Middle to Upper Ordovician Ottawa Formation as originally proposed by Wilson (1937) consisted of limestone with interbeds of silty dolostone, shale, and quartz sandstone. Wilson (1946a, p. 21-24) subdivided the Ottawa Formation into three phases: a lower phase consisting of limestone with interbeds of dolostone, sandstone, and shale; a middle limestone phase which includes thick beds of high CaO content, some of which are coarsely crystalline; and an upper phase consisting of limestone with interbeds of shale (Table 7). Wilson (1946a, p. 24) also subdivided her Ottawa Formation into seven faunal zones: Pamelia, Lowville, Leray, Rockland, Hull, Sherman Fall, and Cobourg, in ascending order (Table 6). The names of all of Wilson's (1946a) faunal zones have been used in the Ottawa-St. Lawrence Lowland in a lithostratigraphic sense (cf. Poole et al. 1970), and the names of two of them (Pamelia and Lowville) were retained for lithostratigraphic use in New York State by Fisher (1977). Many attempts to use the names of

Wilson's (1946a) faunal zones in a lithostratigraphic sense have caused confusion (cf. Kay 1968b, Barnes 1968, Sinclair 1968).

Uyeno (1974, p. 1-2) raised Wilson's (1937) Ottawa Formation to group status, but refrained from using the names of Wilson's (1946a) faunal zones as formational names (with the exception of the Hull Formation) because of the lithostratigraphic-biostratigraphic problem. Uyeno (1974, p. 6) redefined the Hull Formation as relatively pure to argillaceous limestone with shaly partings, contained in two members. The member subdivision was based on the upper member being of generally higher purity, coarser crystallinity, and greater bed thickness than the lower member. Since Uyeno (1974, p. 6) noted that the lower contact of the Hull Formation could not be placed with confidence at any of the localities examined by him, it is considered advisable herein to discontinue use of the Hull Formation as a unit within the Ottawa Group.

Williams and Wolf (1982, p. 133) also refrained from using the names of Wilson's (1946a) faunal zones as formational names, and subdivided Uyeno's (1974) Ottawa Group into six lithostratigraphic units (A to F, in ascending order). Units A and B were together equivalent to the lower phase of Wilson (1946a), Units C and D to the middle phase, and Units E and F to the upper phase (Table 7). Unit A consisted of interbedded silty dolostone and quartz sandstone; Unit B of interbedded lithographic to finely crystalline limestone, silty dolostone, and shale; Unit C of lithographic to finely crystalline limestone; Unit D of sublithographic to coarsely crystalline limestone; Unit E of interbedded sublithographic to coarsely crystalline limestone and shale; and Unit F of sublithographic to finely crystalline nodular limestone.

Williams and Rae (1983) adopted a revised version of Liberty's (1967) application to the Ottawa-St. Lawrence Lowland of lithostratigraphic terminology developed in south-central Ontario by Okulitch (1939) and Liberty (1955, 1963, 1969) (Table 6). Five separate formations (Shadow Lake, Gull River, Bobcaygeon, Verulam, and Lindsay, in ascending order) are considered herein to be mappable in the Ottawa-St. Lawrence Lowland, as parts of the Ottawa Group (Tables 6 and 7). The Shadow Lake and Gull River Formations were originally described by Okulitch (1939) from exposures located in the vicinity of Coboconk in south-central Ontario, the names being of local derivation. Overlying formations were described by Liberty (1969) from exposures located in the vicinity of Bobcaygeon, Verulam Township, and Lindsay, respectively. The lower member of Liberty's (1969, p. 63-73) Whitby Formation was referred to an upper (Collingwood) member of the Lindsay Formation by Russell and Telford (1983).

The Shadow Lake Formation of the Ottawa-St. Lawrence Lowland is equivalent to Unit A of Williams and Wolf (1982) (Table 7). The lower member of the Gull River Formation is equivalent to Unit B, and the upper member of the Gull River Formation to the lower part of Unit C. The lower and middle members of the Bobcaygeon Formation are together equivalent to the upper part of Unit C, and the upper member of the Bobcaygeon Formation is equivalent to Unit D. The Verulam Formation is equivalent to Unit E, and the lower member of the Lindsay Formation to Unit F. The upper (Eastview) member of the Lindsay Formation is equivalent to Wilson's (1937) Eastview Formation (Williams and Rae 1983, p. 109).

The lithostratigraphic subdivision of the Ottawa Group used herein is reflected in the chemical composition of each formation. The variation in CaO content of the formations in south-central Ontario is shown in Figure 11, and some published analyses from the Ottawa-St. Lawrence Lowland for the various lithostratigraphic units are listed in Table 13. The Ottawa Group is characterized by a general increase in the CaO content from the base of the Group upwards. An abrupt increase from approximately 48% CaO in the upper part of the Gull River Formation to approximately 54% CaO in the lower part of the Bobcaygeon Formation occurs at the formational contact. This is followed by a gradual decrease to approximately 50% CaO, then an abrupt decrease to approximately 45% CaO at the contact between the lower and middle members of the Bobcaygeon Formation. Sections higher in the Bobcaygeon Formation contain up to approximately 54% CaO, and the lower contact of the Verulam Formation is marked by an abrupt decrease to approximately 45% CaO. This

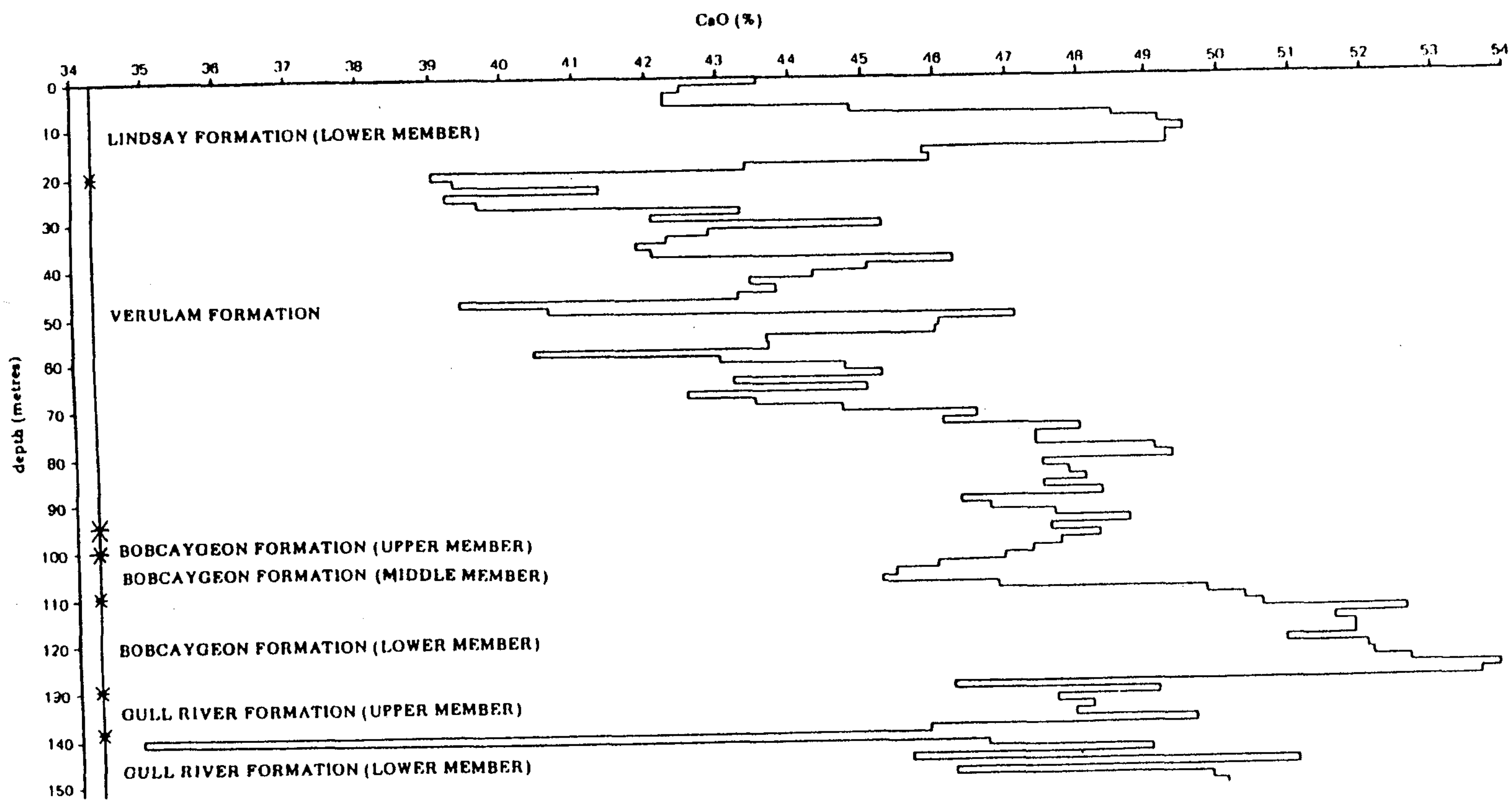

Figure 11. **CaO content of drillcore from St. Lawrence Cement Inc. hole R-16, Ogden Point, south-central Ontario (after St. Lawrence Cement Inc. 1976).**

FORMATION	MEMBER	MAP AREA	NTS	REFERENCES	SECTION OR INTERSECTION (see Appendices 1 and 2) Name	Thickness(m)	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	CO_2 %
							(a = Average)					
Lindsay	lower	Russell	31G/6	Hewitt 1964a, p.40	LQ RU-2	13.7	6.30	0.09	3.49	49.30	0.62	40.04
Bobcaygeon	upper	Ottawa	31G/5	Hewitt and Vos 1972,p.23-24	LQ OT-11b	14.9	6.49a	0.48a	1.02a	49.8a	1.56a	40.4a
		Ottawa	31G/5	Hewitt 1960, p.80-81	AQ OT-3	12.2	1.31a	0.31a	0.28a	54.8a	1.11a	42.14a
Bobcaygeon	lower	Arnprior	31F/8	Hewitt 1964a, p.37	LQ AR-5	7.0	5.20a	0.04a	1.06a	50.21a	0.92a	41.91a
		Cornwall	31G/2	Hewitt and Vos 1972, p.37 (unit PC2)	LQ CO-2	4.6	1.01	0.60	0.95	53.5	0.91	42.0
		Winchester	31G/3	Goudge 1938, p.195	LQ WI-3	4.0	1.32	0.54	0.82	53.81	0.52	42.58
Gull River	upper	Cornwall	31G/2	Hewitt and Vos 1972, p.37 (unit PC1)	LQ CO-2	8.8	6.34	1.08	3.33	48.3	1.47	38.9
		Ottawa	31G/5	Hewitt 1964a, p.38 (unit MF6)	LQ OT-3	6.1	10.13a	0.20a	3.59a	46.84a	0.63a	38.65a
		Ottawa	31G/5	Hewitt and Vos 1972, p.31 Hewitt 1960, p.77-79 (units DB3 and 4)	AQ OT-2	10.1	6.60a	0.90a	2.19a	48.06a	1.13a	39.19a
Gull River	lower	Cornwall	31G/2	Hewitt 1960, p.82-83 (unit HY1)	DH CO-1	17.7	10.81a	0.99a	3.00a	41.85a	4.11a	36.59a
		Ottawa	31G/5	Hewitt 1964a, p.38 (units MF4 and 5)	LQ OT-3	4.8	18.18	0.26	5.50	37.04	4.54	34.48
		Winchester	31G/3	Hewitt and Vos 1972, p.31 Hewitt 1960, p.82-84	AQ WI-1	9.1	8.86a	1.14a	2.76a	40.60a	6.29a	39.12a

TABLE 13. Chemical analyses of the Ottawa Group.

is followed by a gradual decrease to approximately 40% CaO in the upper part of the Verulam Formation, and an abrupt increase at the lower contact of the Lindsay Formation. Alternating sections of higher (approximately 49%) and lower (approximately 43%) CaO content characterize the lower member of the Lindsay Formation.

The Ottawa Group is equivalent to the combined Black River Group and overlying Trenton Group of adjacent New York State (Kay 1968a, Walker 1973, Cameron and Mangion 1977, Fisher 1977, Titus 1986-see Tables 6 and 7) and Quebec (Clark 1972a, 1972b-see Table 6). The uppermost unit of the Black River Group, the Chaumont Formation (Kay 1929) in New York State and the Leray Formation in Quebec, is characterized by a relatively low shale content. The lowermost unit of the Trenton Group, the Napanee Formation (Kay 1937, p. 255-256) in New York State and the Ouareau Formation in Quebec, is characterized by a relatively high shale content. The contact between the Black River and Trenton Groups is equivalent to the contact between the lower and middle members of the Bobcaygeon Formation of the Ottawa-St. Lawrence Lowland.

Shadow Lake Formation

Definition. The lower part of the lower phase of the Ottawa Formation (herein, Ottawa Group) of Wilson (1946a) is here referred to the Shadow Lake Formation (Table 7; Plate 8).

This Middle Ordovician unit was first described in south-central Ontario by Okulitch (1939) and subsequently redefined by Liberty (1955, 1969). The type section at Shadow Lake consists of a roadcut and an adjacent quarry on the west side of Highway 35, 5 km north of the village of Coboconk, about 125 km northeast of Toronto.

At its type locality, where it occurs as the oldest Paleozoic rock unit, the Shadow Lake Formation consists of silty dolostone with thin shale interbeds. The formation unconformably overlies the Precambrian basement, but its lower contact is not exposed. Okulitch (1939, p. 321-325) placed the conformable upper contact of the Shadow Lake Formation with the Gull River Formation at the base of a unit consisting of interbedded lithographic limestone (commonly mottled with dolomite) and silty dolostone. Liberty (1969, p. 153-154) redefined the upper contact, placing it at the base of his lower buff beds (dolostone and dolomitic limestone) and 2.1 metres below Okulitch's (1939) contact. Our re-examination of the type section supports positioning the Shadow Lake-Gull River formational contact essentially as redefined by Liberty (1969).

The Shadow Lake Formation of south-central Ontario contains two mappable units (lower and upper). The lower unit consists of interbedded calcareous quartz sandstone (commonly feldspathic or conglomeratic) and dolomitic siltstone. The upper unit consists of silty to sandy dolostone and dolomitic siltstone with quartz sandstone interbeds and shaly partings.

Strata equivalent to only the upper unit of the Shadow Lake Formation of south-central Ontario are recognized in the Ottawa-St. Lawrence Lowland, where the formation is underlain disconformably by the Rockcliffe Formation. The lower contact of the Shadow Lake Formation with the Rockcliffe Formation is defined here as the upper limit of occurrence of shale interbeds greater than 10 cm thick.

The Shadow Lake Formation as defined in the Ottawa-St. Lawrence Lowland is equivalent in part to the Pamelia Formation of New York State (Kay 1968a, Walker 1973, Cameron and Mangion 1977, Fisher 1977-see Tables 6 and 7) and Quebec (Clark 1972a, 1972b-see Table 6). The Pamelia Formation of New York State was redefined by Walker (1973, p. 9) as "the thin dolomitic sandstone and superjacent buff dolostones overlying the Precambrian complex in the Black River Valley". Use of the Pamelia Formation in the Ottawa-St. Lawrence Lowland (cf. Poole <u>et al.</u> 1970) is not continued herein, since Walker's (1973, p. 9) definition of the upper contact of the Pamelia Formation as "the top of the highest dolostone within the highest 10-foot interval containing greater than 50 percent dolostones" is not sufficiently diagnostic.

<u>Distribution</u>. The Shadow Lake Formation, which rarely outcrops, subcrops beneath drift cover and overlying bedrock

formations in the central and northern parts of the Ottawa-St. Lawrence Lowland (Figure 10). In the southern part of the Lowland, only units stratigraphically below the Shadow Lake Formation are present in the Mallorytown (31B/5), Brockville (31B/12), Perth (31C/16), and Merrickville (31B/13) map areas; but the Shadow Lake Formation subcrops beneath drift cover and the overlying Gull River Formation in the Westport (31C/9) map area.

The only known exposure of the Shadow Lake Formation in the Lowland is at Prince of Wales Falls, along the Rideau River in Hog's Back Park (Ottawa map area, 31G/5; S OT-5a in Appendix 1) (Plate 8). It is used herein as the principal reference section. The location of the outcrop area of the formation at Prince of Wales Falls is shown in Figure 5. As indicated in Appendix 2, many drillholes have intersected the formation; references to drillhole descriptions are included in Appendix 2.

Lithology. The Shadow Lake Formation consists of calcitic to non-calcitic silty to sandy dolostone, with shaly partings and thin interbeds of calcareous quartz sandstone. The dolostones are sublithographic to finely crystalline, very thinly to thickly bedded, light greenish grey in colour, and buff to reddish brown weathering. The sandstones are generally fine grained, but coarse grained quartz is present in some beds.

The Shadow Lake Formation of the Ottawa-St. Lawrence Lowland was deposited in a periodically exposed nearshore environment (Barnes 1967, p. 218-219). The dolostones of the Shadow Lake Formation of south-central Ontario resulted from penecontemporaneous growth of dolomite in a supratidal environment (Mukherji 1969). Walker (1973) also inferred a supratidal environment for the partially equivalent Pamelia Formation of New York State. The presence of quartz sandstone interbeds indicates that a supply of terrigenous clastics from Precambrian topographic highs continued to be available in early Blackriveran time.

Thickness. A nearly constant thickness of the Shadow Lake Formation of the Ottawa-St. Lawrence Lowland and its equivalent in adjacent Quebec is indicated. The Shadow Lake Formation ranges in thickness from 2.5 to 2.8 metres, and the Pamelia Formation is 2.9 metres thick in the St. Vincent quarry near Montreal (Hofmann 1972, p. 13).

Measured thicknesses (in metres) for the exposed section and drillhole intersections of Appendices 1 and 2 are listed in Table 14.

Exposure	Thickness	Drillhole	Thickness
S OT-5a	2.45	GDH HA-1	2.6
		DH OT-5	2.5
		DH OT-11	2.6
		DH RU-24	2.8
		GDH WE-4	2.8

TABLE 14. Thickness (in metres) of the Shadow Lake Formation of the Ottawa-St. Lawrence Lowland.

Age. Macrofossils have not been reporteu Lake Formation. A sparse conodont fauna of Blacn was reported from the Shadow Lake Formation of south- Ontario by Winder et al. (1975, p. 140-141). The lower of the sequence referred to the Pamelia faunal zone by Wilson (1946a), which is of Blackriveran age (Barnes et al. 1981), spans strata here identified as the Shadow Lake Formation.

Gull River Formation

Definition. Strata equivalent to the combined upper part of the lower phase and lowest part of the middle phase of the Ottawa Formation (herein, Ottawa Group) of Wilson (1946a) are here referred to as the Gull River Formation (Table 7; Plate 9). This conclusion is based on the results of the present mapping in the Ottawa-St. Lawrence Lowland, together with re-examination of the Gull River Formation and associated units in their type areas in south-central Ontario. Formal redefinition of the Gull River Formation and associated units in south-central Ontario is beyond the scope of this report. However, the stratigraphic assignments developed during this study, particularly those involving the Gull River and Bobcaygeon Formations, suggest the need for some modification to existing lithostratigraphic nomenclature. The following comments are intended only to clarify the proposed assignments in the Ottawa-St.

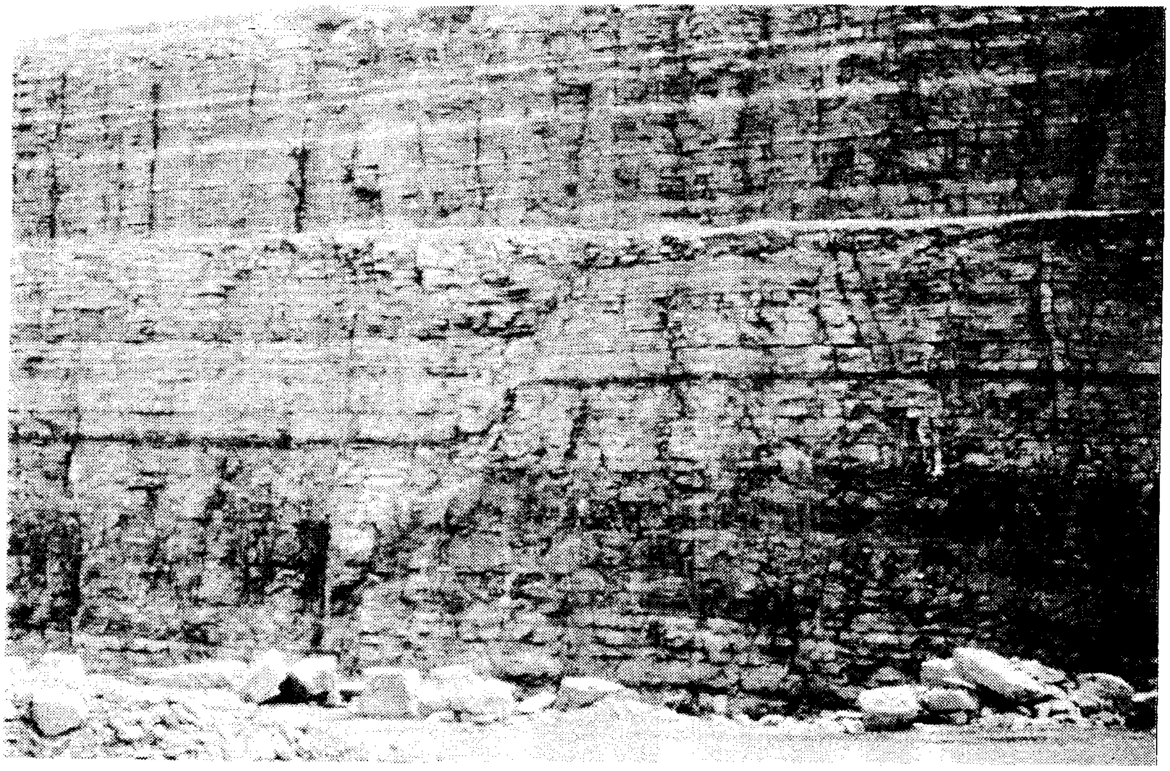

Plate 9. Gull River Formation (lower and upper members) transected by a fault of minor displacement, Fallowfield (McFarland) quarry (Ottawa map area, 31G/5; LQ OT-3 in Appendix 1). The prominent dark colored shale bed in the middle part of the section is 20 cm thick and 8 m below the base of the upper member. Photo RW-1-18 (1982).

Lawrence Lowland, but implications for future re-evaluation and formal redefinition of the Gull River Formation and associated units in their type areas are clear.

The Middle Ordovician Gull River Formation was first described in south-central Ontario by Okulitch (1939) and subsequently redefined by Liberty (1955, 1969). The type section for the lower part of the formation is the roadcut and the adjacent quarry on the west side of Highway 35, 5 km north of the village of Coboconk, about 125 km northeast of Toronto. Interbedded lithographic limestone (commonly mottled with dolomite) and dolostone of the Gull River Formation are exposed at the type section, and conformably overlie silty dolostone of the Shadow Lake Formation.

The type section for the upper part of the Gull River Formation is a roadcut on the east side of Highway 35, in the southern part of the village of Coboconk, about 120 km northeast of Toronto (Table 15). At this section, Okulitch (1939, p. 331-335) assigned a lower unit of generally massive lithographic limestone to the Gull River Formation; a middle unit of generally massive lithographic to sublithographic limestone with abundant fallen colonies of the coral _Tetradium_ to the Moore Hill Formation; and an upper unit of thinly bedded to massive, sublithographic to medium crystalline limestone (with chert nodules in the upper part) to the Coboconk Formation. Neither the base of the Gull River Formation nor the top of the overlying Coboconk Formation were considered to be present in the section.

Liberty (1969, p. 155-158) referred to the uppermost part of Okulitch's (1939) Gull River Formation as the middle member (upper submember) of his redefined Gull River Formation. He also referred the Moore Hill Formation to the upper member of the Gull River Formation and the Coboconk Formation to the lower member of Liberty's (1963) Bobcaygeon Formation.

<table>
<tr><th colspan="3">THIS STUDY</th><th colspan="3">LIBERTY 1969</th><th>OKULITCH 1939</th></tr>
<tr><th>FORMATION</th><th>MEMBER</th><th>SUBMEMBER</th><th>FORMATION</th><th>MEMBER</th><th>SUBMEMBER</th><th>FORMATION</th></tr>
<tr><td rowspan="3">Bobcaygeon</td><td rowspan="3">Lower</td><td>Upper</td><td>Bobcaygeon</td><td colspan="2">Lower</td><td>Coboconk</td></tr>
<tr><td rowspan="2">Lower</td><td rowspan="2">Gull River</td><td colspan="2">Upper</td><td>Moore Hill</td></tr>
<tr><td>Middle</td><td>Upper</td><td>Gull River</td></tr>
</table>

TABLE 15. Stratigraphy of the Coboconk roadcut, south-central Ontario.

Despite the subdivisions proposed by Olulitch (1939) and Liberty (1969) there is a lack of significant lithological contrast, mappable over appreciable distances, between the lower and middle units of the Coboconk roadcut. They may be regarded better as a single stratigraphic unit. In addition, differences in grain size (that is, fine and medium grained limestones of the Bobcaygeon Formation overlying lithographic and sublithographic limestones of the Gull River Formation) as used by Liberty (1969, p. 42) do not seem to be a suitable criterion in defining the formational contact. Lithographic limestone is present in the Bobcaygeon Formation as well as in the Gull River

Formation, and there is a fining eastward from Coboconk of the more coarsely crystalline beds in the lower Bobcaygeon Formation. Thus, with no valid reasons for separating the three units in the Coboconk roadcut, it may be preferable to include them in a single stratigraphic unit referable to the Bobcaygeon Formation.

Beds stratigraphically lower than those in the Coboconk roadcut section and included in the lower part of Okulitch's (1939) Gull River Formation are exposed elsewhere in the vicinity of Coboconk. Liberty (1969) referred them to the lower member and lower submember of the middle member of his Gull River Formation. It is to these beds that the strata of the Ottawa-St. Lawrence Lowland which are called herein the Gull River Formation are equated. In both the Coboconk area and the Ottawa-St. Lawrence Lowland, two lithological divisions of these strata can be recognized. A lower member consists of interbedded limestone, dolostone, and silty dolostone, and an upper member consists of lithographic to finely crystalline limestone. The contact between the members is placed at the top of the uppermost silty dolostone (or siltstone) bed. The conformable upper contact of the Gull River Formation, as mapped in the Ottawa-St. Lawrence Lowland, is the base of a generally massive high-purity limestone unit.

The Gull River Formation as defined in the Ottawa-St. Lawrence Lowland is equivalent to the Lowville Formation and the upper part of the Pamelia Formation of adjacent New York

State (Walker 1973, Cameron and Mangion 1977, Fisher 1977-see Tables 6 and 7). Kay (1968a) (Table 7) replaced the Lowville Formation with the Gull River Formation in New York. The contact between the lower and upper members of the Gull River Formation (as used herein) coincides with the contact between the lower and upper units of the Lowville Formation noted by Johnsen (1971). No equivalent of the lower member of the Gull River Formation is present in adjacent Quebec, and the upper member is equivalent to the Lowville Formation of Quebec (Clark 1972a, 1972b-see Table 6). Use of the Lowville Formation in the Ottawa-St. Lawrence Lowland (cf. Poole et al. 1970) is not continued herein, since Walker's (1973, p. 9) definition of the lower contact of the Lowville Formation (the upper contact of the Pamelia formation) as "the top of the highest dolostone within the highest 10-foot interval containing greater than 50 percent dolostones" is not sufficiently diagnostic.

Distribution. The Gull River Formation outcrops and subcrops beneath younger bedrock formations in the central and northern parts of the Ottawa-St. Lawrence Lowland (Figure 10). In the southern part of the Lowland, only units stratigraphically below the Gull River Formation outcrop and subcrop in the Mallorytown (31B/5), Brockville (31B/12), Perth (31C/16), and Merrickville (31B/13) map areas. There is an isolated occurrence of the Gull River Formation in the Westport (31C/9) map area.

Many of the exposed sections of the Gull River Formation are described in Appendix 1, which includes references to other published section descriptions. Good exposures of both members which are used herein as the principal reference sections are the Cornwall (Macleod) quarry (LQ CO-1), located in the Cornwall map area (31G/2); and the Fallowfield (McFarland) (Plate 9) and Blackburn (north) quarries (LQ OT-3 and LQ OT-11a, respectively), located in the Ottawa map area (31G/5). The upper contact of the Gull River Formation is exposed in all three quarries. There are also good exposures of the lower member in the Munster (LQ KE-3, Kemptville map area, 31G/4), Westport (LQ WE-6, Westport map area, 31C/9), and Winchester Springs (Cruickshank) (LQ WI-1, Winchester map area, 31G/3) quarries, and at Prince of Wales Falls (Figure 5) (S OT-5a and - 5b, Ottawa map area, 31G/5). The upper member is also well exposed in the Cornwall (Permanent) (LQ CO-2, Cornwall map area, 31G/2), Fallowfield (Tomlinson and Dibblee) (LQ OT-4 and LQ OT-5, Ottawa map area, 31G/5), McCarthy Road (AQ OT-2, Ottawa map area, 31G/5), and Rockland (AQ TH-1, Thurso map area, 31G/11) quarries.

As indicated in Appendix 2, many drillholes have intersected the Gull River Formation; references to drillhole descriptions are included in Appendix 2.

<u>Lithology</u>. The <u>lower member</u> of the Gull River Formation consists mainly of interbedded limestone and silty dolostone

(grading into siltstone) with shaly partings. Silty dolostone beds are up to 2 metres thick, and some limestone beds are mottled with dolomite. Interbeds of quartz sandstone up to one metre thick, and of shale up to 60 cm thick, also occur. Published chemical analyses for the lower member are listed in Table 13.

Limestones of the lower member are lithographic to finely crystalline and thinly to thickly bedded. Fresh surfaces are medium to dark grey to brownish grey, and weathered surfaces are light to medium bluish grey to brown. Ripple marks, desiccation cracks, and sulphate nodules and molds occur in some beds. Many beds are intraclastic, and some of the intraclastic beds are also oolitic; the dark grey oolitic beds are up to 60 cm thick, and weather bluish grey. Shelly fossils and burrows are common, and stromatolitic beds occur.

The silty dolostones are sublithographic to finely crystalline, calcitic to non-calcitic, and thinly to thickly bedded. Fresh surfaces are light greenish grey to dark brownish grey, and weathered surfaces are buff to reddish brown. Burrows, calcite-filled vugs, and conchoidal fractures are common.

The quartz sandstones are fine to coarse grained, very thinly to medium bedded, and calcareous to non-calcareous. Fresh surfaces are light grey to light greenish grey, and weathered surfaces are greenish grey. Burrows are common, and a pelecypod-bearing bed was noted by Raymond (1911, p. 192-193).

The shales are black, and some beds contain numerous ostracods. One ostracod-bearing shale bed, noted by Raymond (1911, p. 190-191) to occur in the Ottawa map area (31G/5) at Westboro (UTM 440400E, 5026850N) and Rockcliffe (UTM 446525E, 5033000N), was referred by him (1911, p. 195-197) to the lowermost part of the sequence overlying his (1905) Aylmer Formation. The base of the bed was considered by Williams and Rae (1983, p. 108) to be the base of the sequence overlying the Rockcliffe Formation. The bed is considered herein to lie within the lower part of the Gull River Formation, rather than at the base of the Ottawa Group, as a result of the present redefinition of the Ottawa Group.

The upper member of the Gull River Formation consists of lithographic to finely crystalline limestone with shaly partings. Fresh surfaces are medium to dark grey to brownish grey. Weathered surfaces are generally light to medium bluish grey to brown, but some lithographic beds weather white. The limestones are very thinly to thickly bedded, and shelly fossils and burrows are common. Many beds are intraclastic, and an intraclastic bed in the lower part of the member is also oolitic; the dark grey oolitic bed is up to 85 cm thick, and weathers bluish grey. "Birdseye" texture, a term which refers to small scattered lenses of white calcite, occurs in some lithographic beds.

Published chemical analyses for the upper member are listed in Table 13.

The Gull River Formation of the Ottawa-St. Lawrence Lowland was deposited in a periodically exposed nearshore environment (Barnes 1967, p. 218-219). The dolostones and dolomitic limestones of the Gull River Formation of south-central Ontario resulted from penecontemporaneous growth of dolomite in a supratidal environment (Mukherji 1969). Walker (1973) inferred a supratidal to subtidal environment for the partially equivalent Lowville Formation of New York State. The presence of quartz sandstone interbeds indicates that a supply of terrigenous clastics from Precambrian topographic highs was available until deposition of the upper part of the formation.

Thickness. The lower member of the Gull River Formation is 62.6 metres thick in the Russell map area (31G/6), but is considerably thinner elsewhere: 42.3 metres in the Ottawa map area (31G/5) and 33.9 metres in the Hawkesbury map area (31G/10). The thickness apparently decreases eastward from the Hawkesbury map area, since no equivalent of the lower member exists in the St. Vincent quarry near Montreal.

The thickness of the upper member of the Gull River Formation shows little variation at different localities in the Ontario portion of the Ottawa-St. Lawrence Lowland, and averages approximately 9 metres. The thickness of the equivalent Lowville Formation shows an eastward decrease in adjacent Quebec, and is 4.1 metres in the St. Vincent quarry near Montreal (Hofmann 1972, p. 13).

Measured thicknesses (in metres) of the lower and upper members for the exposed sections and drillhole intersections of Appendices 1 and 2 are listed in Table 16 (the "+" symbol indicates that the entire thickness of the member does not occur in the exposure or drillhole). In addition, the thickness of the lower member in the Cornwall map area (31G/2) is 38.1 metres (equal to the sum of the intersection in DH CO-1 and the section in LQ CO-1, less 0.8 metre overlap). Measurements reported in other publications for the exposed sections of Table 16, and for other sections no longer exposed (LQ CO-3 and AQ CO-1), are included in Appendix 1.

LOWER MEMBER				UPPER MEMBER			
Exposure	Thickness	Drillhole	Thickness	Exposure	Thickness	Drillhole	Thickness
LQ CA-1	1.00+	DH CO-1	24.1+	LQ CO-1	8.90	DH CO-2	8.8
LQ CO-1	14.80+	DH CO-2	17.7+	LQ CO-2	9.50	GDH HA-1	8.2
LQ CO-2	4.70+	GDH HA-1	33.9	LQ CO-6	4.20+	DH OT-5	11.6
LQ KE-3	10.35+	DH OT-5	42.3	LQ KE-1	2.65+	DH OT-10	7.6
LQ MO-1	0.90+	DH OT-10	37.2+	LQ OT-3	9.21	DH OT-11	12.5
LQ OT-3	20.98+	DH OT-11	41.8	LQ OT-4	4.90+	DH OT-12	8.7
LQ OT-5	10.11+	DH OT-12	7.1+	LQ OT-5	7.11	DH RU-24	8.8
LQ OT-11a	12.35+	DH RU-24	62.6	LQ OT-11a	8.20		
AQ OT-2	8.02+	GDH WE-4	4.6+	AQ OT-1	4.70+		
S OT-5a	6.00+			AQ OT-2	8.85		
S OT-5b	13.50+			AQ TH-1	7.85		
AQ TH-1	2.40+						
LQ WE-6	16.70+						
LQ WI-1	14.15+						
LQ WI-2	4.25+						
LQ WI-6	1.40+						
AQ WI-1	0.50+						

TABLE 16. Thickness (in metres) of the Gull River Formation of the Ottawa–St. Lawrence Lowland.

Age. The paleontology of the Gull River Formation of the Ottawa-St. Lawrence Lowland has been described by Raymond (1911), Wilson (1921, 1932a, 1946b-c, 1947, 1948, 1951, 1956b, 1961), and Fritz (1957). Brachiopods, bryozoa, corals, crinoids, ostracods, gastropods, pelecypods, cephalopods, trilobites, and stromatolites are abundant. The upper part of the upper member is a bioclastic limestone consisting of fallen colonies of the coral Tetradium, commonly extensively replaced by sparry calcite. The combined upper part of the sequence referred to the Pamelia faunal zone and all of that referred to the Lowville faunal zone by Wilson (1946a) span strata here identified as the Gull River Formation. The shelly fossils indicate a Blackriveran age for the formation (Barnes et al. 1981).

Bobcaygeon Formation

Definition. Strata equivalent to all but the lowest part of the middle phase of the Ottawa Formation (herein, Ottawa Group) of Wilson (1946a) are here referred to the Bobcaygeon Formation (Table 7; Plate 10). As noted above, the lowest part of the middle phase is assigned to the Gull River Formation. Use of the name Bobcaygeon Formation in the Ottawa-St. Lawrence Lowland is based on results of the present mapping, together with re-examination of the Bobcaygeon Formation in its type area in south-central Ontario. The stratigraphic assignment proposed herein

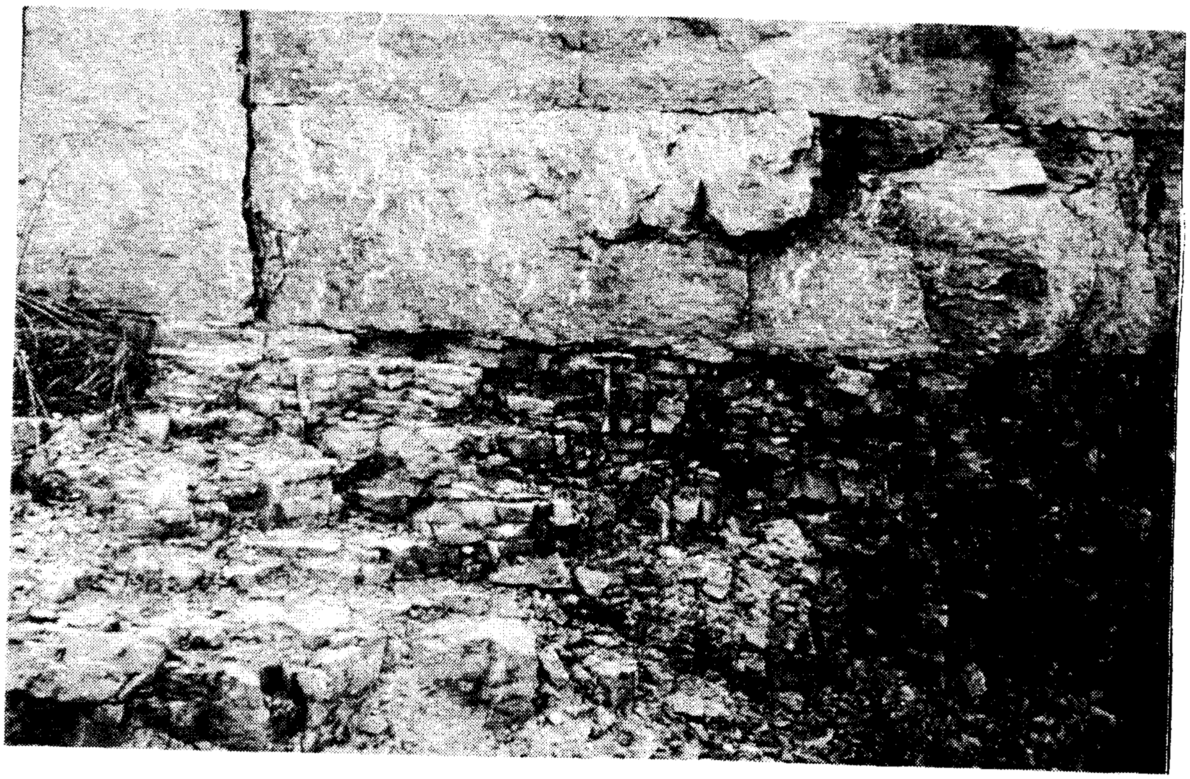

Plate 10. Bobcaygeon Formation (lower member), Pakenham quarry (Arnprior map area, 31F/8; AQ AR-1 in Appendix 1). The upper part of the section is lighter coloured, more thickly bedded, and more coarsely crystalline than the lower part of the section. Photo RW-2-34 (1982).

suggests the need for some modifications to existing lithostratigraphic nomenclature (see discussion under Gull River Formation, Definition).

The Middle Ordovician Bobcaygeon Formation, consisting of limestone with shaly partings, was first defined in south-central Ontario by Liberty (1963). In the Ottawa-St. Lawrence Lowland the Bobcaygeon Formation can be divided into three members that are roughly equivalent to the three members defined in south-central Ontario by Liberty (1969). The contact between the lower and upper members of Uyeno's (1974) redefined lithostratigraphic Hull Formation is equivalent to the contact between the middle and upper members of the Bobcaygeon Formation, and the upper contact of the Hull Formation is equivalent to the upper contact of the Bobcaygeon Formation. As noted above, use of the Hull Formation as a lithostratigraphic unit is not continued herein because Uyeno (1974, p. 6) could not place its lower contact with confidence at any of the localities examined by him.

There are some significant differences between the member subdivision of Liberty (1969) for south-central Ontario and that proposed herein for the Ottawa-St. Lawrence Lowland. The lower member of the Bobcaygeon Formation of the Ottawa-St. Lawrence Lowland contains strata equivalent to those of south-central Ontario placed in the upper part of the Gull River Formation by Liberty (1969) (see discussion under Gull River Formation, Definition). Another significant difference is that subdivision into members in the Ottawa-St. Lawrence Lowland is based on shale content (as detailed below), while Liberty's (1969) subdivision in south-central Ontario is based on differences in grain size. Although the lower member west of Ottawa can be divided into lower (A) and upper (B) lithological units based on grain size differences (as detailed below), these differences do not seem to be a suitable criterion in defining contacts between members.

Tables 6 and 7 illustrate the relationships between the Bobcaygeon Formation, as defined in the Ottawa-St. Lawrence Lowland, and the formations of the Black River and Trenton groups in southern Quebec (Clark 1972a, 1972b) and north-central New York State (Kay 1968a, Walker 1973, Cameron and Mangion 1977, Fisher 1977).

Distribution. The Bobcaygeon Formation outcrops and subcrops beneath younger bedrock formations in the central and northern parts of the Ottawa-St. Lawrence Lowland (Fig. 10) in the Arnprior (31F/8), Carleton Place (31F/1), Ottawa (31G/5), Kemptville (31G/4), Thurso (31G/11), Russell (31G/6), Winchester (31G/3), Hawkesbury (31G/10), Alexandria (31G/7), and Cornwall (31G/2) map areas. Due to the high resistance to erosion of the lower member of the Bobcaygeon Formation, natural outcrops are generally upland pavements. The middle and upper members are less resistant.

Many of the exposed sections of the Bobcaygeon Formation are described in Appendix 1, which includes references to other published section descriptions. Good exposures which are used herein as the principal reference sections for the lower part of the formation (including the lower contact of the lower member) are the Blackburn (north) quarry (LQ OT-11a, Ottawa map area, 31G/5) and the Rockland quarry (AQ TH-1, Thurso map area, 31G/11). The principal reference section for the upper part of the formation (including the contact between the middle and upper members) is the Blackburn (south) quarry (LQ OT-11b, Ottawa map area, 31G/5). There are also good exposures of the lower member in the Almonte (Cavanagh) (LQ AR-2) and White Lake (LQ AR-4) quarries, located in the Arnprior map area (31F/8); and in the Huntley (LQ OT-1) and Stittsville (LQ OT-2) quarries, located in the Ottawa map area (31G/5). The middle and upper members are also well exposed in the Embrun (Blair) quarry (LQ RU-5, Russell map area, 31G/6) and in the L'Orignal (main) quarry (LQ HA-1, Hawkesbury map area, 31G/10), respectively.

As indicated in Appendix 2, many drillholes have intersected the Bobcaygeon Formation; references to drillhole descriptions are included in Appendix 2.

<u>Lithology</u>. The Bobcaygeon Formation consists of interbedded lithographic to coarsely crystalline fossiliferous limestone with planar to undulating shaly partings. Lithographic beds

are subordinate and commonly have "birdseye" texture. Medium to coarsely crystalline beds commonly are crossbedded and contain stylolites, and some coarsely crystalline beds fill channels. Some beds contain black chert as nodules up to 20 cm in diameter, lenses up to 5 cm thick, and fine grained disseminations. The limestones are very thinly to massive bedded. In some quarries, blasting has resulted in the massive bedding of the lower part of the formation appearing thinner. Fresh surfaces are light to dark grey to brownish grey, the more coarsely crystalline beds being lighter in colour than the more finely crystalline beds. Weathered surfaces are light to medium grey to brownish grey to bluish grey, the bluish grey colour being restricted to the more finely crystalline beds. Burrows and intraclasts are common.

The lower member of the Bobcaygeon Formation consists of interbedded lithographic to coarsely crystalline limestone with subordinate shaly partings. It can be divided into submembers from Ottawa westward, in its outcrop areas in the Ottawa (31G/5), Kemptville (31G/4), Arnprior (31F/8), and Carleton Place (31F/1) map areas. Medium and coarsely crystalline limestones do not occur in the lower member to the east of Ottawa; their presence in the upper part of the lower member from Ottawa westward provides the basis for a subdivision into lower (A) and upper (B) lithological units. Chert occurs only in the upper unit.

Published chemical analyses for the lower member are listed in Table 13.

The middle member of the Bobcaygeon Formation consists of interbedded lithographic to coarsely crystalline limestone with interbeds up to 35 cm thick containing numerous undulating shaly partings. The middle member has a higher shale content than the lower and upper members. The shaly beds are characterized by nodular structure, the result of deformation of the lithographic to finely crystalline limestone interbeds into nodules.

The upper member of the Bobcaygeon Formation consists of interbedded lithographic to coarsely crystalline limestone with subordinate shaly partings. It contains dolomitized zones up to 20 cm thick. Published chemical analyses for the upper member are listed in Table 13.

The Bobcaygeon Formation of the Ottawa-St. Lawrence Lowland was deposited in an intracontinental shelf environment. A low to moderate energy environment is indicated for the more finely crystalline beds, and a high energy environment for the more coarsely crystalline beds (Barnes 1967, p. 219-231). Similar environments were inferred by Walker (1973) and Cameron and Mangion (1977) for the equivalent strata of New York State.

Thickness. The thickness of the Bobcaygeon Formation ranges from 79.9 metres to 87.3 metres in the northwestern part of the Ottawa-St. Lawrence Lowland, and decreases eastward to

51.2 metres in the Hawkesbury map area (31G/10). A continued eastward decrease is indicated by a combined thickness of only 8.5 metres for the equivalents (the Leray, Ouareau, Mile End, and Deschambault Formations) of the Bobcaygeon Formation in the St. Vincent quarry near Montreal (Hofmann 1972, p. 13).

The thickness of the lower member shows some local variability, and decreases eastward from a maximum of 29.0 metres in the Ottawa map area (31G/5) to 14.1 metres in the Hawkesbury map area (31G/10). The equivalent Leray Formation is only 3.4 metres thick in the St. Vincent quarry (Hofmann 1972, p. 13). To the west of Ottawa, the lower unit of the lower member is at least 13.4 metres thick and the upper unit is at least 11.3 metres thick.

The thickness of the middle member shows very little local variability, and decreases eastward from a maximum of 26.3 metres in the Ottawa map area (31G/5) to 22.4 metres in the Hawkesbury map area (31G/10). The equivalent Ouareau and Mile End Formations have a combined thickness of only 3.1 metres in the St. Vincent quarry (Hofmann 1972, p. 13).

The thickness of the upper member shows considerable local variability, and decreases eastward from a maximum of 37.2 metres in the Ottawa map area (31G/5) to 14.7 metres in the Hawkesbury map area (31G/10). The equivalent Deschambault Formation is only 2.0 metres thick in the St. Vincent quarry (Hofmann 1972, p. 13).

Measured thicknesses (in metres) of the lower, middle and upper members for the exposed sections and drillhole intersections of Appendices 1 and 2 are listed in Table 17 (the "+" symbol indicates that the entire thickness of the member does not occur in the exposure or drillhole). Measurements reported in other publications for the exposed sections of Table 17 and for other sections no longer exposed (AQ CO-1, AQ OT-3, AQ OT-9 and AQ OT-10), are included in Appendix 1.

LOWER MEMBER							
Exposure	Thickness	Exposure	Thickness	Exposure	Thickness	Drillhole	Thickness
LQ AR-1	1.25+B	AQ AR-1	7.50+B	LQ OT-4	5.95+	DH CO-1	5.2+
	3.75+A	LQ CO-1	1.70+	LQ OT-5	1.50+	GDH HA-1	14.1
LQ AR-2	11.05+B	LQ CO-2	4.30+	LQ OT-11a	17.70+	DH OT-5	29.0
	5.45+A	LQ CO-3	1.70+	AQ OT-1	5.10+	DH OT-10	16.2+
LQ AR-3	3.50+B	LQ CO-6	3.45+	AQ OT-2	4.00+	DH OT-11	23.8
LQ AR-4	4.00+B	LQ OT-1	11.30+B	AQ TH-1	19.50+	DH OT-12	14.7+
	13.40+A	LQ OT-2	6.50+B	LQ WI-3	4.60+	DH RU-24	20.4
LQ AR-5	6.60+B		4.00+A				
	1.50+A	LQ OT-3	5.95+				

MIDDLE MEMBER			
Exposure	Thickness	Drillhole	Thickness
LQ OT-11b	25.00+	GDH HA-1	22.4
AQ OT-4	8.80+	DH OT-5	23.4
AQ OT-8	2.60+	DH OT-11	26.3
LQ RU-5	12.00+	DH RU-24	25.1
LQ WI-3	5.90+		

UPPER MEMBER			
Exposure	Thickness	Drillhole	Thickness
LQ HA-1	15.20+	GDH HA-1	14.7
AQ HA-1	4.25+	DH OT-5	27.5
LQ OT-11b	30.00+	DH OT-11	37.2
AQ OT-8	6.00+	DH RU-24	37.8

TABLE 17. Thickness (in metres) of the Bobcaygeon Formation of the Ottawa-St. Lawrence Lowland.

<u>Age</u>. The paleontology of the Bobcaygeon Formation of the Ottawa-St. Lawrence Lowland has been described by Raymond (1921), Wilson (1921, 1946b-c, 1947, 1948, 1951, 1956b,

1961), Fritz (1957), Schopf (1966), Barnes (1967), Steele and Sinclair (1971), and Uyeno (1974). Brachiopods, bryozoa, corals, stromatoporoids, trilobites, large cephalopods, gastropods, pelecypods, ostracods, and crinoids are abundant. The sequence referred to the Leray, Rockland, and Hull faunal zones by Wilson (1946a) spans strata here identified as the Bobcaygeon Formation. The Leray-Rockland and Rockland-Hull contacts are not equivalent to contacts between the members of the Bobcaygeon Formation, the former being located within the lower member and the latter within the middle member. Shelly fossils indicate a Blackriveran age for the Leray faunal zone sequence, a Blackriveran to Rocklandian age for the Rockland faunal zone sequence, and a Rocklandian to Kirkfieldian age for the Hull faunal zone sequence (Barnes et al. 1981).

Conodonts also indicate that the Bobcaygeon Formation ranges in age from Blackriveran to Kirkfieldian. The lower member in the Rockland quarry (Thurso map area, 31G/11; AQ TH-1 in Appendix 1), locality 11 of Schopf (1966, p. 8) and locality 21 of Barnes (1967), contains Blackriveran and Rocklandian conodont faunas (Schopf 1966, p. 23; Barnes 1967, p. 237). The middle and upper members in the Ottawa map area (31G/5) contain a Rocklandian to Kirkfieldian conodont fauna (Uyeno 1974, p. 8-9).

Verulam Formation

Definition. The lower part of the upper phase of the Ottawa Formation (herein, Ottawa Group) of Wilson (1946a) is here referred to the Verulam Formation (Table 7; Plate 11). This Middle Ordovician unit, consisting of limestone with shale interbeds, was first defined in south-central Ontario by Liberty (1955) and more fully described by him in 1969. He established two members, but the distinctive crossbedded calcarenite characterizing his upper member has not been recognized in the Ottawa-St. Lawrence Lowland. Therefore, the Verulam Formation as mapped in the Ottawa-St. Lawrence Lowland is lithologically equivalent to the lower member of the Verulam Formation of Liberty (1969) with only slight modification. For instance, Liberty (1969, p. 52) defined the conformable lower contact of the formation as the base of a very argillaceous unit; in this report the lower contact is placed at the lower limit of shale interbeds greater than 5 cm thick. The conformable upper contact is defined as the upper limit of shale interbeds greater than 5 cm thick.

The Verulam Formation of the Ottawa-St. Lawrence Lowland is equivalent in part to the Montreal Formation of Quebec (Clark 1972a, 1972b - see Table 6) and the combined Sugar River and Denley Formations of New York State (Kay 1968a, Fisher 1977 - see Tables 6 and 7). The Steuben Formation of New York State, equivalent to Liberty's (1969)

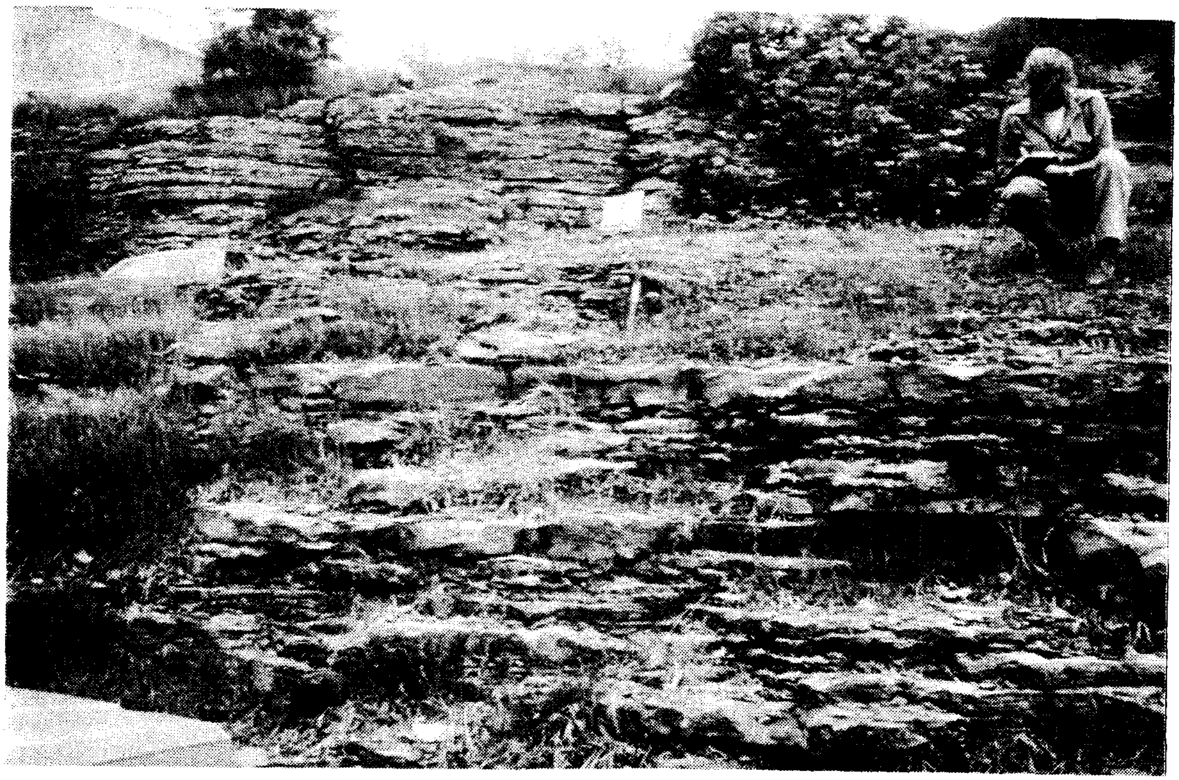

Plate 11. Verulam Formation, Lebreton Street, Ottawa (Ottawa map area, 31G/5; UTM 444910E, 5027480N). Photo AL-2-15 (1982).

upper member of the Verulam Formation, has not been recognized in the Ottawa-St. Lawrence Lowland.

Distribution. The Verulam Formation outcrops in the central part of the Ottawa-St. Lawrence Lowland in the Arnprior (31F/8), Ottawa (31G/5), Russell (31G/6), Winchester (31G/3), and Cornwall (31G/2) map areas (Figure 10). It subcrops beneath younger bedrock formations in the eastern part of the Ontario portion of the Lowland, to the north of its outcrop areas.

Because of the low resistance to erosion of the Verulam Formation, natural outcrops are generally lowland pavements, river cuts, and escarpments capped by the more resistant overlying Lindsay Formation. Some of the exposed sections of the Verulam Formation are described in Appendix 1. A good exposure which is used herein as the principal reference section for the formation (including the upper contact) is the lower part of the escarpment along the Ottawa River at Rideau Falls (S OT-6, Ottawa map area, 31G/5). Other good exposures of the Verulam Formation are the Victoria Island roadcut (S OT-8, Ottawa map area, 31G/5) and the Osnabruck quarry (LQ WI-4, Winchester map area, 31G/3). As indicated in Appendix 2, many drillholes have intersected the formation.

Lithology. The Verulam Formation consists of interbedded sublithographic to coarsely crystalline fossiliferous limestone with interbeds up to 15 cm thick of dark grey calcareous shale. The beds are of very thin to medium thickness. The limestones are light to dark grey to brownish grey, the more coarsely crystalline beds being lighter in colour than the more finely crystalline beds. The former weather brown, and the latter weather bluish grey. Burrows and intraclasts are common, and ripple marks occur in some beds.

The formation was deposited in an intracontinental shelf environment. A low to moderate energy environment is indicated for the more finely crystalline limestone beds, and a high energy environment for the more coarsely crystalline beds.

Thickness. The Verulam Formation and its equivalent in adjacent Quebec thicken to the southeast. The Verulam Formation is 32.0 metres thick in the Ottawa map area (31G/5) and 65.4 metres thick in the Hawkesbury map area (31G/10). The equivalent Montreal Formation is 106.7 metres thick in the Cartier Natural Gas (St. Hubert) well, drilled near Montreal (Clark 1972a, p. 12).

Measured thicknesses (in metres) for the exposed sections and drillhole intersections of Appendices 1 and 2 are listed in Table 18 (the "+" symbol indicates that the entire thickness of the formation does not occur in the exposure or drillhole).

Exposure	Thickness	Drillhole	Thickness
S OT-6	2.30+	GDH HA-1	65.4
S OT-8	2.20+	DH OT-5	31.1+
LQ WI-4	3.00+	DH OT-11	32.0
		DH RU-24	39.7

TABLE 18. Thickness (in metres) of the Verulam Formation of the Ottawa-St. Lawrence Lowland.

Age. The paleontology of the Verulam Formation of the Ottawa-St. Lawrence Lowland has been described by Raymond (1921), Wilson (1946b-c, 1947, 1948, 1951, 1956b, 1961), and Fritz (1957). Brachiopods, bryozoa (notably *Prasopora*), gastropods, and crinoids are very abundant. The combined sequence referred to the Sherman Fall faunal zone and the lower Cobourg faunal zone by Wilson (1946a) spans strata here identified as the Verulam Formation. The shelly fossils indicate a Kirkfieldian to Shermanian age for the formation (Barnes *et al.* 1981).

Lindsay Formation

Definition. The upper part of the upper phase of the Ottawa Formation (herein, Ottawa Group) and the overlying Eastview Formation of Wilson (1946a) are here referred to the Lindsay Formation (Tables 7 and 19; Plate 12). Liberty (1963) first defined the Upper Ordovician Lindsay Formation in south-central Ontario. The overlying unit was defined as the Whitby Formation, and divided into lower, middle, and upper members, by Liberty (1969). Russell and Telford (1983) revised this nomenclature and redefined the lower member of the Whitby Formation as the Collingwood Member of the Lindsay Formation. The lower contact of the Collingwood Member is gradational, but could be selected arbitrarily as the first appearance of definite black shale beds in the Lindsay Formation.

The middle and upper members of the Whitby Formation were renamed the Blue Mountain Formation by Russell and Telford (1983). The contact between this unit and the underlying Lindsay Formation was marked by the change from calcareous shale below (Collingwood Member) to non-calcareous shale above.

SOUTHEASTERN ONTARIO				SOUTH-CENTRAL ONTARIO			
THIS STUDY		WILSON 1946a		RUSSELL AND TELFORD 1983		LIBERTY 1969	
FORMATION	MEMBER	FORMATION	PHASE	FORMATION	MEMBER	FORMATION	MEMBER
BILLINGS		BILLINGS		BLUE MOUNTAIN		WHITBY	UPPER
							MIDDLE
LINDSAY	EASTVIEW	EASTVIEW		LINDSAY	COLLINGWOOD		LOWER
	LOWER	OTTAWA	UPPER (UPPER PART)			LINDSAY	

TABLE 19. The Lindsay and Billings Formations of southeastern Ontario, and their equivalents in south-central Ontario.

The sequence in the Ottawa-St. Lawrence Lowland corresponds closely to the stratigraphic scheme proposed by Russell and Telford (1983). That is, the upper part of the upper phase of the Ottawa Formation (Wilson 1946a) is equivalent to the Lindsay Formation as first defined by

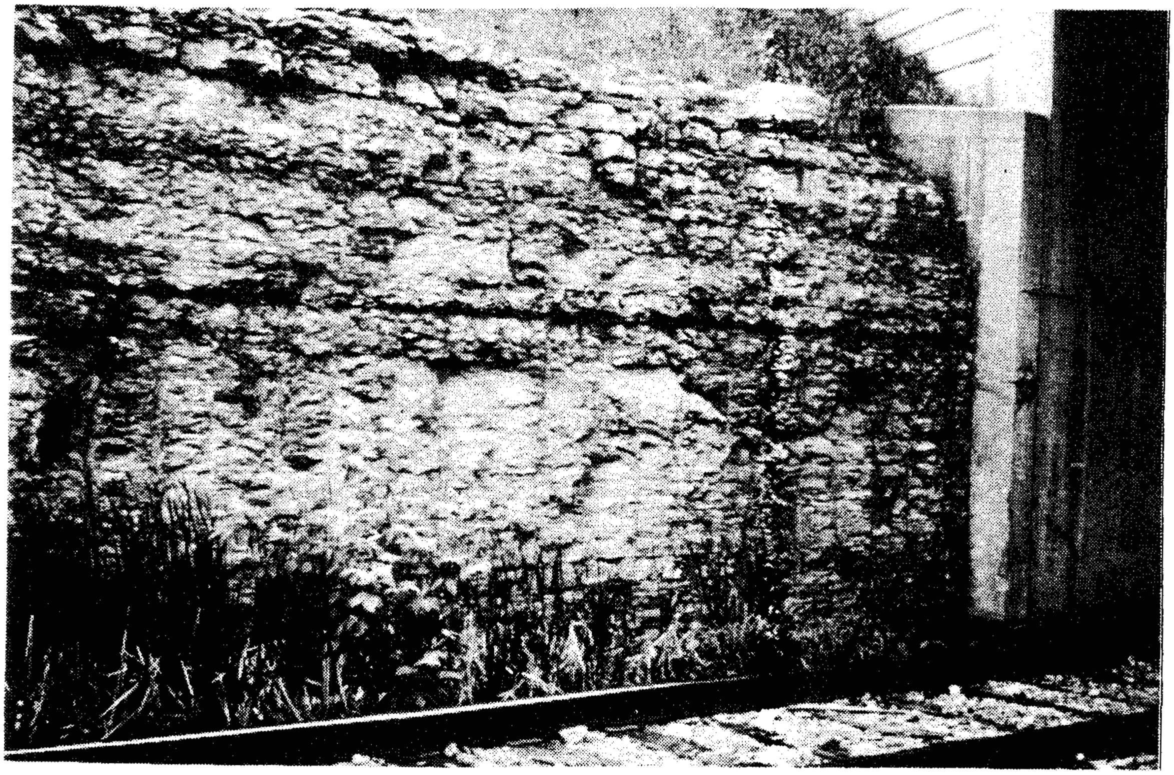

Plate 12. Lindsay Formation (lower member), Dow's Lake, Ottawa (Ottawa map area, 31G/5; UTM 444590E, 5026830N). Photo AL-2-10 (1982).

Liberty (1963), and the overlying Eastview Formation (Wilson 1946a) is equivalent to the upper part or Collingwood Member of the redefined Lindsay Formation. In the Ottawa-St. Lawrence Lowland, the upper part of the Lindsay Formation can therefore be referred to as the Eastview Member. Contact relationships of the Lindsay Formation (and its Eastview Member) in the Ottawa-St. Lawrence Lowland are the same as those in south-central Ontario.

The Tetreauville Formation of Quebec (Clark 1972a, 1972b- see Table 6) and the Hillier Formation of New York State (Kay 1968a, Fisher 1977 - see Tables 6 and 7) are equivalent in part to the Lindsay Formation of the Ottawa-St. Lawrence Lowland. The Quebec and New York sequences do not contain strata equivalent to the Eastview Member.

Distribution. The Lindsay Formation outcrops in the central and northern parts of the Ottawa-St. Lawrence Lowland in the Ottawa (31G/5), Thurso (31G/11), Russell (31G/6), Winchester (31G/3), Hawkesbury (31G/10), Alexandria (31G/7), and Cornwall (31G/2) map areas (Figure 10). It subcrops beneath younger bedrock formations in the central part of the Lowland.

Because of the high resistance to erosion of the lower member of the Lindsay Formation, natural outcrops are generally upland pavements. Many of the exposed sections are described in Appendix 1, which includes references to other published section descriptions. A good exposure which is used herein as the principal reference section for the lower member is the Canaan quarry (LQ RU-2, Russell map area, 31G/6). Other good exposures are in quarries at St. Isidore (LQ AL-2, Alexandria map area, 31G/7), Navan (LQ RU-1, Russell map area, 31G/6), and Sarsfield (LQ RU-3, Russell map area, 31G/6).

The principal reference section for the upper part of the formation (including the contact between the lower and upper members) is the Saint Laurent Blvd. escarpment (Ottawa map area, 31G/5; S OT-4 in Appendix 1).

As indicated in Appendix 2, many drillholes have intersected the Lindsay Formation; references to drillhole descriptions are included in Appendix 2.

Lithology. The lower member of the Lindsay Formation consists of interbedded sublithographic to coarsely crystalline fossiliferous limestone with undulating shaly partings and interbeds up to 5 cm thick of dark grey calcareous shale. The beds are very thin to thick. The limestones are light to dark grey to brownish grey, the more coarsely crystalline beds being lighter in colour than the more finely crystalline beds. The former weather brown, and the latter predominate and weather bluish grey. Burrows, feeding trails, and intraclasts are common. The abundance of shaly partings has resulted in deformation of the more finely crystalline limestone beds to produce a characteristic nodular structure; the presence of limestone nodules up to 15 cm in diameter is particularly evident on weathered surfaces. A published analysis for the lower member is listed in Table 13.

The upper (Eastview) member of the Lindsay Formation consists of interbedded dark grey to dark brown calcareous shale and sublithographic to finely crystalline petroliferous fossiliferous limestone. The beds are thin to thick. The limestones are medium to dark grey, weather bluish grey, and are commonly nodular.

The formation was deposited in an intracontinental shelf environment. A low to moderate energy environment is indicated for the more finely crystalline limestone beds, and a high energy environment for the more coarsely crystalline beds.

Thickness. The lower member of the Lindsay Formation and its equivalent in adjacent Quebec (the Tetreauville Formation) thicken to the southeast. The lower member of the Lindsay Formation is 19.7 metres thick in the Ottawa map area (31G/5) but the Tetreauville Formation is 125.0 metres thick in the Cartier Natural Gas (St. Hubert) well, drilled near Montreal (Clark 1972a, p. 12). In contrast, the upper (Eastview) member of the Lindsay Formation thickens to the northwest. The upper member is 10.8 metres thick in the Russell map area (31G/6), but is not present in the Montreal area.

Measured thicknesses (in metres) of the lower and upper members for the exposed sections and drillhole intersections of Appendices 1 and 2 are listed in Table 20 (the "+" symbol indicates that the entire thickness of the member does not occur in the exposure or drillhole). Measurements reported in other publications for the exposed sections of Table 20 are included in Appendix 1.

LOWER MEMBER						UPPER MEMBER	
Exposure	Thickness	Exposure	Thickness	Drillhole	Thickness	Exposure	Thickness
LQ AL-1	6.60+	S OT-6	5.85+	GDH HA-1	24.6+	S OT-4	0.45+
LQ AL-2	10.85+	LQ RU-1	15.50+	DH OT-11	19.7	Drillhole	Thickness
LQ CO-4	4.20+	LQ RU-2	17.00+	GDH RU-1	9.1+	DH AL-5	9.2
LQ CO-5	5.60+	LQ RU-3	12.00+	DH RU-24	21.9	DH OT-11	5.3
AQ CO-2	4.65+	LQ RU-6	3.30+			GDH RU-1	7.7
S OT-4	6.55+	LQ WI-5	4.50+			DH RU-24	10.8

TABLE 20. Thickness (in metres) of the Lindsay Formation of the Ottawa-St. Lawrence Lowland.

Age. The paleontology of the Lindsay Formation of the Ottawa-St. Lawrence Lowland has been described by Raymond (1921), Wilson (1946b-c, 1947, 1948, 1951, 1956b, 1961) and Fritz (1957). Brachiopods, bryozoa, trilobites, gastropods, and crinoids are abundant.

The upper part of the sequence referred to as the Cobourg faunal zone by Wilson (1946a) spans strata here identified as the lower member of the Lindsay Formation. The shelly fossils indicate a Shermanian to Edenian age for the lower member (Barnes *et al.* 1981).

Tuffnell and Ludvigsen (1984, p. 27-28) described three biostratigraphic units which occur in the Collingwood Member of the Lindsay Formation and in the Blue Mountain (south-central Ontario) and Billings (Ottawa-St. Lawrence Lowland) Formations, and which are based on the frequency of occurrence of four species of the trilobite Triarthrus. Although none of the units were noted to occur in that part of the Ottawa area section which is referred here to the upper (Eastview) member of the Lindsay Formation, fauna A (T. eatoni) was noted in the Collingwood Member at Toronto and Collingwood, and fauna B (T. canadensis) in the Collingwood Member at Manitoulin Island. An Edenian to Maysvillian age is indicated for the Collingwood Member. Shelly fossils indicate a Maysvillian age for the Eastview Member (Barnes et al. 1981).

Billings Formation

Definition. The Upper Ordovician Billings Formation (Plate 13) as originally proposed by Wilson (1937) consisted of dark brown to black shale. It was named for Billings Bridge in the Ottawa map area (31G/5), where it outcrops. Wilson (1946a, p. 27) placed the conformable lower contact of the formation at the top of the uppermost limestone bed of the underlying Eastview Member of the Lindsay Formation (Wilson's Eastview Formation). Since thin limestone interbeds occur in the Billings Formation, the thickness of

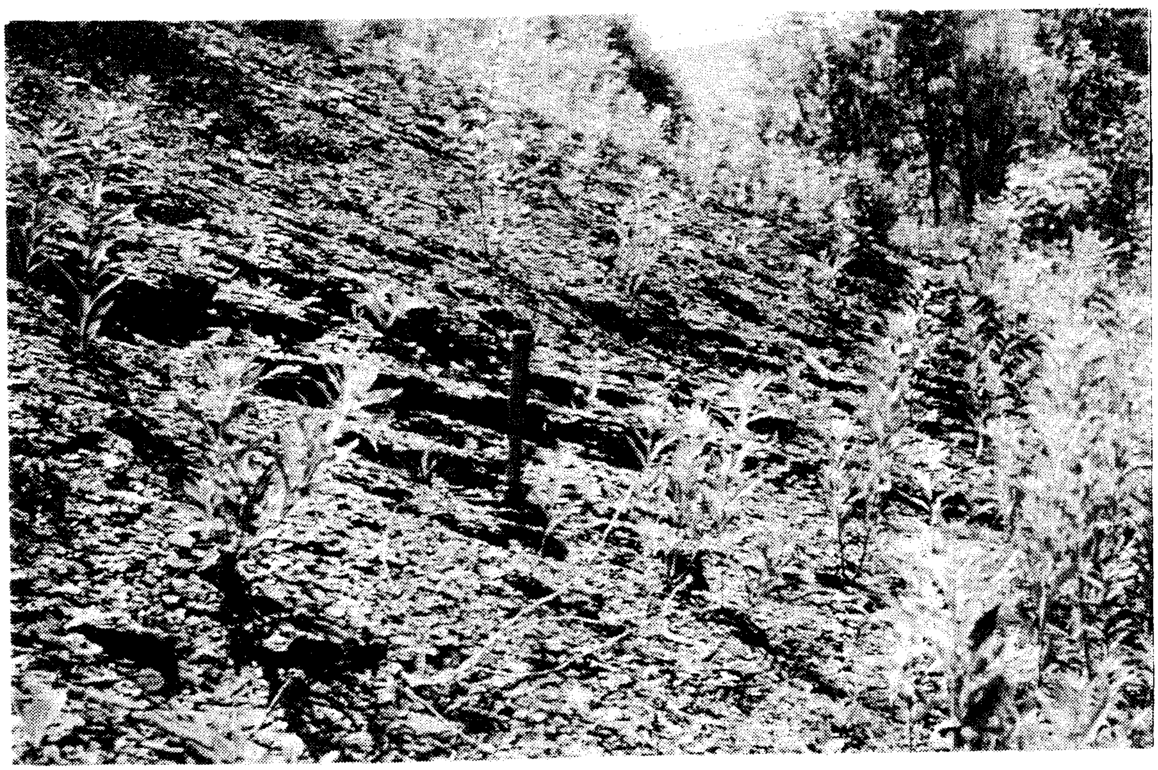

Plate 13. Billings Formation, Cyrville road cut (Ottawa map area, 31G/5; S OT-11a in Appendix 1). Photo DW-2-14 (1982).

the uppermost limestone bed of the Eastview Formation is critical for accurate location of the contact. It is specified here as being greater than 2 cm. The shale of the Billings Formation is non-calcareous to slightly calcareous, while that of the Eastview Member is calcareous.

Although Wilson (1946a, p. 27) placed the conformable upper contact of the Billings Formation with the Carlsbad Formation between black shale below and grey shale above, the colour difference is not sufficiently distinctive to be used as the only criterion for a formational boundary. A valid lithological subdivision can be made on the basis of the occurrence of interbedded siltstone and limestone. The upper contact of the Billings Formation is redefined here as the base of the lowest siltstone or limestone bed which is greater than 2 cm thick.

The Billings Formation is equivalent to at least part of the Blue Mountain Formation of south-central Ontario (Russell and Telford, 1983 - see Tables 6 and 19) and to the Lachine Formation of the Utica Group of adjacent Quebec (Clark 1972a, 1972b - see Table 6).

Distribution. The Billings Formation outcrops sparsely in the central part of the Ottawa-St. Lawrence Lowland in the Ottawa (31G/5) and Russell (31G/6) map areas (Fig. 12). It also subcrops beneath younger bedrock formations in the central part of the Lowland.

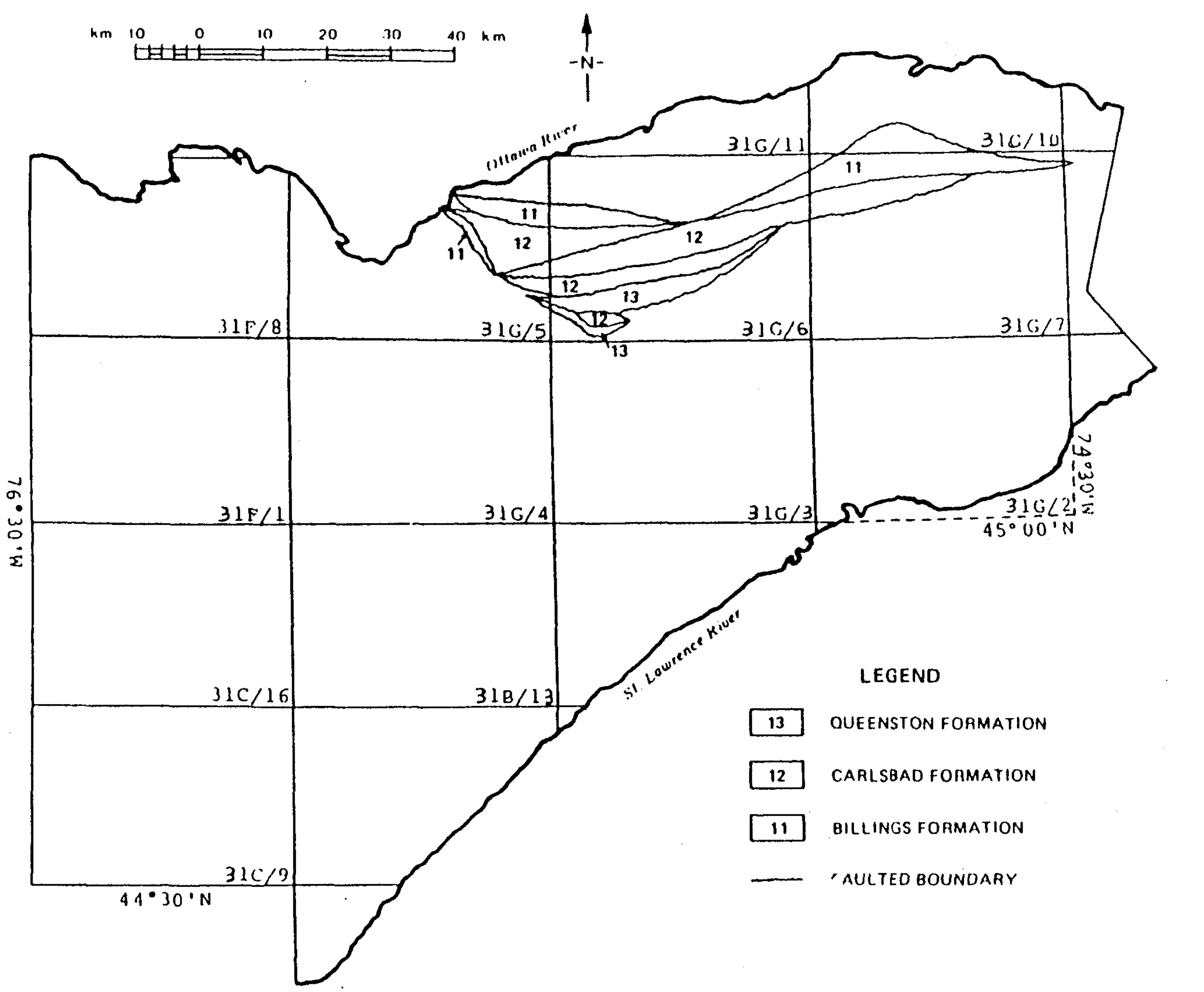

Figure 12. Distribution of the Billings, Carlsbad, and Queenston Formations of the Ottawa-St. Lawrence Lowland.

Due to the low resistance to erosion of the Billings Formation, natural outcrops are generally river cuts. A good exposure which is used herein as the principal reference section is the Cyrville roadcut (S OT-11a, Ottawa map area, 31G/5) (Plate 13), described in Appendix 1. As indicated in Appendix 2, many drillholes have intersected the formation; references to drillhole descriptions are included in Appendix 2.

Lithology. The Billings Formation consists of dark brown to black shale, with laminae of finely crystalline dark grey limestone in the lower part of the formation and calcareous siltstone interbeds up to 2 cm thick in the upper part. The shales are non-calcareous to slightly calcareous, and are pyritiferous and fossiliferous in places. The siltstones are medium grey to greenish grey in colour, and weather buff to reddish brown.

The lower part of the Billings Formation is subject to sulphate alteration, which results in foundation heave. Gillott et al. (1974, p. 483) noted gypsum and jarosite in shales consisting of illite, chlorite, quartz, calcite and pyrite. Quigley et al. (1973, p. 1014) concluded that gypsum is the primary cause of heave, indicating that the heave potential of pyritiferous shale is dependent on the carbonate content.

The Billings Formation was probably deposited in an intracontinental shelf environment, below storm wave base.

The clastics were derived from the rising Appalachian Mountains to the east, and the presence of pyrite indicates deposition under reducing conditions.

Thickness. The Billings Formation and its equivalent in adjacent Quebec thicken to the southeast. The Billings Formation is 62.0 metres thick in the Russell map area (31G/6) and the Lachine Formation is 124.4 metres thick in the Cartier Natural Gas (St. Hubert) well, drilled near Montreal (Clark 1972a, p. 12).

Measured thicknesses (in metres) for the exposed section and drillhole intersections of Appendices 1 and 2 are listed in Table 21 (the "+" symbol indicates that the entire thickness of the formation does not occur in the exposure or drillhole).

Exposure	Thickness	Drillhole	Thickness
S OT-11a	10.00+	DH HA-1	56.7+
		GDH OT-2	23.3+
		DH OT-11	32.5+
		GDH RU-1	18.2+
		DH RU-24	62.0

TABLE 21. Thickness (in metres) of the Billings Formation of the Ottawa-St. Lawrence Lowland.

Age. The paleontology of the Billings Formation has been described by Foerste (1924). Cephalopods, trilobites, brachiopods, and graptolites are present, and are commonly pyritized.

A trilobite fauna characterized by *Triarthrus rougensis* and *T. spinosus* was recognized by Tuffnell and Ludvigsen

(1984) in both the Billings and Blue Mountain Formations. The trilobites suggest a Maysvillian age, which is consistent with the assignment of Barnes et al. (1981) that was based mainly on graptolites.

Carlsbad Formation

Definition. The Upper Ordovician Carlsbad Formation (Plate 14) as originally proposed by Wilson (1937) consisted of interbedded shale, calcareous siltstone, and silty limestone. It was named for Carlsbad Springs in the Russell map area (31G/6), where it was intersected in a well drilled by the Standard Oil Company (DH RU-26 of Appendix 2). Wilson (1946a, p. 27) placed the conformable lower contact of the Carlsbad Formation between black shale below and grey shale above. This definition is not sufficiently diagnostic, and the lower contact is redefined here as the base of the lowest siltstone or limestone bed which is greater than 2 cm thick.

Wilson (1940a) described the Russell Formation as the stratigraphic unit which overlies the Carlsbad Formation. The Highway 417 roadcut 9 km north of Russell (Russell map area, 31G/6; UTM 471000E, 5020300N) lies within the outcrop area described by Wilson (1946a, p. 30). Insufficient lithological differences are apparent between the Carlsbad and Russell Formations for them to be considered as separately mappable units (Liberty 1967; Williams and Wolf

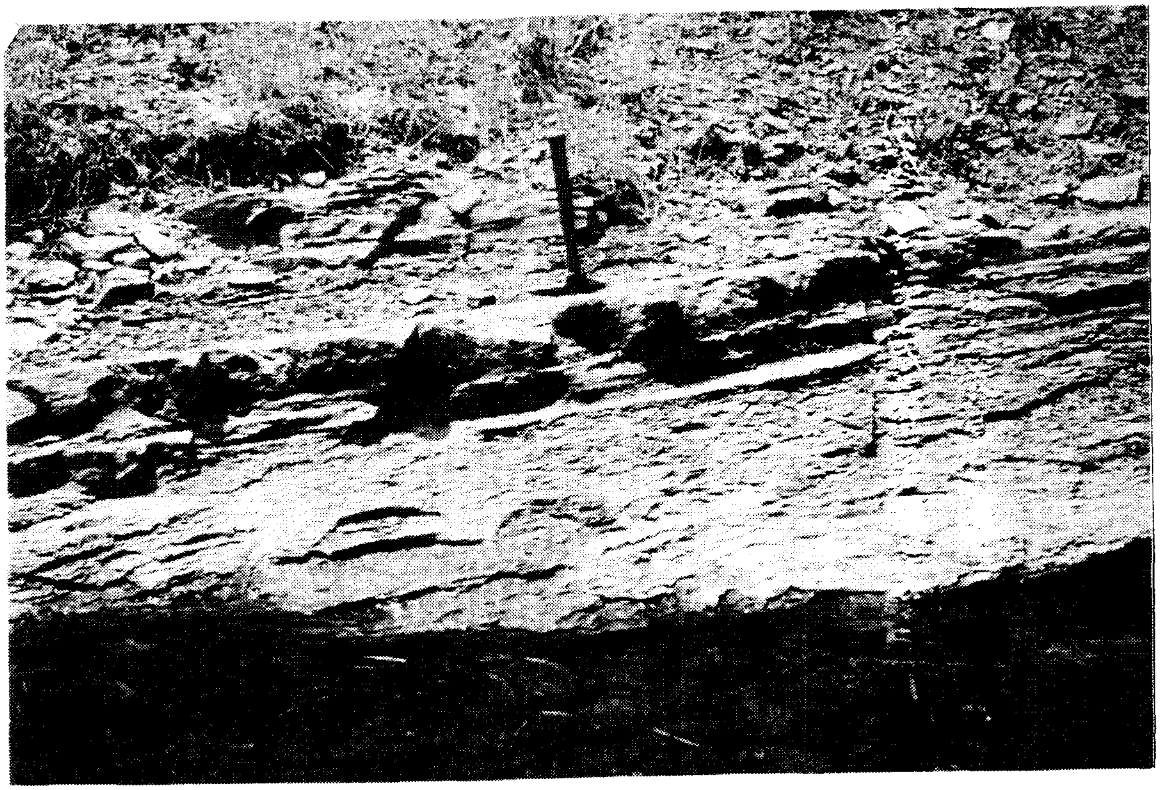

Plate 14. Carlsbad Formation, Cyrville roadcut (Ottawa map area, 31G/5; S OT-11b in Appendix 1). Photo DW-2-15 (1982).

1982, p. 134). Wilson's (1940a) Russell Formation is therefore included here within the Carlsbad Formation, of which it may be considered a calcareous upper member. The conformable upper contact of the Carlsbad Formation is therefore redefined here, as the lower limit of the red mudrock of the overlying Queenston Formation.

The redefined Carlsbad Formation is equivalent to the Georgian Bay Formation of south-central Ontario (Liberty 1969 - see Table 6) and to the Nicolet River Formation of the Lorraine Group of adjacent Quebec (Clark 1972a, 1972b - see Table 6).

Distribution. The Carlsbad Formation outcrops sparsely in the central part of the Ottawa-St. Lawrence Lowland in the Ottawa (31G/5) and Russell (31G/6) map areas (Figure 12). It also subcrops beneath the Queenston Formation in the central part of the Lowland.

Due to the low resistance to erosion of the Carlsbad Formation, natural outcrops are usually found in river valleys. A good exposure which is used herein as the principal reference section is the Cyrville roadcut (S OT-11b, Ottawa map area, 31G/5) (Plate 14), described in Appendix 1. As indicated in Appendix 2, many drillholes have intersected the formation; references to drillhole descriptions are included in Appendix 2.

Lithology. The Carlsbad Formation consists of interbedded shale, fossiliferous calcareous siltstone, and silty bioclastic limestone. The shales are dark grey in colour and calcareous to non-calcareous. The siltstones and limestones are very thinly to medium bedded, medium grey to greenish grey in colour, and weathering a buff to reddish brown colour. Crossbedding and flute casts are common, and ripple marks occur in some beds.

The Carlsbad Formation was probably deposited in an intracontinental shelf environment. The clastics were derived from the rising Appalachian Mountains to the east.

Thickness. The Carlsbad Formation and its equivalent in adjacent Quebec thicken to the southeast. The Carlsbad Formation is 186.9 metres thick in the Russell map area (31G/6), and the Nicolet River Formation is at least 300 metres thick at Montreal (Clark 1972a, p. 12).

Measured thicknesses (in metres) for the exposed section and drill hole intersections of Appendices 1 and 2 are listed in Table 22 (the "+" symbol indicates that the entire thickness of the formation does not occur in the exposure or drillhole).

Exposure	Thickness	Drillhole	Thickness
S OT-11b	3.50+	GDH OT-2	67.9+
		DH RU-23	131.1+
		DH RU-24	186.9

Table 22. Thickness (in metres) of the Carlsbad Formation of the Ottawa-St. Lawrence Lowland.

Age. The paleontology of the Carlsbad Formation has been described by Foerste (1924). Crinoids, brachiopods, pelecypods, cephalopods, trilobites, and bryozoa are very abundant. The shelly fossils indicate a Richmondian age for the Carlsbad Formation (Barnes et al. 1981).

Queenston Formation

Definition. The Upper Ordovician Queenston Formation (Plate 15) was named by Grabau (1908) for the town of Queenston, located in the Niagara Peninsula of southern Ontario. Its occurrence in south-central Ontario was described by Caley (1940, p. 22-24) and Liberty (1969, p. 79-83). At its type locality the Queenston Formation is a distinctive red shale or mudrock, and the conformable lower contact is the lower limit of red colouration. Foerste (1916) noted the occurrence of the Queenston Formation in the Ottawa-St. Lawrence Lowland, where it constitutes the youngest Paleozoic rock unit known to be present.

The Queenston Formation is equivalent to the Becancour River Formation of the Queenston Group of adjacent Quebec (Clark 1972b - see Table 6).

Distribution. The Queenston Formation outcrops in the central part of the Ottawa-St. Lawrence Lowland, in the Russell map area (31G/6) (Fig. 12). It also subcrops

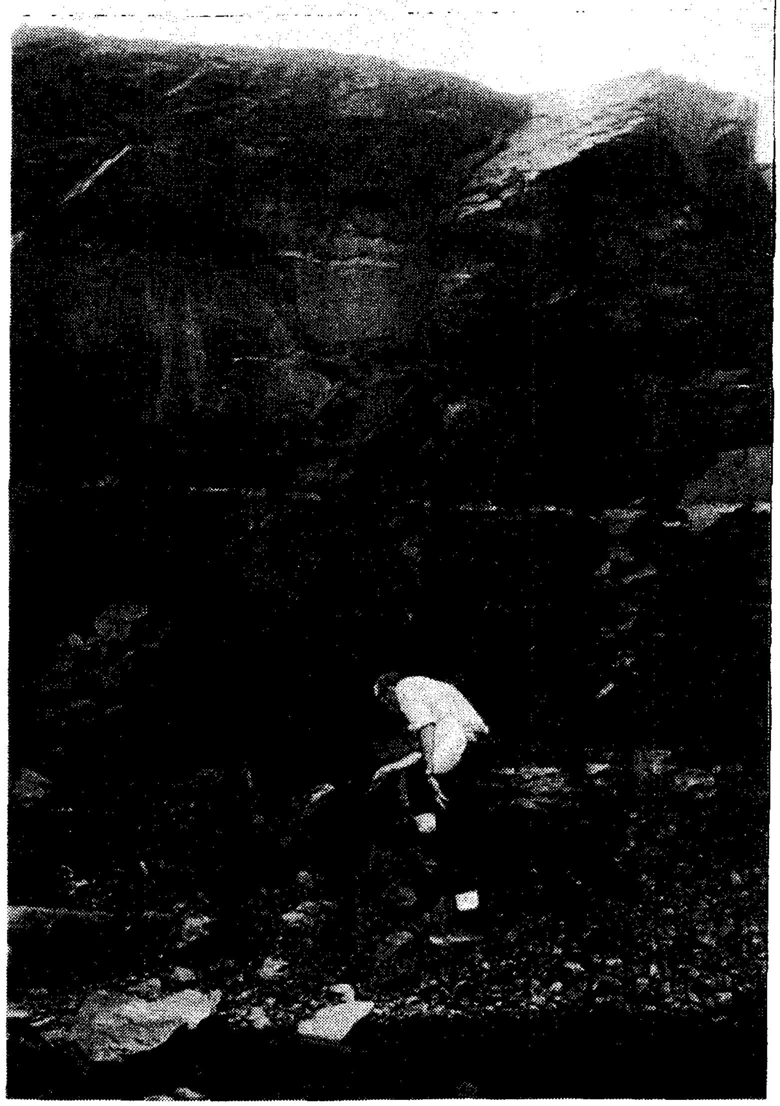

Plate 15. Queenston Formation, Russell quarry (Russell map area, 31G/6; LQ RU-4 in Appendix 1). Photo DW-2-27 (1982).

beneath surficial deposits in the central part of the Lowland.

The Queenston Formation has a low resistance to erosion, and the only known exposure in the Lowland is the Russell quarry (LQ RU-4, Russell map area, 31G/6) (Plate 15), described in Appendix 1 and also by Guillet (1967, p. 76-78). It is used herein as the principal reference section. As indicated in Appendix 2, the formation has been intersected in Consumers' Gas Company well 16306 (DH RU-6) and the Geological Survey of Canada Russell well (DH RU-24), both drilled in the Russell map area (31G/6).

Lithology. The Queenston Formation consists of red to light greenish grey, very thinly to thickly bedded, slightly calcareous siltstone and shale. Interbeds of silty bioclastic limestone occur in the lower part of the formation. The red colour is predominant, with the light greenish grey colour occurring along joints, along bedding planes, and as reduction spots. Desiccation cracks and ripple marks are present.

The chemical composition of a 4.6-metre section in the Russell quarry was reported by Guillet (1967, p. 77) as follows: 58.06% SiO_2, 6.28% Fe_2O_3, 15.9% Al_2O_3, 4.48% CaO, 2.78% MgO, 1.21% Na_2O, 3.42% K_2O, 3.67% CO_2, and 3.80% H_2O.

The Queenston Formation was probably deposited in an intracontinental shelf environment. The clastics were derived from the rising Appalachian Mountains to the east.

The colouration is probably a post-depositional feature, the red colour being due to oxidation of the iron content and the green colour to subsequent reduction (Liberty 1969, p. 82).

Thickness. The Queenston Formation of the Ottawa-St. Lawrence Lowland has a thickness in excess of 49.7 metres.

Measured thicknesses (in metres) for the exposed section and drillhole intersections of Appendices 1 and 2 are listed in Table 23 (the "+" symbol indicates that the entire thickness of the formation does not occur in the exposure or the drillhole).

Exposure	Thickness	Drillhole	Thickness
LQ RU-4	9.15+	DH RU-6	49.7+
		DH RU-24	13.0+

TABLE 23. Thickness (in metres) of the Queenston Formation of the Ottawa-St. Lawrence Lowland.

Age. The paleontology of the Queenston Formation of the Ottawa-St. Lawrence Lowland has been described by Foerste (1924). Corals, bryozoa, and brachiopods are present in the bioclastic limestone beds. The shelly fossils indicate a Richmondian age for the Queenston Formation (Barnes et al. 1981).

IGNEOUS INTRUSIONS

Ultramafic Dikes

Eight vertical carbonatite dikes, striking easterly and up to 40 cm thick, are exposed in the Francon Blackburn quarries (Ottawa map area, 31G/5; LQ OT-11 in Appendix 1) (Fig. 13; Plate 16). They have been described by Hon (1970), Bolton and Liberty (1972, p. 21-22), Rushforth (1985) and Hogarth and Rushforth (1986). The dikes consist mainly of dolomite, and are characterized by calcite, phlogopite, and apatite phenocrysts and a variety of rounded xenocrysts derived mainly from Precambrian rocks. Hon (1970, p. 34-36) quoted a K-Ar age determination (obtained from phlogopite by M. Shafiqullah) of 190 Ma, but noted the probability of contamination by Precambrian biotite. Bolton and Liberty (1972, p. 22) reported a paleomagnetic study by A. Larochelle that gave a pole coincident with that of the Oka carbonatite complex of adjacent Quebec. K-Ar age determinations for the Oka complex yielded an age of 118 Ma (Cretaceous) (Shafiqullah et al. 1970). A carbonatite dike (Crepeau 1963) is exposed in the Lachute map area (31G/9), along the southern bank of the Ottawa River between the Carillon Dam and the Ontario-Quebec border (UTM 548100E, 5045550N); the dike strikes east-northeast and is up to 40 cm thick.

It is possible that mica peridotite dikes will be discovered in the Ontario portion of the Ottawa-St. Lawrence

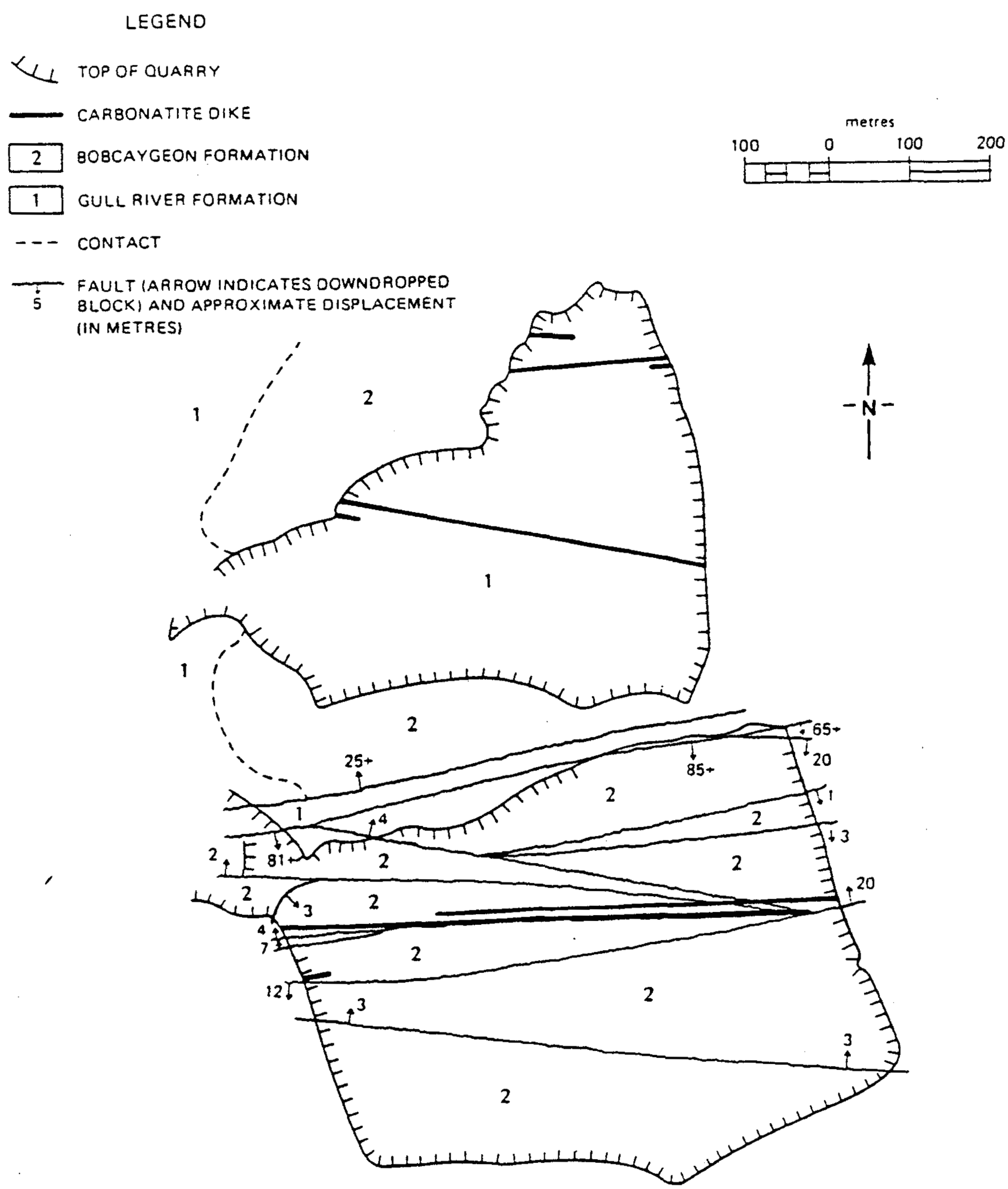

Figure 13. Bedrock geology of the vicinity of the Francon quarries, Blackburn.

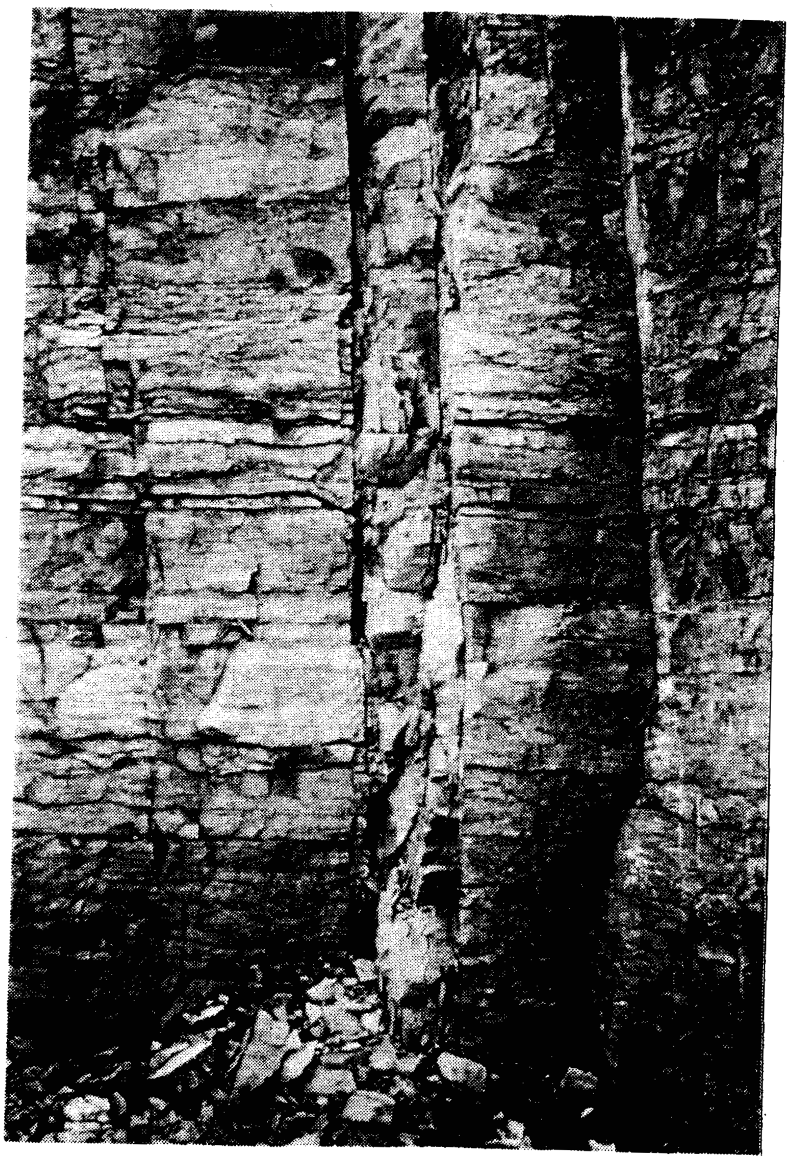

Plate 16. Carbonatite dike in the Gull River and Bobcaygeon Formations, Francon Blackburn north quarry (Ottawa map area, 31G/5; LQ OT-11a in Appendix 1). Photo RW-2-2 (1982).

Lowland, since they occur in adjacent areas. The Ogdensburg dike of northern New York State was described by Newland (1931); it has an average thickness of 1.2 m and strikes east-southeast. The Varty Lake dike of south-central Ontario was described by Hon (1970) and Barnett et al. (1984); it is up to 1.5 m in thickness and strikes east-southeast. Hon (1970, p. 34-35) quoted K-Ar age determinations (obtained by M. Shaffiqullah from phlogopite) of 166 and 167 Ma (Jurassic), and Barnett et al. (1984, p. 1468) obtained an age of 170 Ma by K-Ar dating (whole-rock, acid-treated whole-rock, and phlogopite). The Picton dike of south-central Ontario was described by Barnett et al. (1984); it is up to 70 cm in thickness, strikes east-southeast, and has a much lower content of phlogopite phenocrysts than the Varty Lake dike. Barnett et al. (1984, p. 1468) obtained acid-treated whole-rock K-Ar age determinations of 173 and 175 Ma.

The carbonatite dikes show a close spatial relationship to fault junctions (Fig. 13), as do the mica peridotite dikes of adjacent New York State and south-central Ontario.

STRUCTURAL GEOLOGY

Joints

The Paleozoic rocks of the Ottawa-St. Lawrence Lowland are intersected by steeply dipping joints which form four sets. Approximately 300 orientations measured at localities throughout the Lowland indicate that the joint sets strike at approximately 015°, 055°, 100°, and 145°. Outcrop areas are generally characterized by two joint sets striking approximately at right angles, resulting in the occurrence of rectangular blocks. The 100° joint direction is the most dominant, and the 055° orientation is the least dominant. Joints in carbonate units have commonly been widened by solution, and joints belonging to all joint sets have commonly been filled by calcite. Minor pyrite, barite, celestite, or gypsum accompanies the calcite in places.

The principal joint planes are usually moderately (30 cm to 1 metre) to widely (greater than 1 metre) spaced, and the spacing increases with increasing bed thickness. No specific rock type was noted to have a much greater or lesser joint spacing than other rock types. Numerous closely (less than 30 cm) spaced joints commonly occur close to a fault and strike parallel to it, suggesting a genetic relationship between each joint set and faults of a particular orientation.

A regional consistency in the orientation of joint sets, and in the relative dominance of each set, is apparent; Williams, Corkery and Lorek (1985) recognized four joint sets (005°, 045°, 085°, and 135°) in the Niagara Peninsula of southern Ontario, the 045° orientation being subordinate and the other three directions being dominant.

Faults

The Paleozoic rocks of the Ottawa-St. Lawrence Lowland are transected by numerous steeply dipping normal faults and fault zones (Plates 9, 17, and 18) which strike from southeast to northeast and have vertical displacements which exceed 1000 metres in places (Williams 1983). The faults and associated features form part of a major tectonic zone, the Ottawa Valley rift zone, which includes the Ottawa-Bonnechere graben of Kay (1942) and extends west-northwesterly from the St. Lawrence River to Lake Nipissing. Accurate fault interpretation in the Lowland requires a good knowledge of the stratigraphy within each fault block, and of the locations of fault block boundaries. An improved understanding of the detailed stratigraphy has contributed to the detection of relative vertical displacement and the estimation of the amounts of displacement, thus making verification of postulated faults and identification of other faults possible. In areas (particularly in the northwestern part of the Lowland) where outcrops are abundant and good exposures of faults and fault zones exist, the accurate location of fault block boundaries is possible. Extrapolation from adjacent areas is necessary in areas of limited exposure, and can be aided by the use of drillhole information, geophysical survey data, and fault-controlled topographic features.

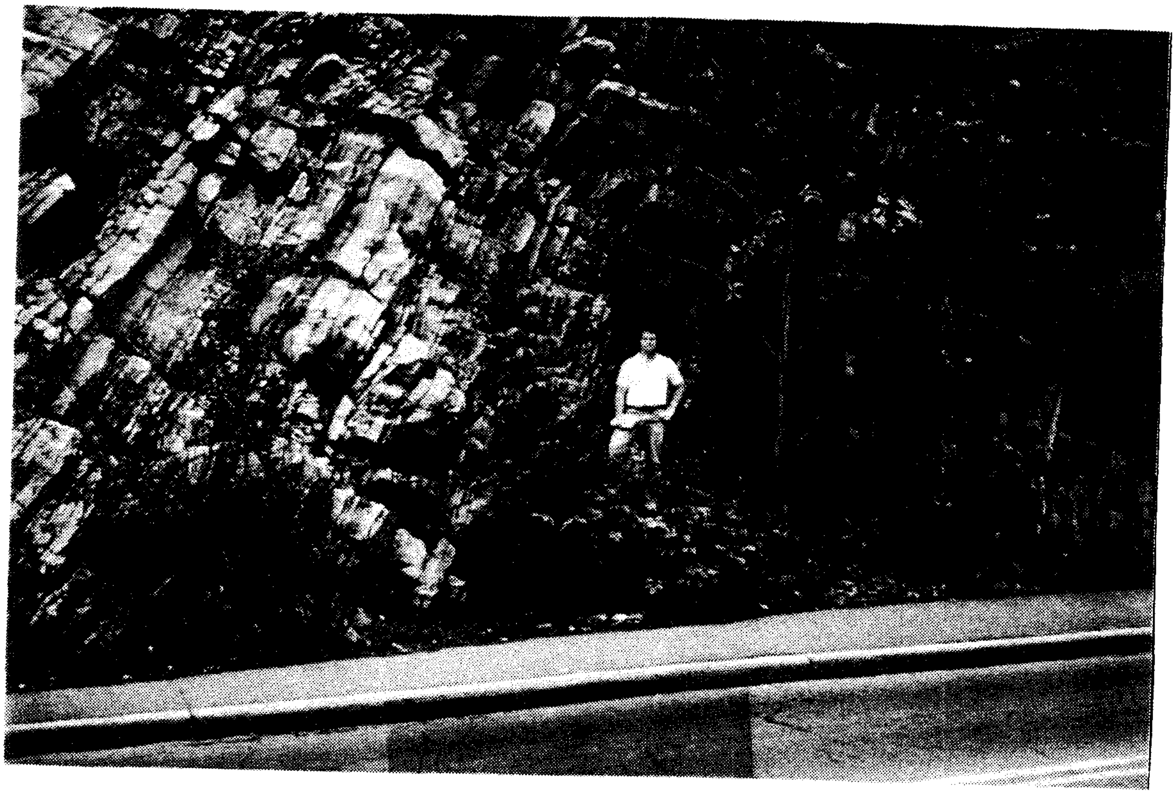

Plate 17. Steeply dipping Bobcaygeon Formation within a fault zone, McCarthy Road, Ottawa (Ottawa map area, 31G/5; UTM 446980E, 5023390N). Photo AL-3-34 (1982).

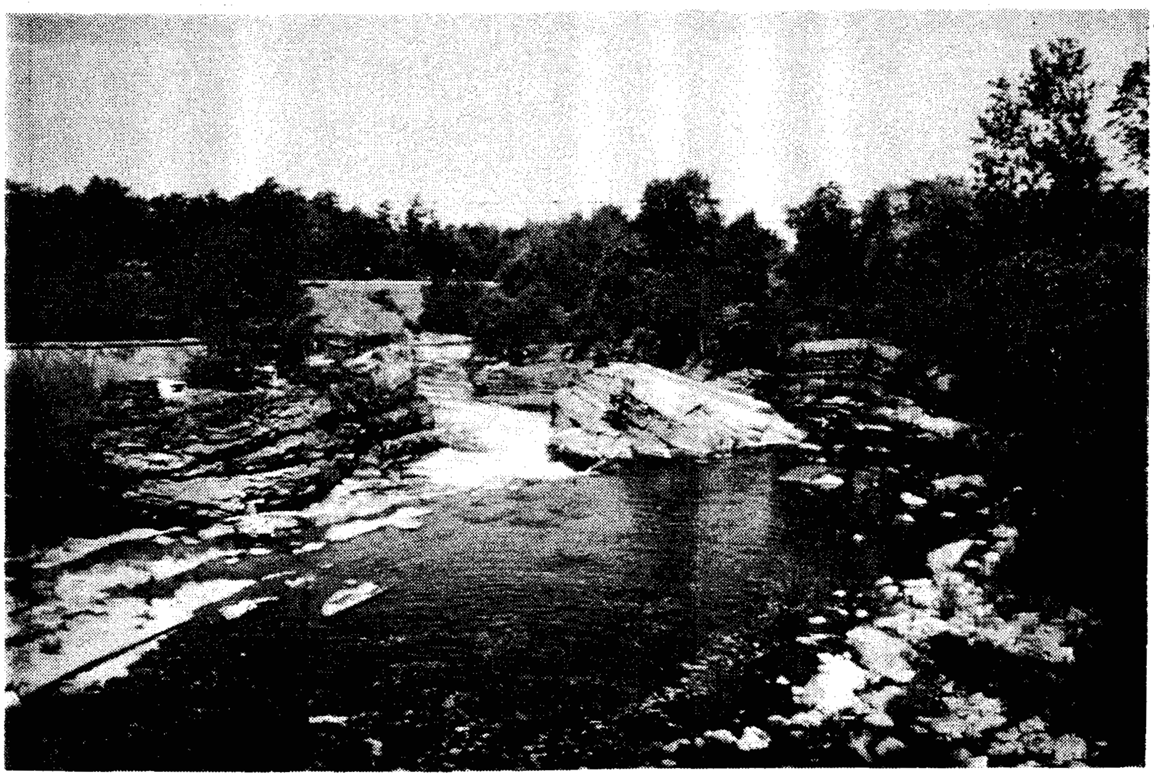

Plate 18. Moderately to steeply dipping Rockcliffe, Shadow Lake, and Gull River Formations within a fault zone (looking northwest), Prince of Wales Falls, Hog's Back Park, Ottawa (Ottawa map area, 31G/5; S OT-5 in Appendix 1). Photo AL-3-22 (1982).

Faults which have vertical displacements of at least 15 metres are indicated in Figure 3. Some areas in the northern part of the Lowland are characterized by relatively high fault density (Williams, Rae and Wolf 1984). The relative displacement between each of the fault blocks of the Lowland is shown in Figure 14. The fault block which was selected for assignment of an arbitrary value of zero relative displacement is located in the southwestern part of the Russell map area (31G/6). The top of the Paleozoic section which is known to exist in the Lowland (49.7 metres above the base of the Queenston Formation) occurs in this fault block. This selection avoids the use of a combination of positive and negative relative displacements. In order to assign positive (rather than negative) values to other fault blocks, their upward (rather than downward) displacement relative to the datum must be used. The surface and subsurface information contained in Appendices 1 and 2 was employed to calculate relative displacements. As an example, the value of 25 metres for the fault block located to the immediate northeast of the block assigned an arbitrary value of zero was determined by comparing the elevations of the contact between the Carlsbad and Queenston Formations in the two blocks: 49.5 metres above sea level (DH RU-24 of Appendix 2) and 25.0 metres above sea level (DH RU-6 of Appendix 2), respectively.

Fault traces are normally gently curved but may be distinctly curved in the vicinity of fault junctions.

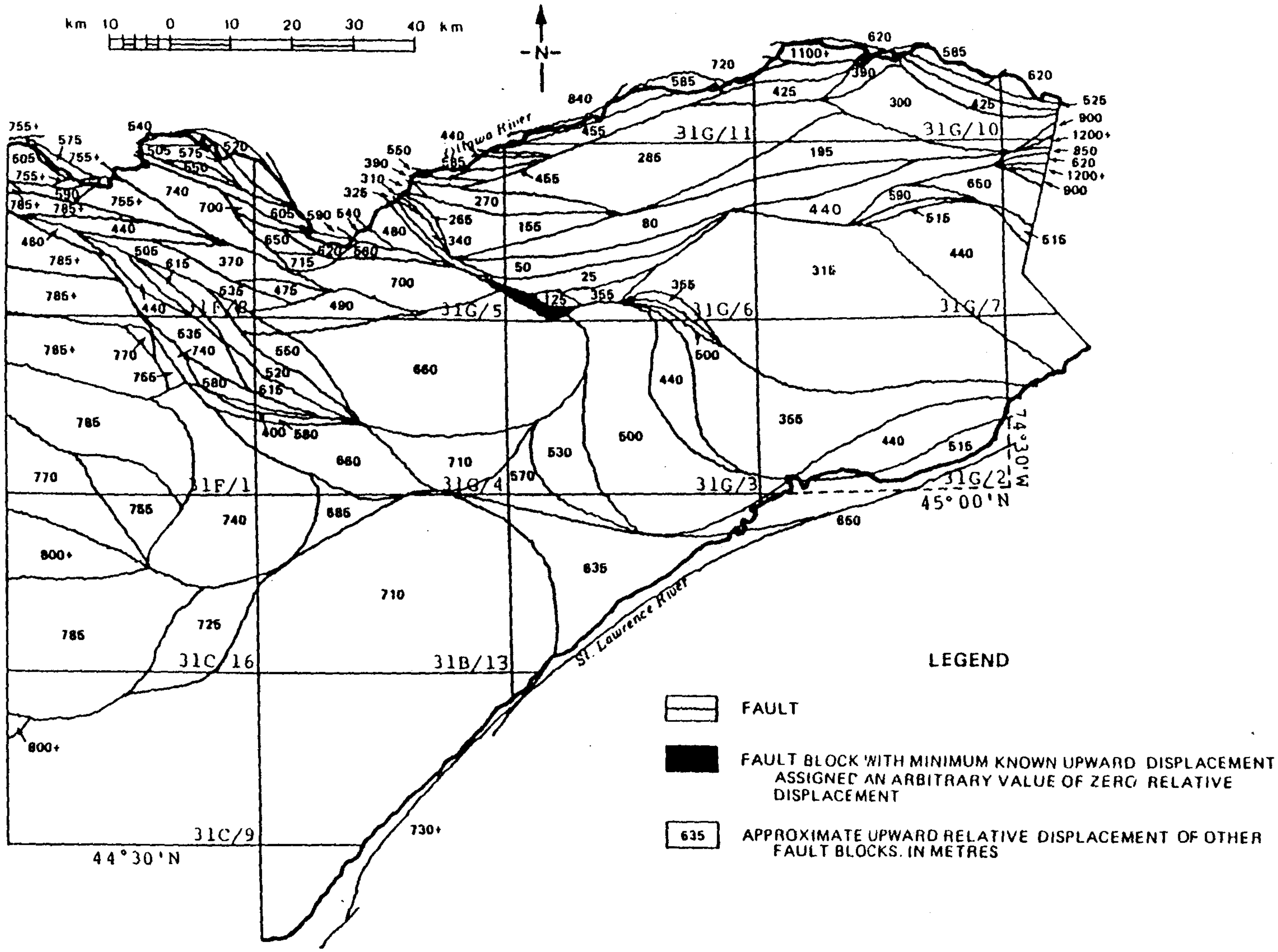

Figure 14. **Relative displacement (in metres) between fault blocks of the Ottawa-St. Lawrence Lowland.**

Distinct fault curvature is well documented at many localities which include the southwestern part of the Russell map area (31G/6), where exposures are abundant and many deep holes have been drilled. Fault junctions generally consist of a single fault branching from the main fault, but major junctions involve a larger number of faults. The vertical displacement at a fault junction is approximately equal to the sum of the displacements along each set of faults which branches from the junction.

Bedding in the Paleozoic rocks is normally close to horizontal, but within many fault zones the beds dip steeply toward the downthrown block (Plates 17 and 18). Steeply plunging slickensides are common on fault planes, but gently plunging slickensides and small folds were also observed. The folds are transected by faults of minor displacement. Norris (1967) described an anticline-syncline pair within a fault zone, exposed in a roadcut along the Queensway at Parkdale Avenue in Ottawa (31G/5; UTM 443150E, 5027150N). The folds have horizontal axes trending northwest, parallel to the strike of the faults, and were classified by Norris (1967, p. 306) as flexural-slip parallel folds. Calcite veins commonly occur along faults. Minor pyrite, barite, celestite, or gypsum accompanies the calcite in places.

Topographic lows are commonly fault-controlled; only a few non-linear segments of the Ottawa River do not follow fault traces, and the St. Lawrence River follows a fault trace along all but the extreme northeastern part of its course through the Ontario portion of the Ottawa-St. Lawrence Lowland. Topographic lows occur along segments of fault traces in the Perth map area (31C/16). Other notable fault- controlled topographic lows are the Madawaska River, Cody Creek, Buckham Bay, and Constance Creek (Arnprior map area, 31F/8); the Mississippi River (southern part of the Arnprior map area, 31F/8; and northern part of the Carleton Place map area, 31F/1); the southern part of Mississippi Lake (Carleton Place map area, 31F/1); and the Rideau Lakes (Perth map area, 31C/16; and Westport map area, 31C/9).

A change in the nature of the topography commonly occurs from one fault block to another. Precambrian outcrop areas are characterized by hummocky topography; the more resistant Paleozoic units (the Covey Hill, Nepean, March, Oxford, Rockcliffe, Bobcaygeon, and Lindsay Formations) generally outcrop in upland areas; and the less resistant units (the Shadow Lake, Gull River, Verulam, Billings, Carlsbad, and Queenston Formations) generally outcrop in lowland areas.

Geophysical methods are very useful in tracing faults. In order to aid fault interpretation in those parts of the Russell map area (31G/6) which are characterized by very little bedrock exposure, Thompson (1985a) conducted a seismic reflection survey in the vicinity of Casselman and also (1985b) ran seismic reflection and refraction profiles at eleven sites; profiles 1 and 9 were located within the reflection survey area, and the others were located elsewhere in the Russell map area (31G/6). The reflection survey revealed the existence of a linear depression in the bedrock surface, closely following a segment of the South Nation River which appears to delineate a fault trace. Faults were interpreted from the profiles on the basis of changes in the elevation of the bedrock surface (as determined by reflection) and changes in the velocity of seismic waves in the bedrock (as determined by refraction). A VLF (very low frequency) electromagnetic survey and a magnetotelluric survey in the vicinity of Leitrim (Ottawa map area, 31G/5) detected three individual faults separating fault blocks of contrasting resistivity (Telford _et al._ 1977).

Many of the faults of the Ottawa-St. Lawrence Lowland have been recognized and named previously, as shown in Figure 3. Wilson (1938a, 1938b) referred to the Hazeldean and Gloucester faults, and to a set of faults located in the northeastern part of the Ottawa map area (31G/5) which is referred to here as the Ottawa River fault series. Kay (1942) referred to the Douglas, Pakenham, Shamrock, Mount St. Patrick, Madawaska, and Plevna faults; Wynne-Edwards (1967, p. 87-88) to the Rideau Lake fault; and Globensky (1982a, p. 48-49) to the Rigaud and Sainte Justine faults. Using LANDSAT imagery, Sanford _et al._ (1984, p. 91) plotted a well defined major fracture (referred to here as the St. Lawrence River fault) along the course of the St. Lawrence River through the Ontario portion of the Lowland. Major faults which are characterized by a vertical displacement exceeding 200 metres occur within two fault series which trend approximately east-west: one to the south, referred to here as the Central fault series, which includes the Pakenham, Hazeldean, Gloucester and Rigaud faults; and a second to the north, the Ottawa River fault series. The Central series extends easterly from the Arnprior map area (31F/8) to the Vaudreuil map area (31G/8), and the Ottawa River series extends easterly through both Ontario and adjacent Quebec. The north side of all major faults of the Central series, except for the Hazeldean fault, is downthrown; and the south side of most major faults of the Ottawa River series is downthrown.

Good exposures of the major faults are common in the northwestern part of the Ottawa-St. Lawrence Lowland. Exposed faults are as follows:

Pakenham fault. A branch of the Pakenham fault was observed in the natural gas pipeline excavation in the Arnprior map area (31F/8) at Panmure (UTM 409900E, 5016750N). The fault zone is characterized by steep bedding dips, intense fracturing, and calcite veins. It is 20 metres wide, strikes 120°, and separates the Rockcliffe (to the southwest) and Bobcaygeon (to the northeast) Formations. Another branch of the Pakenham fault was documented in a pavement outcrop located in the Kemptville map area (31G/4) at Prospect (UTM 422240E, 4996490N), where the Rockcliffe (to the south) and Bobcaygeon (to the north) Formations are in fault contact. A third branch, which strikes 115° and separates the Gull River (to the south) and Bobcaygeon (to the north) Formations, was observed in the Stittsville (Dibblee) quarry (Kemptville map area, 31G/4; LQ KE-1 in Appendix 1). In the Stittsville (West Carleton) quarry (Ottawa map area, 31G/5; LQ OT-2 in Appendix 1), a number of faults striking 105° with vertical displacement of up to 5 metres occur in the Bobcaygeon Formation.

Hazeldean fault. Branches of the Hazeldean fault have been documented in the Arnprior map area (31F/8) at the Kingdon mine (UTM 401500E, 5032500N). The main ore vein occurs along a fault in Precambrian marble and amphibolite which strikes 115°. The north vein occurs along a fault which strikes 145° and separates Precambrian rock (to the northeast) and the Oxford Formation (to the southwest) (Uglow 1916, p. 21-22; Wilson 1924, p. 96-97). In the McFarland quarry at Fallowfield (Ottawa map area, 31G/5; LQ OT-3 in Appendix 1), located 500 metres southwest of the Hazeldean fault trace, a number of southeast-striking faults with vertical displacements amounting to several metres occur in the Gull River and Bobcaygeon Formations (Plate 9).

Gloucester fault. Exposures of branches of the Gloucester fault are common in the Ottawa map area (31G/5). In the Dunrobin quarry (LQ OT-6 of Appendix 1), a fault striking 105° separates the Oxford (to the north) and Rockcliffe (to the south) Formations. In a roadcut at Harwood Plains (S OT-1 of Appendix 1), a fault zone 5 metres wide and striking 100° separates the Nepean (to the south) and March (to the north) Formations. In the Transitway excavation immediately northeast of Churchill Street, Ottawa (UTM 440860E, 5026890N), a fault zone in the Gull River Formation strikes 135°. In the Transitway excavation immediately southwest of Parkdale Avenue, Ottawa (UTM 442660E, 5027950N), a fault zone 20 metres wide and striking 145° separates the Gull River (to the southwest) and Bobcaygeon (to the northeast) Formations; within the fault zone, the beds dip steeply to the northeast. In the Transitway excavation immediately northeast of Stonehurst Street, Ottawa (UTM 443010E, 5028130N), and in the nearby Ottawa River Parkway roadcut immediately east of Parkdale Avenue, Ottawa (UTM 442700E, 5028530N), the Bobcaygeon Formation is exposed southwest of a fault zone which is at least 10 metres wide and strikes 145°; within the fault zone, beds dip steeply to the northeast. Two other fault zones, of relatively minor displacement and within which the beds dip moderately to the northeast, occur in the Bobcaygeon Formation in the Parkway roadcut; they are up to 4 metres wide and strike 140° and 145°, respectively.

At the Prince of Wales Falls, Hog's Back Park, Ottawa (S OT-5 of Appendix 1) (Figure 5; Plates 8 and 18), three major faults strike southeast and divide the outcrop area into four fault blocks (A to D, from southwest to northeast). The lower member of the Rockcliffe Formation outcrops in block A. The upper member of the Rockcliffe

Formation, the Shadow Lake Formation, and the lower member of the Gull River Formation outcrop in block B. The lower member of the Gull River Formation outcrops in block C, and the middle member of the Bobcaygeon Formation in block D. The Rideau River follows the trace of the southwesternmost major fault. Two other faults of relatively minor displacement occur within blocks A and C. The beds dip moderately to steeply to the northeast along the northeast bank of the Rideau River, and moderately to the southwest along the southwest bank. Another fault exposure is located along the east bank of the Rideau River 400 metres north of Prince of Wales Falls; the fault strikes 150° and separates the Gull River (to the southwest) and Bobcaygeon (to the northeast) Formations. A fault zone in the Bobcaygeon Formation, which strikes 140°, is exposed along the Rideau River 1100 metres north of Prince of Wales Falls; the beds dip steeply to the northeast. The campus of Carleton University (located to the immediate northwest of the latter locality) is divided into three main fault blocks; the relative displacement across the faults being northeast side down and totalling 200 metres (Michel and Munro 1986). The lower member of the Gull River Formation subcrops in the southwesternmost fault block (equivalent to block C of Figure 5), the middle member of the Bobcaygeon Formation in the middle block (equivalent to block D of Figure 5), and the Billings Formation in the northeasternmost fault block.

In the roadcut located at the railroad overpass along Riverside Drive, Ottawa (UTM 445670E, 5021820N), a fault zone in the Gull River Formation is 50 metres wide and strikes 095°; within the fault zone, the beds dip steeply to the north. At the roadcut located immediately south of the intersection of Walkley Road and McCarthy Road, Ottawa (UTM 446980E, 5023390N), a fault zone striking 125° separates the Gull River (to the south) and Bobcaygeon (to the north) Formations; within the fault zone, the beds dip steeply to the northwest (Plate 17). At Leitrim (UTM 451900E, 5019560N), the beds dip steeply to the northeast within a fault zone in the Lindsay Formation. At Billings Bridge (UTM 447240E, 5025870N), a fault zone exposed in a stream cut located immediately northeast of Bank Street is 1 metre wide and strikes 130°; within the fault zone, which separates the Billings (to the northeast) and Carlsbad (to the southwest) Formations, the beds dip steeply to the southwest. In a roadcut along the northeast side of Highway 417 at Cyrville (S OT-11 of Appendix 1), a fault zone within which the beds dip steeply to the south separates the Billings (to the north) and Carlsbad (to the south) Formations (Plates 13 and 14).

Branches of the Gloucester fault are also exposed in the Russell map area (31G/6). Along the South Castor River at Russell (UTM 469060E, 5010840N), the beds dip steeply to the north within a fault zone in the Gull River and Bobcaygeon Formations. Along the Castor River at Russell

(UTM 473060E, 5011950N), the beds dip steeply to the south within a fault zone in the Gull River Formation. In the Embrun (Blair) quarry (LQ RU-5 of Appendix 1), the Bobcaygeon Formation is exposed to the northeast of a fault zone at least 20 metres wide and striking 120°; within the fault zone, the beds dip moderately to the northeast. Several other faults of relatively minor displacement and a series of calcite-celestite-pyrite veins up to 10 cm thick occur in the Bobcaygeon Formation adjacent to the Embrun quarry fault zone, and strike parallel to it.

Ottawa River fault series. Exposures of a series of faults located south of the Ottawa River, within 2.5 km of the river and striking subparallel to it, are common in the northeastern part of the Ottawa map area (31G/5). In the cliff along the bank of the Ottawa River at Rockcliffe Park (UTM 445800E, 5032650N), faults striking 140° and 110° occur in the Bobcaygeon Formation; fault contacts with the Rockcliffe Formation (to the north) and the Lindsay Formation (to the south) are not exposed. At Beechwood Cemetery, Ottawa (UTM 447700E, 5032310N), the beds dip steeply to the southeast within a fault zone in the Bobcaygeon Formation. A fault striking 070°, separating the Lindsay (to the north) and Billings (to the south) Formations, is exposed 300 metres northeast of the Montreal Road-St. Laurent Blvd. intersection, Ottawa (UTM 449500E, 5032110N). Immediately north of the Montreal Road-Langs Road intersection, Ottawa (UTM 450180E, 5032360N), the beds dip steeply to the south within a fault zone in the Lindsay Formation. The sequence exposed in the Francon north quarry at Blackburn (LQ OT-11a of Appendix 1) is separated from that of the south quarry (LQ OT-11b of Appendix 1) by a fault zone (Figure 13) which strikes 085° and is exposed at the north end of the south quarry; the Gull River (to the north) and Bobcaygeon (to the south) Formations are in contact across the fault zone, within which the beds dip steeply to the southeast. Several other east-striking faults with vertical displacements of up to 20 metres are exposed in the Francon south quarry at Blackburn and have a net displacement (north side down) of 5 metres to the west and 19 metres to the east; the discrepancy is accounted for by a relatively steep (approximately 10° to the south) bedding dip to the east. A fault exposure located immediately south of the Ottawa River in the Thurso map area (31G/11) occurs in the Cumberland quarry (AQ TH-2 of Appendix 1). The fault, which strikes 105° and separates the Oxford (to the south) and Rockcliffe (to the north) Formations, is characterized by a 60-cm wide zone of crushed rock.

Other faults and fault zones are not known to be exposed, but their presence can be interpreted on the basis of evidence for vertical displacement along them. The Douglas fault separates Precambrian rock (to the south) and the Oxford Formation (to the north). The Mount St. Patrick fault separates Precambrian rock (to the southwest) and the

March Formation (to the northeast). The Madawaska fault separates Precambrian rock (to the southwest) and the Nepean Formation (to the northeast). The Plevna fault separates Precambrian rock (to the north) and the Nepean Formation (to the south). The Rideau Lake fault separates Precambrian rock (to the northwest) and the Nepean Formation (to the southeast). The Rigaud fault separates Precambrian rock and the Nepean, March, Oxford, and Rockcliffe Formations (to the southeast) and the Lindsay and Billings Formations (to the northwest). The Sainte Justine fault separates the Oxford (to the northeast) and Rockcliffe (to the southwest) Formations, and the St. Lawrence River fault separates the Oxford (to the southeast) and Rockcliffe (to the northwest) Formations.

The existence of normal faults in the Ottawa-St. Lawrence Lowland indicates that crustal extension occurred at some time after deposition of the Cambrian-Ordovician sedimentary sequence. The strike of a particular fault coincides with the strike of the plane containing the maximum and intermediate principal stresses as they existed at the time of formation of the fault.

Buckles

The occurrence of stress-relief buckles in southern Ontario has been described by White and Russell (1982) and Russell et al. (1982). The buckles are elongated domes which are transected in places by thrust faults, and affect only the surface layers of bedrock and drift cover. They are the result of contemporary high horizontal compressive stress, and commonly form on quarry floors as a response to release of vertical compressive stress. Buckles which are not dependent on human activity are termed "pop-ups". Axes of buckles in southern Ontario trend generally northwest (although orientations are considerably scattered, due at least in part to control by pre-existing structures), indicating that the maximum compressive stress is regionally oriented northeast.

One buckle, originally reported by Adams (1982, p. 1883) and referred to as pop-up number 30 by White and Russell (1982, p. 44) and Russell _et al._ (1982, p. 115), occurs at the top of the eastern end of the Fallowfield (Dibblee) quarry (Ottawa map area, 31G/5; LQ OT-5 in Appendix 1). It has a trend of 165°, a length of 13 metres, a relief of 60 cm, and a thickness of 1.7 metres of disturbed strata.

Approximately 90 metres to the northeast of the South Mountain (Cruickshank) quarry (Morrisburg map area, 31B/14; LQ MO-2 in Appendix 1), a pop-up with a relief of 10 cm and a thickness of 6 cm of disturbed strata was observed. The southeastern part of the pop-up has a trend of 145° and a length of 4 metres, and the northern part of the pop-up has a trend of 000° and a length of 7 metres.

Six quarry-floor buckles occurring in the Fallowfield (McFarland) quarry (Ottawa map area, 31G/5; LQ OT-3 in

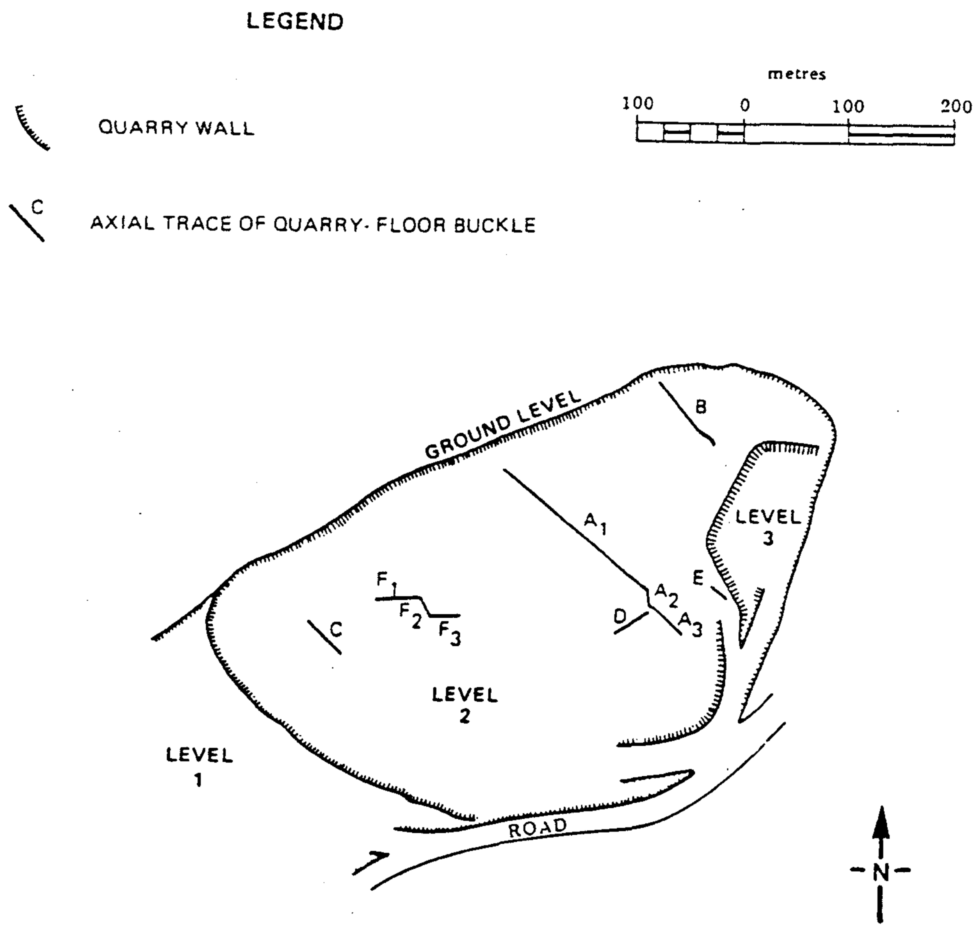

Figure 15. Quarry - floor buckles in the H.J. McFarland Construction Company Limited quarry, Fallowfield (after Adams 1982).

Appendix 1) (Figure 15) were described by Adams (1982) and referred to as occurrence number 2 by White and Russell (1982, p. 50) and by Russell et al. (1982, p. 116), who also noted that the axis of the principal buckle had a trend of 135° and followed the trace of a pre-existing fault.

Several quarry-floor buckles are present in an abandoned quarry located 5 km southeast of Burritts Rapids (Merrickville map area, 31B/13; UTM 441430E, 4978180N). The best exposed buckle has a trend of 070°, a length of at least 6 metres, a relief of at least 20 cm, and a thickness of at least 25 cm of disturbed strata.

Quarry-floor buckles occurring in the Cornwall (Macleod and Permanent) quarries (Cornwall map area, 31G/2; LQ CO-1 and LQ CO-2 in Appendix 1) were referred to as occurrences numbers 7 and 8 by Russell et al. (1982, p. 116). In the Macleod quarry, a buckle which followed the trace of a pre-existing fault of minor displacement had a trend of 110°, a length of 100 metres, and a relief of 20 cm; other buckles with similar dimensions had trends of 060°, 155°, and 170°. In the Permanent quarry, a buckle had a trend of 135°, and a buckle with a trend of 155° and a relief of 10 cm was noted by J. Bowlby (Ontario Hydro, personal communication, 1986). Trends similar to those at Cornwall have been reported from adjacent Quebec (Saull and Williams 1974), the Terrebonne and St. Eustache localities being referred to as occurrences numbers 3 and 4 by White and Russell (1982, p. 50) and Russell et al. (1982, p. 116).

Regional Tectonics

The Ottawa-St. Lawrence Lowland has been characterized by alternating periods of crustal extension and shortening (which correlate with ocean opening and closure, respectively) since the Precambrian (Saull and Williams 1974, p. 1623; Selleck 1980). A period of extension (correlated with opening of the Iapetus Ocean) which predated deposition of the Cambrian-Ordovician sedimentary sequence was followed later in the Paleozoic by a period of shortening during which the ocean closed and the Appalachian Mountains formed. There are no major structures in Ontario which can be attributed to Paleozoic shortening, which was followed by a period of extension which resulted in block faulting in the rift zones (including the Ottawa Valley rift zone) of the St. Lawrence rift system (Kumarapeli and Saull 1966). The Ottawa Valley rift zone was probably connected to the global rift system prior to opening of the Atlantic Ocean during the Mesozoic (Kumarapeli and Saull 1966, p. 653-655). Extension occurred as recently as the Cretaceous, as indicated by the occurrence of carbonatite dikes of probable Cretaceous age. Crustal stress data show that the Lowland is in compression at the present time (Adams 1987).

The Ottawa Valley rift zone, which includes the Ottawa-Bonnechere graben of Kay (1942), trends east-southeast. Its axis is well defined to the east of Ottawa, where fault blocks containing outcrops of the uppermost units of the

Ordovician sedimentary sequence exist. The rift zone axis is characterized by the occurrence of marginal horsts. The presence of gently plunging slickensides and small folds indicates that compressional stress existed locally along the margins of fault blocks. Faults which postdate the Cambrian-Ordovician sedimentary sequence are considered here to have resulted from reactivation of some of the pre-existing faults during the Mesozoic, although an earlier age is possible. Reactivation has been documented for the Rideau Lake fault, along which much less movement occurred after deposition of the Paleozoic strata than before their deposition (Wynne-Edwards 1967, p. 87-88).

Other rift zones are located in adjacent Ontario, Quebec, and New York State. These include the south-easterly-trending Timiskaming Valley and the north-northeasterly-trending Champlain Valley rift zones, and an extension of the St. Lawrence rift system southwesterly through Lake Ontario and Lake Erie (referred to here as the Southern Great Lakes rift zone). Faults and joint sets of the Ottawa Valley rift zone have orientations which correspond to the trends of the four rift zones (although the orientation corresponding to the trend of the Ottawa Valley rift zone is dominant), indicating that the complexity of the fault pattern (Figures 3 and 14) may have resulted from the successive formation of faults striking parallel to each rift zone. A horizontal minimum compressive stress trending northeast would have resulted in formation of faults striking parallel to the Timiskaming Valley rift zone. Subsequent minimum compressive stress trends of north-northeast, northwest, and west-northwest would have resulted in formation of faults striking parallel to the Ottawa Valley rift zone, the Southern Great Lakes rift zone, and the Champlain Valley rift zone, respectively. Such a sequence is compatible with the observation of Williams Corkery and Lorek (1984, p. 297) that mineralization occurs along their 135° and 080° joint sets, but not along their 045° and 005° sets, indicating a greater age for the former.

Alkaline igneous activity is typically associated with rift zones. Intrusions commonly form alignments, outcropping along lines (parallel to the trend of a rift zone) which are characterized by uplift (the result of intrusion at depth along the alignments). Intrusions are commonly concentrated in rift zone junction areas, at intersections between two sets of lines. As noted above, easterly-striking carbonatite dikes are known to intrude Paleozoic rocks in the Ontario portion of the Ottawa-St. Lawrence Lowland (within the Ottawa Valley rift zone) at two localities. To the east, in the Quebec portion of the Lowland, are the plugs, dikes, and sills of the Monteregian Hills alkaline igneous province. The concentration of igneous activity represented by the Monteregian Hills shows a spatial correlation with the area of junction of the Ottawa Valley, Southern Great Lakes, and Champlain Valley rift zones, and occurs within a belt trending parallel to the Ottawa Valley rift zone.

Two earthquakes of magnitude greater than 5 have occurred in historical times (in 1732 and 1944) in that part of the western Quebec seismic zone of Basham et al. (1979) which includes the area of junction of the Ottawa Valley, Southern Great Lakes, and Champlain Valley rift zones. It is therefore possible that the seismicity is related to the rift system (Adams and Basham 1989), and more specifically to the rift zone junction. This hypothesis is compatible with Barosh's (1986) correlation of seismic activity in the eastern United States and adjacent Canada with areas characterized by north-and northwest-striking high-angle fault zones and present - day vertical movement. The magnitude of the 1732 Montreal earthquake was 5.6 to 6.0 (Leblanc 1981), and that of the 1944 Cornwall-Massena earthquake was 5.7 (Forsyth 1981). The possibility of fault reactivation is a factor in the assessment of earthquake hazard (Saull and Williams 1974, p.1624).

ECONOMIC GEOLOGY

Crushed Stone

Crushed stone is used mainly as aggregate in the construction of roads, bridges and railroads, and in the manufacture of concrete. Aggregates include terrazzo chips, roofing granules, and stucco dash. Other important uses of crushed stone are in the production of cement and chemical lime, and as agricultural limestone and metallurgical fluxing stone.

Crushed stone used as aggregate must have high physical durability and low chemical reactivity. The production of cement requires limestone with a high shale content, and carbonate rock used as fluxing stone and in lime production must be of high purity. The only requirement for agricultural limestone is that the rock must be ground sufficiently fine to allow rapid absorption into the soil.

Occurrences of rock useable for crushed stone production have been described by Miller (1904), Frechette (1918), Picher (1920), Keele and Cole (1922), Goudge (1938), Hewitt (1960, 1964a), Hewitt and Vos (1972), Rogers (1980), and Derry et al. (1989). Aggregate resources of the Ottawa-St. Lawrence Lowland have been assessed by Proctor and Redfern Limited (1975), Sado and Vos (1976), and Fletcher and Klugman (1979). Proctor and Redfern Limited (1975) estimated total possible reserves of crushed stone for use as aggregate at 164.2 billion tons for eastern Ontario (including 84.3 billion tons for the Ottawa-St. Lawrence Lowland, of which 49.5 billion tons are located in the Regional Municipality of Ottawa-Carleton). The potential reserves realistically available are much less because of physical and legal restrictions, and were estimated at 19.6 to 25.8 billion tons for eastern Ontario (including 14.7 to

19.2 billion tons for the Ottawa-St. Lawrence Lowland, of which 4.6 to 6.3 billion tons are located in the Regional Municipality of Ottawa-Carleton).

Suitable raw materials for crushed stone in the Ottawa-St. Lawrence Lowland consist of the carbonate rocks of the March, Oxford, Rockcliffe, Gull River, Bobcaygeon, Verulam, and Lindsay Formations. The sandstones and conglomerates of the Covey Hill, Nepean, and Rockcliffe Formations have been used to a limited extent in aggregate production; and shales of the Billings, Carlsbad and Queenston Formations are also useable as fill material and lightweight expanded aggregate (MacMaster 1978, Caswell and Trak 1985). Most of the licensed and abandoned quarries of Appendix 1 are present or past producers of aggregate. The locations of the licensed quarries are shown in Figure 16, producers of crushed stone are listed in Table 24, and the suitability of the various formations for crushed stone production is shown in Table 25.

FORMATION	CRUSHED STONE					DIMENSION STONE		BRICK AND TILE	SILICA SAND
	AGGREGATE	CEMENT	CHEMICAL LIME	FLUXING STONE	AGRICULTURAL STONE	ARCHITECTURAL STONE	STRUCTURAL STONE		
Queenston								x	
Carlsbad									
Billings									
Lindsay	x	x			x				
Verulam		x							
Bobcaygeon	x		x	x	x	x	x		
Gull River	x				x		x		
Shadow Lake									
Rockcliffe	x		x	x	x	x	x		
Oxford	x								
March	x						x		
Nepean							x		x
Covey Hill									

TABLE 25. Uses and potential uses of the Paleozoic formations of the Ottawa-St. Lawrence Lowland.

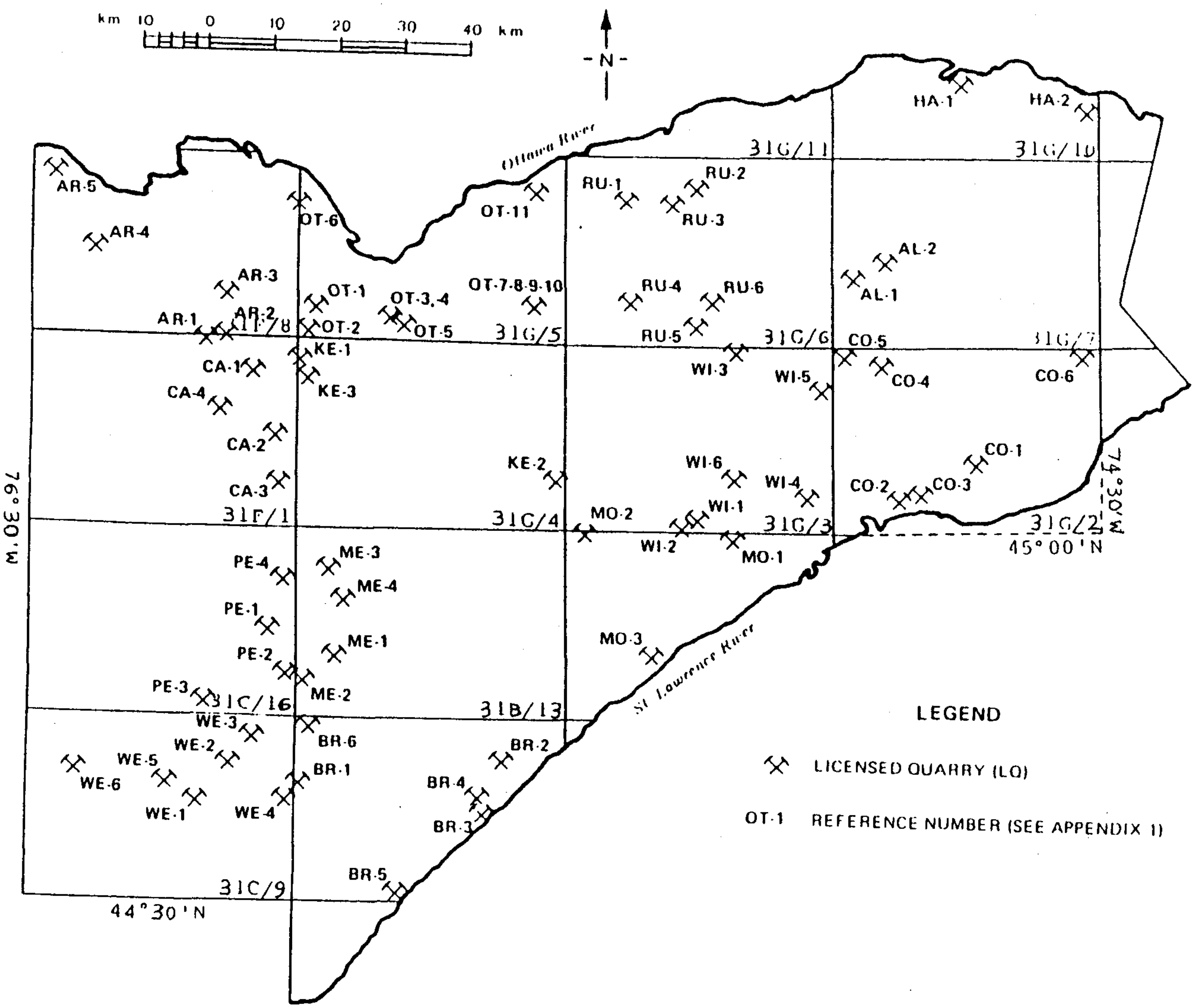

Figure 16. **Licensed quarries of the Ottawa - St. Lawrence Lowland (as of January 1986).**

PRODUCER	LICENSED QUARRIES (LQ) (SEE APPENDIX 1)
Armbro Aggregates	OT-7
Bertrand Concrete Products Ottawa Inc.	AR-3, OT-9
Bertrand et Frere Construction Co. Ltd.	AL-2, HA-1, RU-3
A.L. Blair Construction Co. Ltd.	AL-1, CO-4, CO-5, RU-5, WI-3, WI-4, WL-5
Burntlands Aggregate Ltd.	AR-1
Thomas Cavanagh Construction Ltd.	AR-2, CA-2, CA-3, KE-3
William Clow	BR-5
Cornwall Gravel Co. Ltd.	CO-1, WI-6
Corporation of Clarence Township	RU-2
Cruickshank Construction Ltd.	CO-6, MO-1, MO-2, WI-1
Dibblee Construction Co. Ltd.	BR-4, CO-3, KE-1, OT-5, OT-8, PE-4, RU-6, WI-2
George W. Drummond Ltd.	OT-10
Duffy Road Oiling Ltd.	CA-4
Mac Fetterly	MO-3
Forbes Building Materials Ltd.	KE-2
Francon Ottawa-Division of Canfarge Ltd	OT-11
Griffin Brothers Gananoque Ltd.	WE-6
Hoffman Concrete Products Ltd.	AR-4
George Kennedy	OT-6
Laurent Leblanc	RU-1
Allan MacMillan	CA-1
H.J. McFarland Construction Co. Ltd.	OT-3
Permanent Concrete Ltd.	BR-3, CO-2
Gertrude Ronan	ME-2
O. Shirley and Son	PE-1
Smith Construction Co. Arnprior Ltd.	AR-5
Spratt Sand and Gravel Ltd.	OT-1
G. Tackaberry and Sons Construction Co. Ltd.	BR-1, BR-2, BR-6, ME-1, ME-3 ME-4, PE-2, WE-2, WE-3, WE-4
R.W. Tomlinson Ltd.	OT-4
West Carleton Sand and Gravel Inc.	OT-2
Whissell Concrete Products	HA-2
Ivan and Donald Wills	PE-3

TABLE 24. Crushed stone producers of the Ottawa-St. Lawrence Lowland (as of January 1986).

The lower part of the March Formation is an excellent source of skid-resistant aggregate. Rogers (1980, p. 13-15; 1981) determined that a thickness of about 9.4 metres of interbedded sandy dolostone and dolomitic quartz sandstone with an average insoluble residue content of about 65% is available in the Ottawa map area (31G/5), and that a thickness of about 6 metres is available in the Carleton Place (31F/1) and Brockville (31B/12) map areas. Dolostone beds of the Oxford Formation and the upper part of the March Formation are quarried extensively for use as aggregate. Some shaly interbeds up to 30 cm thick occur, and are characterized by low durability. Areas in which the March and Oxford Formations outcrop and subcrop beneath drift cover are shown in Figure 9.

In the eastern part of the Ontario portion of the Ottawa-St. Lawrence Lowland, the upper member of the Rockcliffe Formation contains interbeds up to 4.5 metres thick of high-purity medium to coarsely crystalline limestone. This rock has been quarried for use as aggregate, and could be used as fluxing stone and in lime production. Areas in which the Rockcliffe Formation outcrops and subcrops beneath drift cover are shown in Figure 10.

Limestone and silty dolostone beds of the Gull River Formation are quarried extensively for use as aggregate. Interbeds of quartz sandstone and shale occur in the lower member, and are characterized by low durability. Van Dine and Truax-Harrison (1982) concluded that the use of silty dolostone from the lower member of the Gull River Formation as aggregate in asphalt resulted in popouts. The lack of adhesion between the asphalt cement and dolostone aggregate particles (which have well developed crystals) was cited as the cause. However, Rogers (1983a) concluded that the dolostone particles which deteriorated were argillaceous, non-durable, and frost-sensitive; and pointed out (p. 544-545) that other dolostones with well developed crystals give excellent performance when used in asphalt pavements. Some dolomitic limestone beds of the Gull River Formation, particularly the lower member, react with the alkalis in cement when used as concrete aggregate (Rogers 1983b, 1985, 1986; Rae 1984). Alkali-carbonate reactivity has caused excessive expansion and cracking of highway structures in the Cornwall and Ottawa areas, and some concrete has required replacement within three years of construction. Rogers (1985, 1986) has suggested the following specification requirements: acceptance of an aggregate if concrete prisms made with 3.0% Na_2O equivalent cement do not exceed 0.01% expansion after 84 days of storage in a moist room; and if the 84-day expansion requirement is exceeded, acceptance of an aggregate if concrete prisms made with 1.25% Na_2O equivalent cement do not exceed 0.025% expansion after one year. Higher limits are tolerable for concrete which will not be located in a moist environment and exposed to deicing salts, and the reaction can be slowed by use of low-alkali cement. Areas in which the Gull River Formation outcrops and subcrops beneath drift cover are shown in Figure 10.

Limestone beds of the Bobcaygeon Formation are quarried extensively for use as aggregate, and the high-purity beds of the lower and upper members could be used as fluxing stone and in lime production. The occurrence of massive beds commonly results in higher costs for quarrying than for other stratigraphic units. Shaly interbeds up to 35 cm thick occur in the middle member, and are characterized by low durability. Some beds of the lower and upper members contain abundant chert nodules and fine grained disseminated chert, and react with the alkalis in cement when used as concrete aggregate. Testing of aggregate from two quarries in the Ottawa map area (31G/5) detected excessive expansion due to alkali-silica reactivity (Rogers 1983b, p. 6-7). The reaction can be slowed by the use of low-alkali cement. Areas in which the Bobcaygeon Formation outcrops and subcrops beneath drift cover are shown in Figure 10.

Cement is manufactured from the Verulam and Lindsay Formations in south-central Ontario, but there is no present production from the Ontario portion of the Ottawa-St. Lawrence Lowland. Higher purity limestone sections occurring within the Lindsay Formation are less suitable for use in cement manufacture, but are sufficiently durable for use as aggregate. Areas in which the Verulam and Lindsay Formations outcrop and subcrop beneath drift cover are shown in Figure 10. Possible sites for future cement producers exist in the Cornwall map area (31G/2), where the Verulam Formation outcrops within 5 km of the St. Lawrence River.

Dimension Stone

The principal uses of dimension stone are as architectural stone, structural stone, and monumental stone. There are many other uses such as flagstone, ashlar and rubble. Rock to be used as dimension stone must have consistent and attractive colour and texture, high physical durability, and low chemical reactivity (deleterious minerals such as sulphides and some iron-magnesium silicates must not be present). In addition, many uses require the extraction of large rectangular blocks from massive beds.

Massive limestone beds, suitable for use as architectural stone and varying from sublithographic to coarsely crystalline, are available in the Bobcaygeon Formation and in the upper member of the Rockcliffe Formation. The Gull River Formation (lithographic to finely crystalline limestone) and the Nepean, March, and Rockcliffe Formations (sandstone) contain beds of sufficient thickness for use as structural stone, as well as thinner beds suitable for use as flagstone and ashlar. The Verulam Formation (limestone and shale) and the Billings and Carlsbad Formations (shale) consist of thinner beds, some of which are also suitable for use as flagstone and ashlar.

Boulders in the Covey Hill Formation are of sufficient size for use as rubble. Many distinctive features occur; examples are the variable colouration of the Nepean Formation, the red colouration of the Rockcliffe Formation in the Carleton Place (31F/1) and Arnprior (31F/8) map areas, and the "birdseye" and oolitic textures of the Gull River Formation. The suitability of the various formations for dimension stone production is shown in Table 25.

Occurrences of rock useable for dimension stone production have been described by Miller (1904), Parks (1912), Frechette (1918), Goudge (1938), Hewitt (1960, 1964a-b), Hewitt and Vos (1972), and Verschuren et al. (1986). Local stone has been used in the past throughout the Ottawa-St. Lawrence Lowland (Verschuren et al. 1985), particularly in construction of canals along the Rideau, Ottawa and St. Lawrence Rivers. The Rideau Canal was built in the 1820's to provide a navigable waterway between Ottawa and Kingston. Rock from the Nepean and March Formations and the Ottawa Group was used in its construction. Many federal government buildings in Ottawa (including the main block of the Parliament Buildings, constructed after the original complex burned in 1916) were built of Nepean Formation sandstone obtained from the Nepean quarries (Ottawa map area, 31G/5; AQ OT-5, -6, and -7 in Appendix 1). Massive limestone of the lower member of the Bobcaygeon Formation was extracted from the St. Albert quarry (Winchester map area, 31G/3; LQ WI-3 in Appendix 1) and marketed as "Silvertone Black Marble".

It was used for interior decorative purposes in many large buildings in Canadian urban centres and New York City (Goudge 1938, p. 191-193). The only currently active producer of dimension stone in the area is Karnuk Marble Industries Incorporated (Derry et al. 1989, p. 39-41). The company manufactures tile and paving stone from massive limestone of the lower member of the Bobcaygeon Formation, which is obtained from the Cornwall (Macleod) quarry (Cornwall map area, 31G/2; LQ CO-1 in Appendix 1).

There is a high potential for increased development of the dimension stone industry in the region. Areas in which the various formations outcrop and subcrop beneath drift cover are shown in Figures 8, 9, 10 and 12. Massive limestone of the Bobcaygeon Formation commonly contains irregular shaly partings which can be expected to affect its durability adversely in places.

Brick and Tile

Siltstone and shale of the Queenston Formation are suitable for use in the manufacture of brick and tile (Table 25). They are extracted from the Russell quarry (Russell map area, 31G/6; LQ RU-4 in Appendix 1) (Figure 16) by Canada Brick. The quarry, previously operated by Domtar Construction Materials Limited, was described by Guillet (1967, p. 76-78) and Guillet and Joyce (1987, p. 51-52). The clay minerals consist of illite and chlorite, illite being most abundant; the quartz content is 32%, calcite 6%, and feldspar 5% (Guillet 1967, p. 77).

Areas in which the Queenston Formation outcrops and subcrops beneath drift cover are shown in Figure 12.

Silica Sand

The principal uses of silica sand are as glass sand, foundry sand, and smelter flux; and in the manufacture of artificial abrasives and ferrosilicon. Quartz sandstone of the Nepean Formation is suitable for use in its production (Table 25). The silica sand potential of the Nepean Formation has been investigated by Cole (1923), Keith (1949), Hewitt (1963), Powell and Klugman (1979), Klugman and Yen (1980), and Collings and Andrews (1986). Powell and Klugman (1979, p. 6) noted that a deposit should contain approximately 99.0% SiO_2, 0.07% Fe_2O_3, 0.5% Al_2O_3, and 0.05% CaO. The sandstone in the vicinity of the Almonte (Mohr) quarry (Carleton Place map area, 31F/1; AQ CA-2 in Appendix 1) was classified by Powell and Klugman (1979, p. 10) as being of high silica potential, as was the stone in the vicinities of other abandoned quarries: Malwood (Arnprior map area, 31F/8; UTM 421650E, 5026250N); DeWitts Corners (Perth map area, 31C/16; UTM 391490E, 4967220N); and Crosby (Westport map area, 31C/9; UTM 399210E, 4948230N).

Licensed quarries in the Nepean Formation include the Philipsville quarry of Arriscraft Corporation and the Forfar quarry of Canfarge Limited (Westport map area, 31C/9; LQ WE-1 and LQ WE-5, respectively, in Appendix 1). Their locations are indicated in Figure 16.

Areas in which the Nepean Formation outcrops and subcrops beneath drift cover are shown in Figure 8.

Gypsum

A bed of laminated gypsum, approximately 1.5 metre thick and occurring in the Oxford Formation, exists in the Cornwall-Lancaster area (Cornwall map area, 31G/2, and Huntingdon map area, 31G/1). Holes drilled by Ontario Hydro in 1954 (Guillet 1964, p. 71) and Westroc Industries Limited during 1969-1972 intersected gypsum which grades up to 78% in purity.

Hematite-Siderite-Calcite

Steeply dipping hematite-siderite-calcite veins occur at Delta (Westport map area, 31C/9; UTM 411640E, 4938440N) and Mansfield (Arnprior map area, 31F/8; UTM 392540E, 5032890N) (Figure 17).

The Delta occurrence was described by Ingall (1901, p. 79), Wright (1920, p. 81-84) and Wynne-Edwards (1967, p. 125-126). Sandstone of the Nepean Formation contains up to 33% hematite adjacent to veins which are up to 15 cm thick. One sample of vein material contained 63.95% Fe

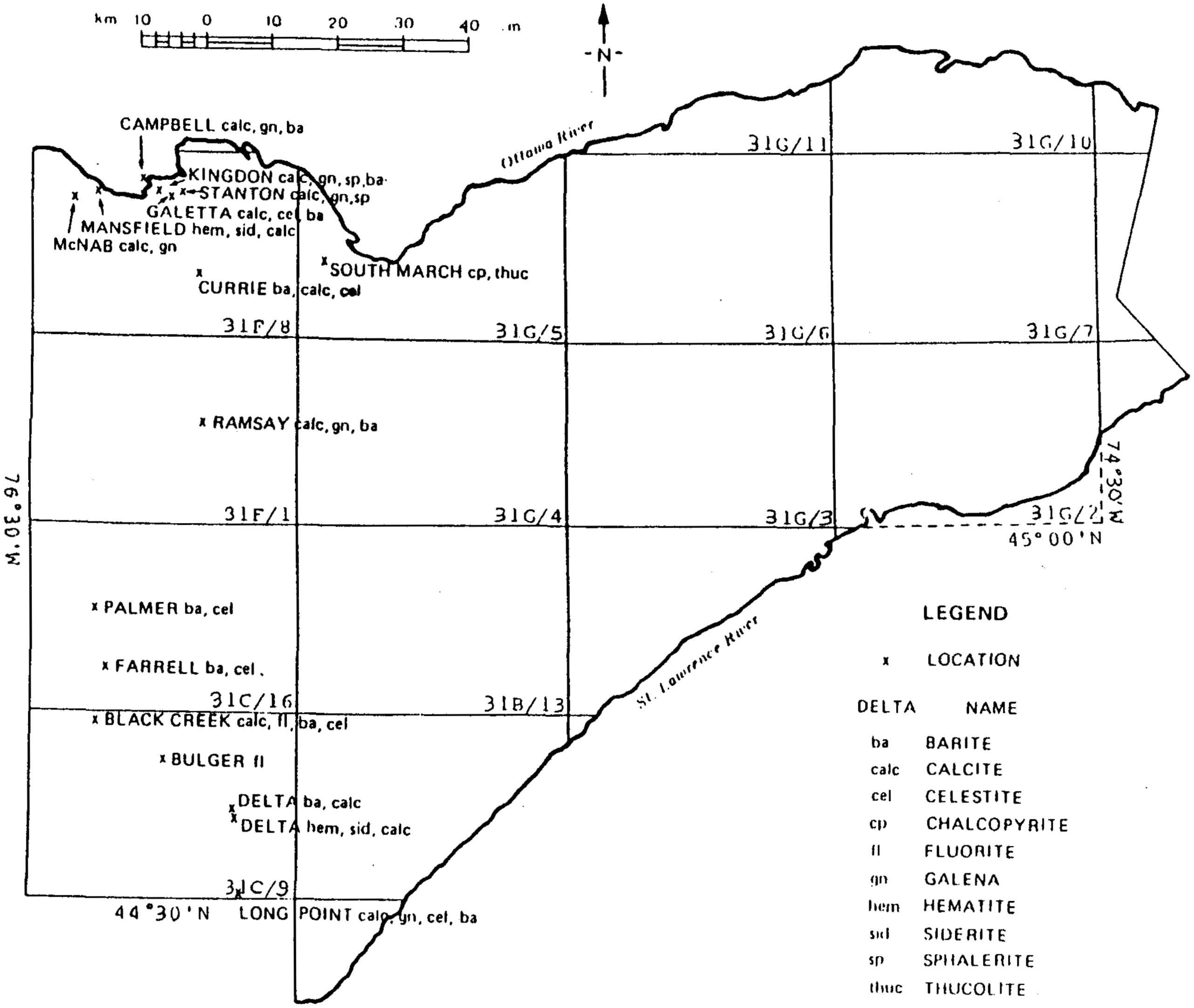

Figure 17. **Mineral occurrences of the Ottawa-St. Lawrence Lowland.**

(Wright 1920, p. 83). Mining began as early as 1810 and the hematite supplied a local smelter, but low yields due to inefficient smelting caused the operation to close within two years. During 1918 and 1919, Drainey Brothers and Consolidated Iron and Steel Corporation dug several pits, sank three shafts to a maximum depth of 6 metres, and shipped four carloads of ore by rail.

The Mansfield occurrence was described by Wilson (1924, p. 112-114), Satterly (1946, p. 61), and Carter et al. (1980, p. 121-122). Wilson (1924, p. 113) reported six trenches up to 50 metres in length, in which veins up to 1 metre thick were exposed. A sample of vein material contained 59.09% Fe (Hunt 1870, p. 260). The veins occur in Precambrian rock and in the Oxford Formation, within a fault zone in which steeply plunging slickensides were noted by Wilson (1924, p. 113). The veins were mined intermittently between 1868 and 1883; 10,000 to 15,000 tons of ore were produced during 1873 and 1874 by Peter Bell Iron Company.

There is little potential for iron ore occurring within Paleozoic strata at Delta, Mansfield, or elsewhere in the Ottawa-St. Lawrence Lowland.

Chalcopyrite-Thucolite

An occurrence of uranium in the March Formation at South March (Ottawa map area, 31G/5; UTM 425250E, 5021950N) (Figure 17) was described by Grasty et al. (1973), Charbonneau et al. (1975), Jonasson et al. (1977), Masson and Gordon (1981, p. 94), and Robertson (1981, p. 29-30). An airborne gamma-ray spectrometer survey detected an anomaly, and the mineralization was discovered during ground investigation (Grasty et al. 1973). Outcrop and drill core samples contained up to 4% chalcopyrite and 0.05% U_3O_8, the uranium occurring in thucolite (Charbonneau et al. 1975).

There is some potential for copper-uranium ore occurring within Paleozoic strata in the Ottawa-St. Lawrence Lowland, and some current interest.

Calcite-Fluorite-Barite-Celestite-Galena-Sphalerite

Steeply dipping veins consisting mainly of calcite are common in the Ottawa-St. Lawrence Lowland. Many veins (Figure 17), up to 3 metres thick and occurring in the western part of the Lowland, contain significant amounts of fluorite, barite, celestite, galena, or sphalerite:

Name	Map area	NTS	UTM	Mineralogy
Bulger	Westport	31C/9	400520E,4948320N	fluorite
Delta	Westport	31C/9	411480E,4938930N	barite, calcite
Black Creek	Westport	31C/9	390570E,4954580N	calcite, fluorite,barite celestite
Long Point	Westport	31C/9	412560E,4928350N	calcite, galena celestite,barite
Palmer	Perth	31C/16	389800E,4970760N	barite,celestite
Farrell	Perth	31C/16	392720E,4962540N	barite,celestite
Ramsay	Carleton Place	31F/1	408660E,5000390N	calcite,galena, barite
McNab	Arnprior	31F/8	389490E,5032050N	calcite, galena
Currie	Arnprior	31F/8	407210E,5020700N	barite, calcite celestite
Galetta	Arnprior	31F/8	402460E,5031830N	calcite, celestite,barite
Kingdon	Arnprior	31F/8	401500E,5032500N	calcite,galena, sphalerite, barite
Campbell	Arnprior	31F/8	399190E,5034850N	calcite,galena, barite
Stanton	Arnprior	31F/8	403670E,5032070N	calcite,galena, sphalerite

Although the strike is generally east to southeast, one occurrence (Stanton) has a northeast strike. The veins commonly occur parallel to and close to faults, and in addition they are commonly located near fault junctions. The main and north veins of the Kingdon mine, the largest of the deposits, occur along faults and at a fault junction. The main vein is hosted by Precambrian rock, and the north vein occurs along a fault which separates Precambrian rock and the Oxford Formation. The other veins all occur within the Precambrian except for the Ramsay and Currie occurrences, which are hosted by the March and Bobcaygeon Formations, respectively. Fluorite-bearing veins are low in galena and sphalerite, and galena-sphalerite-bearing veins are low in fluorite. None of these veins are currently in production.

The Bulger occurrence (Figure 17) is located 3.5 km southeast of a fault junction area along the Rideau Lake fault. Fluorite veinlets up to 3 cm thick occur in Precambrian granite (Wilson 1929, p. 78).

At the Delta locality (Figure 17), Murray (1852, p. 84) described a 70-cm thick barite-calcite vein in Precambrian marble, exposed in a shaft sunk to a depth of 3 metres and at surface along a length of 400 metres.

The Black Creek occurrence (Figure 17) is located 6 km north of the Rideau Lake fault. Wynne-Edwards (1967, p. 124) described a barite-calcite vein 30 cm thick, which was exposed in a pit 6 metres deep in Precambrian marble. In

1981 a trench striking 095°, 30 metres long and up to 15 metres deep, was observed 10 metres west of a pit 10 metres wide and 2 metres deep. A sample from the rock dump, in which veinlets up to 5 cm thick occurred, contained 0.575% F, 26.0% Ba, and 1.19% Sr.

At the Long Point locality (Figure 17), Logan (1863, p.688) described a series of calcite-barite-galena veins up to 60 cm thick in a zone 300 metres wide in Precambrian marble. Several shafts had been sunk to a depth of up to 15 metres, and some lead ore was produced in 1854. Spence (1922, p.79-80) described a celestite vein up to 60 cm thick occurring within the vein zone. A sample from a trench 10 metres long and 8 metres deep contained 97.80% $SrSO_4$ and 0.37% $BaSO_4$; two other samples from the trench contained 99.82% and 99.40% $SrSO_4$, respectively (Spence 1922). Fifteen shafts and pits, from several of which some lead ore was produced in 1875, were found along a length of 1.2 km in 1927 (Wynne-Edwards 1967, p.123-124). In 1981 a trench 15 metres long, and striking 100°, was observed.

The Palmer occurrence (Figure 17) is located 800 metres north of the Plevna fault. Spence (1922, p.52-53) described a barite vein zone 3 metres wide, exposed in a 10-metre long trench excavated in 1917. The vein zone, consisting of individual stringers and veins up to 50 cm thick hosted by Precambrian amphibolite, was traced along a length of 900 metres. A representative sample contained 93.42% $BaSO_4$ and

4.10% $SrSO_4$ (Spence 1922). In 1981 a trench striking 090° (parallel to the Plevna fault) was observed.

The Farrell occurrence (Figure 17) is located 7 km south of the Plevna fault. Spence (1922, p. 55) described a barite vein up to 60 cm thick, occurring in Precambrian granitic gneiss. The vein was exposed along a length of 300 metres in a series of pits excavated in 1918. A representative sample contained 95.26% $BaSO_4$ and 4.00% $SrSO_4$ (Spence 1922). Wilson and Dugas (1961) also identified the location of the vein. Guillet (1963, p. 31) reported a production of 400 tons during 1920-21.

The Ramsay occurrence (Figure 17) is located 1 km southeast of a fault, and 1.8 km east of a fault junction. Logan (1863, p. 688-689) described a calcite-galena vein (the west vein), occurring in the March Formation. The vein was traced along a length of 200 metres and is up to 1.5 metres thick. The galena is concentrated in a zone up to 60 cm thick. In 1858 26 tons of ore were produced from a shaft 11 metres deep, and 10 tons of ore were subsequently produced from another shaft 6 metres deep. Alcock (1930, p. 140-141) described another calcite-galena vein (the east vein, located 250 metres east of the west vein) in the March and Oxford Formations. A series of pits excavated by the Ottawa Valley Syndicate in 1925 along a length of 700 metres followed the vein. Carter et al. (1980, p. 58-60) mapped a trench, 45 metres long and up to 3 metres deep, striking 130° along the west vein. Along the east vein, a pit 30 metres wide and up to 2.1 metres deep, and a trench 30 metres long and 1.8 metres deep, were mapped. A representative sample from the east vein contained 5.30% Pb (Carter et al. 1980). Examination of the east vein in 1969 demonstrated that its eastern part is a single vein striking 110°, whereas its western part consists of a series of calcite-galena veinlets up to several cm thick, striking 130° and occurring in a fracture zone 15 metres wide which strikes 085°. A representative sample contained 5.64% Pb and 0.39% Ba. The west vein strikes parallel to some of the faults in the vicinity, and the east vein has a strike parallel to that of other faults.

The McNab calcite-galena vein (Figure 17), up to 30 cm thick and hosted by Precambrian marble, is located 500 metres south of the junction of the Douglas fault and another fault which strikes parallel to the vein. In 1925 Cominco Limited traced the vein along a length of 55 metres, excavating two pits and a trench 20 metres long. The vein was described by Satterly (1946, p. 61-62) and subsequently mapped by Carter et al. (1980, p. 48-50). Examination of the vein in 1969 indicated a strike of 120°, and a representative sample contained only 0.01% Pb.

The Currie occurrence (Figure 17) is located 100 metres north of a fault, and 500 metres east of a fault junction. Barite-calcite mineralization, exposed in two pits and occurring as breccia matrix and veinlets, was described by Spence (1922, p. 49-50) and Storey and Vos (1981, p. 19-21).

Two samples collected by Spence contained 92.50% $BaSO_4$, 1.00% $SrSO_4$, and 5.00% $CaCO_3$; and 82.39% $BaSO_4$ and 15.53% $CaCO_3$, respectively. Examination of the occurrence in 1981 demonstrated that the mineralization occurs in the Bobcaygeon Formation within a fracture zone striking 105°, the same as the strike of the fault. A representative sample contained 26.3% Ba and 1.25% Sr.

The Galetta occurrence (Figure 17) is located 300 metres southwest of a fault, and 1.2 km southeast of a fault junction. A calcite-celestite vein in Precambrian marble, with an average thickness of 60 cm, was described by Spence (1922, p.77-78), Wilson (1924, p.115-116), and Sabina (1965, p.100). A shaft was sunk to a depth of 13.7 metres in 1910, and a sample collected by Spence from the rock dump adjacent to the shaft contained 93.00% $SrSO_4$ and 1.30% $CaCO_3$. Examination of the occurrence in 1981 indicated that the vein occurs within a fracture zone striking 140°, parallel to some of the faults in the vicinity. A representative sample from the rock dump contained 4.44% Sr and 0.35% Ba.

The calcite-galena-sphalerite-barite veins of the Kingdon mine (Figure 17) were described by Uglow (1916, p.21-22), Hardman (1917, p.180-187), Wilson (1924, p.95-102), Alcock (1930, p.136-138), and Carter et al. (1980, p.29-31). The occurrence of selenite and marcasite was reported by Sabina (1965, p.99-100). There are two veins, the main vein and the north vein (located 500 metres northwest of the main vein). During 1884-85, the James

Robertson Company Limited sank a shaft to a depth of 15 metres on the main vein and mined a small amount of lead ore. During 1914-31 the Kingdon Mining, Smelting and Manufacturing Company produced 905,000 tons of ore yielding 3.32% Pb, 0.05 oz. Ag/ton, and 0.03% Zn from the main vein. The deposit was mined along a length of 823 metres and to a depth of 396 metres by means of three shafts (Carter et al. 1980). Almost the entire Ontario lead production came from the Kingdon mine during its period of operation.

The Kingdon main vein occurs along a fault, and at a fault junction, in Precambrian marble and amphibolite. Slickensides are common, the plunge varying from 65° northwest to vertical. The vein strikes generally 115° and dips steeply. It is relatively straight and thick where the wallrock is marble, but the strike is more variable and the thickness is less (in places, several thinner veins occur) where the wallrock is amphibolite. The vein is up to 3 metres thick, and has an average thickness of 1.5 metres. Galena occurs as disseminated grains and clusters, and is commonly concentrated in bands up to 75 cm thick parallel to the vein contacts. Sphalerite is concentrated in bands along the vein margins. Two samples from a rock dump adjacent to the main vein contained 1.74% Pb, 0.56% Zn, and 0.32% Ba, and 1.05% Zn and 0.38% Ba; respectively.

The Kingdon north vein, trenched along a length of 8 metres, strikes 145° and is up 75 cm thick. It occurs along a fault which separates Precambrian marble and amphibolite (to the northeast) and the Oxford Formation (to the southwest). The north vein was examined in 1969, but could not be found in 1981 and is presumably no longer exposed.

The Campbell occurrence (Figure 17) is located 400 metres northeast of a fault, and 1.8 km northwest of a fault junction. A calcite-galena-barite vein, occurring in a shallow part of the Ottawa River and visible only when the water level is low, was described by Uglow (1916, p.22-23), Wilson (1924, p.102), and Alcock (1930, p.138-139). Development work conducted intermittently from 1908 to 1917 consisted of a shaft 5 metres deep and a trench 8 metres long and 5 metres deep. The Ottawa Valley Syndicate drilled the occurrence in 1925. The vein is up to 90 cm thick, and in places consists of a series of veinlets up to 2 cm thick. It has been traced along a length of 150 metres, strikes parallel to the fault, and occurs in Precambrian marble. Galena occurs as disseminated grains and clusters.

The Stanton occurence (Figure 17) is located 300 metres northeast of a fault, and 2.5 km east of a fault junction. A calcite-galena-sphalerite vein up to 2 metres thick in Precambrian marble was described by Ells (1904, p.68) and Wilson (1924, p.103), and was mapped by Carter et al. (1980, p.31-33). Development work consisted of a shaft of unknown depth, a trench 60 metres long and 2 metres deep, a trench 8 metres long and 3 metres deep, and five pits up to 2.5 metres wide and 3 metres deep. The vein strikes 050°, parallel to some of the faults in the vicinity, and has been traced along a length of 450 metres.

There is a high potential for other calcite-fluorite-barite-celestite-galena-sphalerite deposits, at least as large as the Kingdon deposit, occurring within Paleozoic strata in the Ottawa-St. Lawrence Lowland. Exploration for them should be directed at fault junctions.

Hydrocarbons

The oil shale potential of the Eastview Member of the Lindsay Formation (Figure 10), which consists of interbedded calcareous shale and argillaceous limestone, has been evaluated by the Hydrocarbon Energy Resources Program (HERP) of the Ontario Geological Survey (Johnson 1982). Two holes, SIS 9 (Ottawa map area, 31G/5; GDH OT-2 in Appendix 2) and SIS 10 (Russell map area, 31G/6; GDH RU-1 in Appendix 2), were drilled in the Ottawa-St. Lawrence Lowland by the O.G.S. (Johnson *et al.* 1983, p. 34-36). Although the equivalent Collingwood Member of the Lindsay Formation of south-central Ontario has an organic carbon content of up to 12% and an oil yield of up to 50 litres per tonne (Russell and Telford 1984), the Eastview Member has poor hydrocarbon generating potential (Johnson 1982, p. 135). Conodonts have a high colour alteration index, indicating that the Lowland is overmature (Legall *et al.* 1981).

Petroleum also occurs in the lower member of the Lindsay Formation (Figure 10), and natural gas in the Lindsay and Billings Formations (Figures 10 and 12), in minor quantities (Wilson 1946a, p. 44). Their economic potential is very low, and there is little current interest.

Water

Provincial drinking water standards (in milligrams per litre) are as follows: 500 total dissolved solids, 250 chloride, 250 sulphate, 10 nitrate (as nitrogen), and 0.3 iron (Chin et al. 1980, p. 4).

A water supply test well (Hawkesbury map area, 31G/10; GDH HA-1 in Appendix 2) was drilled from the Lindsay Formation into the Nepean Formation by the Ontario Ministry of the Environment at Alfred during 1979 (McKenna 1980). The overall quality produced by mixing exceeded the criteria for total dissolved solids, chloride, sulphate, and iron. The averages of analyses of water samples collected during drilling from above the Oxford-Rockcliffe contact were 5880 mg/l total dissolved solids, 2960 mg/l chloride, and 230 mg/l sulphate; and the averages from below the contact were 3030 mg/l total dissolved solids, 1260 mg/l chloride, and 480 mg/l sulphate. The sulphate content below the contact was approximately double that above the contact, but the contents of total dissolved solids and chloride below the contact were approximately half of those above the contact.

Chin *et al.* (1980) conducted a comprehensive study of the water resources of the South Nation River basin, which includes approximately half of the Ontario portion of the Ottawa-St. Lawrence Lowland. The maximum values of analyses of water samples collected from Paleozoic bedrock aquifers were 2874 mg/l total dissolved solids, 1142 mg/l chloride, 180 mg/l sulphate, 40 mg/l nitrate (as nitrogen), and 19 mg/l iron. The values of total dissolved solids and iron commonly exceeded provincial criteria, but chloride, sulphate, and nitrate values were generally lower than the criteria. The specific capacity (equal to the yield divided by the available drawdown) of bedrock wells was found to be generally low (less than 15 litres per minute per metre in most cases, but ranging up to 300 litres per minute per metre). Plots of specific capacities and total dissolved solids (Chin *et al.* 1980, Sheets 2 and 4) indicate that water quantity and quality are generally higher below the Oxford-Rockcliffe contact than above it.

It can be concluded that the quality and quantity of water occurring in Paleozoic bedrock decrease from the base of the sequence upwards, and that the best aquifers are the Nepean, March, and Oxford Formations (Figures 8 and 9). Quantities of total dissolved solids in the order of 10,000 milligrams per litre characterize water occurring in the shaly units of the upper part of the sequence (Figures 10 and 12) (Wilson 1946a, p. 42-43). Saline springs, whose sources are in the Lindsay and Carlsbad Formations, were used extensively in the past for medicinal purposes.

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APPENDIX 1 - SECTION DESCRIPTIONS

The following section descriptions are in alphabetical order according to the name of the map area in which the sections occurs, abbreviated as follows:-

AL (Alexandria, NTS 31G/7)
AR (Arnprior, NTS 31F/8)
BR (Brockville, NTS 31B/12)
CA (Carleton Place, NTS 31F/1)
CO (Cornwall, NTS 31G/2)
HA (Hawkesbury, NTS 31G/10)
KE (Kemptville, NTS 31G/10)
MA (Mallorytown, NTS 31B/4)
ME (Merrickville, NTS 31B/5)
MO (Morrisburg, NTS 31B/14)
OT (Ottawa, NTS 31G/5)
PE (Perth, NTS 31C/16)
RU (Russell, NTS 31G/6)
TH (Thurso, NTS 31G/11)
WE (Westport, NTS 31C/9) and
WI (Winchester, NTS 31G/3)

The sections for each map area are separated and numbered in sequence, according to whether they refer to licensed quarries (LQ), abandoed quarries (AQ), or other sections (S). Included are all licenced quarries (Figure 16), all abandoned quarries to which reference has been made in the published literature since 1960, and many other significant sections.

The operator and locality (including township, lot, and concession) are given to quarries, and the type of section and locality are given for other sections; UTM co-ordinates (in metres), elevation of the top of the section (in metres), reference material (including previous section measurements, in metres), and stratigraphic subdivisions are given for also given.

The first column in each description refers to the rock unit number, the second column to the lithology, the third column to the thickness (in metres), and the fourth column to height above the base of the section (in metres). It is to be noted that thickness measurements in quarries are affected by the elevation of the water level at the time of the examination.

Section LO AL-1: A. L. Blair Construction Limited, Tayside Roxborough Township, Lot 10, Concession 10
UTM 502500E, 5018000N
Elevation 65.00 m±
See also Derry *et al.* 1989, p. 28-29 (CW-18, 6.6m)

Lindsay Formation (lower member)

4	Limestone, light to medium grey; light brown weathering; fine to medium crystalline; thin bedded; nodular, intraclastic in places; bryozoa, corals, brachiopods.	1.80 m	4.80-6.60 m
3	Limestone, with irregular shaly partings -medium grey; light brown weathering; fine to coarse crystalline; medium bedded; intraclastic in places.	1.40	3.40-4.80
2	Limestone, with shale interbeds up to 2 cm thick - medium grey; light brown weathering; sublithographic to coarse crystalline; medium bedded; intraclastic in places; crinoids, brachiopods, corals.	0.90	2.50-3.40
1	Limestone, with irregular shaly partings -medium grey; light brown weathering; fine to medium crystalline; thinly to meldium bedded.	2.50	0.00-2.50

Section LO AL-2: Bertrand et Frere Construction Company Limited, St. Isidore
South Plantagemet Township, Lot 7, Concession 20
UTM 508000E, 5022150N
Elevation 55.00 m±
See also Derry *et al.* 1989, p. 29-30 (CW-19, 10.85 m)

Lindsay Formation (lower member)

3	Limestone, with irregular shaly partings -medium grey; light brown weathering; fine to medium crystalline; thinly to medium bedded; nodular. Base of upper lift at 6.70 m.	4.15 m	6.70-10.85 m
2	Limestone, with shaly partings - medium grey; light brown weathering; finely to coarsely crystalline; medium bedded; nodular in places; brachiopods, crinoids, trilobites.	2.85	3.85-6.70
1	Limestone, with irregular shaly partings -medium to dark grey; light brown weathering; finely to medium crystalline; thinly to medium bedded; nodular in places; brachiopods, corals, trilobites, feeding trails.	3.85	0.00-3.85

<u>Section LO AR-1:</u> Burntlands Aggregate Limited, Almonte Ramsay Township,
Lots 16 and 17, Concession 12
UTM 408700E, 5011500N
Elevation 150.00 m±
See also Derry *et al.* 1989, p. 48 (CP-3, 5.0 m)

Bobcaygeon Formation (lower member, unit B)

5	Limestone, with irregular shaly partings -dark grey; finely to coarsely crystalline; thinly bedded; colonial corals.	1.20 m	3.80-5.00 m
4	Limestone, medium grey; coarsely crystalline.	0.05	3.75-3.80

Bobcaygeon Formation (lower member, unit A)

3	Limestone, with irregular shaly partings -medium to dark grey; finely crystalline; thinly bedded.	1.50	2.25-3.75
2	Limestone, with shaly partings - dark grey; sublithographic to finely crystalline; medium bedded.	1.15	1.10-2.25
1	Limestone, light grey; lithographic; medium bedded; "birdseye" texture.	1.10	0.00-1.10

<u>Section LO AR-2:</u> Thomas Cavanagh Construction, Almonte Huntley Township,
Lot 15, Concession 11
UTM 411200E, 5012550N
Elevation 130.00 m±
See also Derry *et al.* 1989, p. 48-49 (CP-4, 16.5 m)

Bobcaygeon Formation (lower member, unit B)

13	Limestone - medium to dark gray; sub-lithographic to fine crystalline; thinly bedded; nodular; stromatoporiods, corals, brachiopods, trilobites.	1.60 m	14.90-16.50 m
12	Limestone - medium to dark grey; sub-lithographic to medium crystalline; medium bedded.	1.10	13.80-14.90
11	Limestone, with irregular shaly partings -medium to dark grey; finely crystalline; thinly bedded.	1.50	12.30-13.80
10	Limestone - dark grey; light to medium grey weathering; sublithographic; thickly bedded.	2.20	10.10-12.30
9	Limestone - light grey; light grey weathering; coarsely crystalline; thickly bedded.	0.50	9.60-10.10

Section LQ AR-2: (cont.) Thomas Cavanagh Construction Limited, Almonte
Huntley Township, Lot 15, Concession 11
UTM 411200E, 5012550N
Elevation 130.00 m±
See also Derry *et al.* 1989, p. 48-49 (CP-4, 16.5 m)

Bogcaygeon Formation (lower member, unit B)

8	Limestone - dark grey; sublithographic; medium bedded. Base to upper lift at 8.00 m.	1.60 m	8.00-9.60 m
7	Limestone - medium to dark grey; finely to medium crystalline; medium bedded; brachipods.	1.25	6.75-8.00
6	Limestone - light grey; coarsely crystalline; massive bedded; cross-bedded.	1.30	5.45-6.75

Bobcaygeon Formation (lower member, unit A)

5	Limestone - medium to dark grey, finely crystalline; thinly to medium bedded.	1.55	3.90-5.45
4	Limestone - dark grey; light grey weathering; sublithographic to finely crystalline; thinly bedded.	1.40	2.50-3.90
3	Limestone - dark grey; light brown weathering; finely crystalline; thick bedded.	0.70	1.80-2.50
2	Limestone - dark grey; light to medium brown weathering; finely crystalline; thinly bedded.	0.80	1.00-1.80
1	Limestone, with shaly partings - dark grey; light brownish grey weathering; finely crystalline; medium bedded; brachiopods.	1.00	0.00-1.00

Section LQ AR-3: Bertrand Concrete Products Ottawa Incorporated, Carp
Huntley Township, Lot 21, Concession 8
UTM 411950E, 5018300N
Elevation 125.00 m±

Bobcaygeon Formation (lower member, unit B)

1	Limestone, with shaly partings - light to medium grey; light grey weathering; finely to coarsely crystalline; thinly to medium bedded; brachiopods, gastropods, bryozoa.	3.50 m	0.00-3.50 m

Section LO AR-4: Hoffman Concrete Products Limited, White Lake McNab Township, Lot 1, Concession 9
UTM 390450E, 5026600N
Elevation 110.00 m±
See also Derry et al. 1989, p. 170 (PE-3, 17.4 m)

Bobcaygeon Formation (lower member, unit B)

8	Limestone, with irregular shaly partings -light grey; light to medium grey; light brown weathering; finely to medium crystalline; thinly bedded; brachiopods.	0.50 m	16.90-17.40 m
7	Limestone, with shaly partings -light grey; light brown weathering; finely to medium crystalline; medium bedded.	2.20	14.70-16.90
6	Limestone, with irregular shaly partings - light brown weathering; finely to coarsely crystalline; thinly to medium bedded; intraclastic at base.	1.30	13.40-14.70

Bobcaygeon Formation (lower member, unit A)

5	Limestone, with irregular shaly partings -medium grey; sublithographic to finely crystalline; thinly bedded; "birdseye" texture; colonial corals.	3.10	10.30-13.40
4	Limestone, with shaly partings - light to medium grey; lithographic to finely crystalline; thinly to medium bedded; "birdseye" texture; colonial corals, ostracods.	2.40	7.90-10.30
3	Limestone, with shaly partings - medium grey; sublithographic to finely crystalline; thinly to medium bedded; "birdseye" texture, intraclastic; colonial corals.	4.40	3.50-7.90
2	Limestone - medium grey; sublithographic to fine crystalline; medium bedded.	1.00	2.50-3.50
1	Limestone, with shaly partings - medium grey; sublithographic to finely crystalline; medium bedded; colonial corals.	2.00	0.00-2.50

Section LQ AR-5: Smith Contruction Company Arnprior Limited, Braeside
McNab Township, Lot 16, Concession A
UTM 387050E, 5035850N
Elevation 135.00 m±
See also Hewitt 1964a, p.36a-37 (7.0m); Steel and Sinclair 1971; Derry et al. 1989, p. 169-170 (PE-2, 8.1 m)

Bobcaygeon Formation (lower member, unit B)

4	Limestone, with shaly partings - medium grey; brownish grey weathering; sublithographic to medium crystalline; thinly to thick bedded; intraclastic, stylolites.	3.00 m	5.10-8.10 m
3	Limestone - medium to dark grey; sublithographic to finely crystalline; thinly bedded; intraclastic.	2.50	2.60-5.10
2	Limestone, with shaly partings - light gray medium crystalline; medium bedded; colonial corals.	1.10	1.50-2.60

Bobcaygeon Formation (lower member, unit A)

1	Limestone - medium grey; sublithographic to fine crystalline; thinly to medium bedded.	1.50	0.00-1.50

Section AQ AR-1: Pakenham, Pakenham Township, Lot 11, Concession 11
UTM 399450E, 5020700N
Elevation 100.00 m±
See also Goudge 1938, p.111 (10.1 m); Barnes 1967, p.238 (8.8 m); Kay 1968b, p.167-168; Barnes 1968, p.171; Verschuren et al. 1986, p.299-302

Bobcaygeon Formation (lower member, unit B)

10	Limestone - medium grey; light to medium grey weathering; finely to coarsely crystalline; thickly to massive bedded; brachipods, corals.	2.45 m	5.05-7.50 m
9	Limestone - medium grey; medium grey weathering; medium to coarsely crystalline; medium bedded; cross-bedded, intraclastic at base; corals.	0.20	4.85-5.05
8	Limestone - medium grey; medium grey weathering; sublithographic to finely crystalline; thinly bedded.	0.75	4.10-4.85
7	Limestone - dark grey; light grey weathering; sublithographic; thickly bedded; lenses and nodules of black chert, corals.	0.55	3.55-4.10

Section AQ AR-1: (cont.) Pakenham, Pakenham Township, Lot 11, Concession 11
UTM 399450E, 5020700N
Elevation 100.00 m±
See also Goudge 1938, p.111 (10.1 m); Barnes 1967, p.238 (8.8 m); Kay 1968b, p.167-168; Barnes 1968, p.171; Verschuren et al. 1986, p.299-302

Bobcaygeon Formation (lower member, unit B)

6	Limestone - medium grey; medium grey weathering; finely crystalline; thinly bedded.	0.15 m	3.40-3.55 m
5	Limestone - medium to dark grey; light to medium grey weathering; sub-lithographic; thinly to thickly bedded; lenses up to 5 cm thick of black chert at 3.25 m; colonial corals.	0.60	2.80-3.40
4	Limestone - medium grey; medium grey weathering; sublithographic to finely crystalline; thinly bedded.	0.20	2.60-2.80
3	Limestone, with shaly partings - medium to dary grey; light to medium grey weathering; sublithographic medium bedded; brachiopods, burrows.	1.55	1.05-2.60
2	Limestone, with shaly partings - dark grey; medium grey weathering; sublithographic to finely crystalline; very thinly to medium bedded; burrows.	0.55	0.50-1.05
1	Limestone - medium grey; dark grey weathering; finely crystalline; thickly bedded.	0.50	0.00-0.50

Section LQ BR-1: G. Tackaberry and Sons Construction Co. Ltd-Lawson, Athens
(previous operator: Brundige Construction Company Limited)
Rear of Yonge and Escott Townships, Lots 15 and 16, Conc. 10
UTM 422300E, 4944300N
Elevation 125.00 m±
See also Hewitt and Vos, 1972, p.8-9 (6.7 m); Rogers 1980, p.56-57); Derry et al. 1989, p. 90-92 (BR-8, 12.45 m)

March Formation

4	Sandy dolostone - light greenish to brownish grey; light grey weathering; finely crystalline; medium bedded.	2.50 m	2.95-6.45 m
3	Dolostone - light brownish grey; light brown weathering; finely to medium crystalline; thinly to medium bedded; calcite-filled vugs.	1.10	2.85-3.95

Section LO BR-1: G. (cont.) Tackaberry and Sons Construction Co. Limited-
Lawson, Athens; (previous operator: Brundige Construction Company Ltd)
Rear of Yonge and Escott Townships, Lots 15 and 16, Conc. 10
UTM 422300E, 4944300N
Elevation 125.00 m±
See also Hewitt and Vos, 1972, p.8-9 (6.7 m); Rogers 1980, p.56-57);
Derry et al. 1989, p. 90-92 (BR-8, 12.45 m)

March Formation

2	Sandy dolostone, with shaly partings - light brownish grey; light grey weathering; very thinly to thinly bedded; calcite-filled vugs.	0.55 m	2.30-2.85 m
1	Dolostone - light brownish grey; light grey weathering; medium crystalline; medium bedded.	2.30	0.00-2.30

Section LO BR-2: G. Tackaberry and Sons Construction Co. Ltd., Maitland
(previous operator: Brundige Construction Company Ltd.)
Augusta Township, Lots 24 and 25, Concession 3
UTM 450500E, 4948250N
Elevation 110.00 m±
See also Goudge 1938, p.81-83; Hewitt 1964a, p.25-26 (2.4 m); Hewitt
and Vos 1972, p.8-9 (6.6 m); Rogers 1980, p.57; Derry et al. 1989,
p.96-97 (BR-14, 6.0 m)

Oxford Formation

1	Dolostone - medium grey; medium crystalline; medium bedded.	6.00	0.00-6.00

Section LO BR-3: Permanent Concrete Limited, Brockville
Elizabethtown Township, Lots 3 to 5, Concession 1
UTM 447500E, 4939800N
Elevation 90.00 m±
See also Goudge 1938, p.122-123; Hewitt 1960, p.19-20 (5.5 m); Hewitt
1964a, p.24-25 (10.6 m); Hewitt and Vos, 1972, p.11-12(16.5 m); Rogers
1980, p.61-62 (21.5 m); Derry et al. 1989, p.95-96 (BR-12, 21.0 m)

Oxford Formation

2	Dolostone - light greenish grey to medium browish grey; buff to reddish brown weathering; finely crystalline; thinly to thickly bedded; calcite-filled vugs. Base of first lift at 13.80.	8.00 m	12.10-20.10 m

March Formation

1	Sandy dolostone, with interbeds of dolostone and calcareous to non-calcareous quartz sandstone up to 3 m thick-medium grey; buff weathering; medium crystalline; coarse grained quartz; medium to thickly bedded; calcite-filled vugs. Base of second lift at 6.80 m.	12.10	0.00-12.10

Section LQ BR-4: Dibblee Construction Company Limited, Brockville
Elizabethtown Township, Lots 3 and 4, Concession 1
UTM 447350E, 4940750N
Elevation 105.00 m±
See also Rogers 1980, p. 63-64 (6.0 m); Derry et al. 1989, p. 96 (BR-13, 5.6 m)

Oxford Formation

1	Dolostone - light grey; finely crystalline; medium bedded.	5.60 m	0.00-5.60 m

March Formation

No longer exposed.

Section LQ BR-5: William Clow-Henderson, Mallorytown
Front of Yonge Township, Lots 2 and 3, Concession 1
UTM 436800E, 4929300N
Elevation 95.00 m±
See also Rogers 1980, p. 54-55; Derry et al. 1989, p. 93-94(BR-10, 4.5m)

March Formation

3	Sandy dolostone - bluish grey to medium grey; finely crystalline; medium to coarse grained quartz; thinly to medium bedded; calcitic.	1.50 m	3.00-4.50 m
2	Quartz sandstone - white to light brown; light brown weathering; medium grained; thinly bedded; well sorted, subrounded, non-calcareous.	1.50	1.50-3.00
1	Sandy dolostone - bluish grey to medium grey; finely crystalline; medium to coarse grained quartz; thinly to medium bedded; calcitic.	1.50	0.00-1.50

Section LQ BR-6: G. Tackaberry and Sons Construction Co. Ltd., Frankville
Kitley Township, Lots 19 and 20, Concession 8
UTM 423650E, 4952650N
Elevation 110.00 m±
See also Derry et al. 1989, p. 89 (BR-7, 4.5 m)

March Formation

1	Dolostone. with interbeds of quartz sandstone - light to medium brownish grey; buff weathering; finely to medium crystalline; thinly to thickly bedded calcite-filled vugs; stromatolites.	4.50 m	0.00-4.50 m

Section AQ BR-1: Brundige Construction Company Limited, Athens
Rear of Yonge and Escott Townships, Lot 14, Concession 9
UTM 423550E, 4943000N
Elevation 130.00 m±
See also Hewitt 1964a, p.22 (3.0 m)

March Formation

1	Dolostone - light brownish to greenish grey; buff weathering; finely to medium crystalline; thickly bedded.	1.90 m	0.00-1.90 m

Section AQ BR-2: Brundige Construction Company Limited, New Dublin
Elizabethtown Township, Lot 22, Concession 6
UTM 436600E, 4943900N
Elevation 115.00 m±
See also Hewitt 1964a, p.23 (6.1m); Hewitt and Vos 1972, p.10 (8.2m); Rogers 1980, p.59

Oxford Formation

1	Dolostone - brownish grey to medium grey; light brownish grey weathering; finely to medium crystalline; medium bedded; calcite-filled vugs.	7.00 m	0.00-7.00 m

Section AQ BR-3: Dodge Construction, Tincap
Elizabethtown Township, Lot 17, Concession 3
UTM 440500E, 4940650N
Elevation 110.00 m±
See also Rogers 1980, p.67 (2.0 m)

Oxford Formation

1	Dolostone - medium grey; light brown weathering; finely crystalline; thickly bedded; calcite-filled vugs.	2.00 m	0.00-2.00 m

Section AQ BR-4: H.J. McFarland Construction Company Limited, Tincap
Elizabethtown Townships, Lot 23, Concession 5
UTM 437200E, 4941900N
Elevation 110.00 m±
See also Hewitt 1964a, p.23-24 (10.9 m); Rogers 1980, p.71

Oxford Formation

1	Dolostone - brownish grey to medium grey; light brownish grey weathering; finely to medium crystalline; medium bedded; calcite-filled vugs.	10.10 m	0.0-10.10 m

Section S BR-1: roadcut, Hayes Corners
UTM 427450E, 4937250N
Elevation 115.00 m±

Nepean Formation

14	Quartz sandstone, with pebbles and cobbles - white to light brown; light grey to reddish brown weathering; coarse grained; thinly bedded; crossbedded at 10.32-10.47 m.	0.75 m	9.72-10.47 m
13	Quartz sandstone - white to light brown; light grey to light brown (with reddish brown spots) weathering; coarse grained; medium bedded; cross-bedded.	0.65	9.07-9.72
12	Quartz sandstone - white to light brown; light grey to light brown (with reddish brown spots) weathering; medium to coarse grained; thinly bedded.	1.15	7.92-9.07
11	Quartz sandstone - white to light brown; light grey weathering; medium grained very thinly bedded.	0.48	7.44-7.92
10	Cobble conglomerate, with matrix of well rounded, well sorted, coarse grained quartz sand - white to light brown; light grey to light brown (with reddish brown spots) weathering; rounded to angular clasts.	0.15	7.29-7.44
9	Quartz sandstone - white to light brown; light to medium brown (with reddish brown spots) weathering; coarse grained; very thinly to thinly bedded.	1.27	6.02-7.29
8	Quartz sandstone, with pebbles - greenish grey; light greenish grey weathering; coarse grained, poorly sorted.	0.05	5.97-6.02
7	Quartz sandstone - white to light brown; light brown to reddish brown (with reddish brown spots) weathering; coarse grained; thinly bedded; burrows.	1.15	4.82-5.97
6	Cobble conglomerate, with matrix of well rounded, well sorted, coarse grained quartz sand - white to light brown; light grey to light brown (with reddish brown sports) weathering; rounded to angular clasts.	0.30	4.52-4.82

Section S BR-1: (cont.) roadcut, Hayes Corners
UTM 427450E, 4937250N
Elevation 115.00m±

Nepean Formation

5	Quartz sandstone - white to light brown; light brown (with reddish brown spots) weathering; medium to coarse grained; very thinly to thickly bedded.	0.50 m	3.94-4.52 m
4	Cobble conglomerate, with matrix of well rounded, well sorted, coarse grained quartz sand - white to light brown; light grey to light brown (with reddish brown spots) weathering; rounded to angular clasts.	0.77	3.17-3.94
3	Quartz sandstone - white to light brown; light grey to reddish brown weathering coarse grained; thinly bedded burrows.	1.25	1.92-3.17
2	Quartz sandstone, with pebbles and cobbles - white; light grey weathering; coarse grained; very thinly to thickly bedded.	0.72	1.20-1.92
1	Boulder conglomerate, with matrix of coarse grained quartz sand - white to ligth brown to light green; green weathering; massive.	1.20	0.00-1.20

Section S BR-2: Highway 401 roadcut, Butternut Bay
UTM 436450E, 4929650N
Elevation 95.00 m±
See also Bond and Greggs 1973, p.1151 (4.9 m); Beauchamp 1979

March Formation

1	Sandy dolostone, containing cobbles and boulders adjacent to steeply dipping contact with Precambrian rock - bluish gray; buff weathering; finely crystalline; thinly to thickly bedded.	6.40 m	0.00-6.40 m

Precambrian

Section S BR-3: roadcut, Hallecks
UTM 439400E, 4933750N
Elevation 90.00 m±
See also Bond and Greggs 1973, p.1153-1154 (9.6 m)

March Formation

7	Quartz sandstone - white; light brown to reddish brown weathering; medium grained; very thinly to massive bedded; cross-bedded in places.	1.00 m	7.70-8.70 m

Section S BR-3: (cont.) roadcut, Hallacks
UTM 439400E, 4933750N
Elevation 90.00 m±
See also Bond and Greggs 1973, p. 1153-1154 (9.6 m)

6	Sandy dolostone - light grey; dark grey to reddish brown weathering; medium grained quartz; medium bedded.	0.30 m	7.40-7.70 m
5	Quartz sandstone - white; light brown to reddish brown weathering; medium grained.	2.60	4.80-7.40
4	Sandy dolostone - light grey; buff to reddish brown weathering; medium grained quartz; thickly bedded.	0.60	4.20-4.80
3	Quartz sandstone - white; light brown to reddish brown weathering; medium grained.	0.40	3.80-4.20
2	Sandy dolostone - light brown; buff weathering; medium grained quartz; medium bedded.	0.60	3.20-3.80
1	Quartz sandstone - white; light brown to reddish brown weathering; medium grained.	3.20	0.00-3.20

Section S BR-4: Highway 401 roadcut, Brockville
UTM 444500E, 4938650N
Elevation 95.00 m±
See also Bond and Greggs 1973, p. 1154 (6.0 m)

March Formation

5	Sandy dolostone -light grey, buff weathering; medium grained quartz thinly bedded.	1.40 m	3.10-4.50 m
4	Sandy dolostone - light grey; medium brownish grey weathering; fine to medium grained quartz; thickly bedded.	0.80	2.30-3.10
3	Quartz sandstone - white to light brown; light brown to reddish brown weathering; medium grained; thinly to medium bedded.	1.00	1.30-2.30
2	Sandy dolostone - light grey to bluish grey; light brownish grey weathering; finely to medium crystalline; medium grained quartz; thick bedded.	0.50	0.80-1.30
1	Quartz sandstone - white to light brown; light brown to reddish brown weathering; medium grained; thin to medium bedded; cross-bedded.	0.80	0.00-0.80

Section S BR-5: Highway 401 roadcut, Prescott
UTM 455050E, 4949800N
Elevation 105.00 m±

Oxford Formation

6	Dolostone - medium grey; light grey weathering; medium crystalline; medium bedded; gastropods.	1.80 m	6.35-8.15 m
5	Dolostone - light brownish grey; brownish grey weathering; finely crystalline; thinly bedded.	2.10	4.25-6.35
4	Dolostone - light grey; light brownish grey weathering; medium crystalline; medium bedded.	0.85	3.40-4.25
3	Dolostone - light grey; light grey weathering; finely to medium crystalline; medium bedded; stromatolites.	0.20	3.20-3.40
2.	Dolostone - light grey; light brownish grey weathering; medium crystalline; medium bedded.	1.45	1.75-3.20
1	Dolostone - medium grey; light grey weathering; medium crystalline; thickly bedded; calcite-filled vugs.	1.70	0.00-1.75

Section LO CA-1: Allan MacMillan, Ashton
Huntley Township, Lot 1, Concession 11
UTM 416750E, 5005500N
Elevation 140.00 m±
See also Goudge 1938, p.50, 56-57 (0.9 m)

Gull River Formation (upper member)

2	Limestone - light brownish grey; light brown weathering; finely crystalline; thinly bedded.	0.40 m	0.60-1.00 m
1	Limestone-dark grey; light brown weathering; finely crystalline; thinly bedded.	0.60	0.00-0.60

Section LO CA-2: Thomas Cavanagh Construction Limited, Ashton
Beckwith Township, Lot 24, Concession 8
UTM 418300E, 4498200N
Elevation 135.00 m±

Rockcliffe Formation (lower member)

2	Quartz sandstone, with dark green shaly partings - light green; medium to dark green weathering; very fine grained; very thinly to thinly bedded; crossbedded, desiccation cracks.	2.70 m	1.90-4.60 m

Section LQ CA-2: (cont.) Thomas Cavanagh Construction Limited, Ashton
Beckwith Township, Lot 24, Concession 8
UTM 418300E, 4498200N
Elevation 135.00 m±

Rockcliffe Formation (lower member)

1	Quartz sandstone, with dark green shaly partings - light green to light brownish green; light brown to light brownish green weathering; very fine to fine grained; medium bedded; non-calcareous crossbedded.	1.90	0.00-1.90

Section LQ CA-3: Thomas Cavanagh Construction Limited, Franktown
Beckwith Township, Lot 16, Concession 2
UTM 419250E, 4989450N
Elevation 135.00 m±
See also Derry et al. 1989, p. 51-52 (CP-7, 1.7 m)

Oxford Formation

1	Dolostone - medium grey to light brown; light grey to buff weathering; finely crystalline; thinly bedded.	1.70 m	0.00-1.70 m

Section LQ CA-4: Duffy Road Oiling Limited, Carleton Place
Ramsay Township, Lots 2 and 3, Concession 8
UTM 410600E, 5001650N
Elevation 130.00 m±
See also Goudge 1938, p.114 (1.8 m); Rogers 1980, p.36-38 (6.5 m); Rogers 1981; Derry et al. 1989, p. 49-50 (CP-5), 8.8 m

Oxford Township

8	Dolostone - light brown; buff weathering; finely crystalline; thinly bedded.	1.00 m	7.80-8.80 m
7	Dolostone, with thin sandy interbeds - light grey to light brown; buff weathering; finely crystalline; coarse grained well rounded quartz; thinly bedded; calcitic.	1.00	6.80-7.80
6	Dolostone - light grey to light brown; buff weathering; finely crystalline; medium bedded; calcite-filled vugs.	2.50	4.30-6.80

March Formation

5	Sandy dolostone - light brownish grey; buff weatheing; medium to coarse grained well rounded quartz; medium bedded; calcite-filled vugs.	0.50	3.80-4.30

Section LO CA-4: (cont.) Duffy Road Oiling Limited, Carleton Place
Ramsay Township, Lots 2 and 3, Concession 8
UTM 410600E, 5001650N
Elevation 130.00 m±
See also Goudge 1938, p.114 (1.8 m); Rogers 1980, p.36-38 (6.5 m); Rogers 1981; Derry *et al.* 1989, p. 49-50 (CP-5), 8.8 m

Oxford Township

4	Dolostone - medium to dark grey; buff weathering; finely crystalline; thinly bedded; calcite-filled vugs.	0.60	3.20-3.80
3	Sandy dolostone - light to medium brownish grey; medium grey weathering; coarse grained quartz; medium bedded; calcite-filled vugs.	0.40	2.80-3.20
2	Quartz sandstone - white; white to reddish brown weathering; medium grained; medium bedded; well rounded, well sorted, calcareous, crossbedded.	1.20	1.60-2.80
1	Sandy dolostone - medium grey; light to medium grey weathering; medium to coarse grained well rounded quartz; thickly bedded.	1.60	0.00-1.60

Section AO CA-1: Ontario Building Materials Limited-Metcalf, Carleton Place
Ramsay Township, Lot 5, Concession 7
UTM 406700E, 5002050N
Elevation 140.00 m±
See also Hewitt 1963, p.23 (3.0 m); Rogers 1980, p.65-66 (2.1 m)

Nepean Formation

2	Quartz sandstone - white; white (with reddish brown spots) weathering; medium grained; thinly bedded; well rounded, well sorted, calcareous, crossbedded, ripple marks.	0.30 m	3.45-3.75 m
1	Quartz sandstone - white; white (with reddish brown spots) weathering; medium grained; thinly bedded; well rounded, well sorted, non-calcareous, crossbedded.	3.45	0.00-3.45

Section AO CA-2: Mohr, Almonte, Ramsay Township, Lot 20, Concession 9
UTM 403550E, 5010200N
Elevation 105.00 m±
See also Rogers 1980, p.65 (2.4 m)

Nepean Formation

1	Quartz sandstone - white; light brown weathering; medium grained; medium bedded.	0.75 m	0.00-0.75 m

Section LO CO-1: Cornwall Gravel Company - Macleod, Cornwall
Cornwall Township, Lots 3 to 5, Concession 4
UTM 521800E, 4992800N
Elevation 30.00 m±
See also Goudge 1938, p.195-196 (1.5 m); Hewitt 1964a, p.42 (3.0 m); Hewitt and Vos 1972, p.20 (18.4 m); Derry *et al.* 1989, p.23-26 (CW-14, 33.4 m)

	Bobcaygeon Formation (lower member)		
12	Limestone - medium to dark brownish grey; bluish grey to medium grey weathering; sublithographic to finely crystalline; medium to massive bedded.	1.70 m	23.70-25.40 m
	Gull River Formation (upper member)		
11	Limestone - medium to dark brownish grey; light bluish grey to medium grey weathering; lithographic to sub-lithographic; very thinly to thinly bedded.	1.80	21.90-23.70
10	Limestone, with shaly partings - medium to dark brownish grey; light bluish grey to medium grey weathering; lithographic to sublithographic; very thinly to thickly bedded; commonly intraclastic, "birdseye" texture in places; crinoids, brachiopods, bryozoa, abundant *Tetradium* in places. Base of first lift at 19.30 m.	7.10 m	14.80-21.90 m
	Gull River Formation (lower member)		
9	Silty dolostone - light greenish grey to medium brownish grey; buff to reddish brown weathering; sublithographic to finely crystalline; medium to thickly bedded; intraclastic, calcitic to non-calcitic, calcite-filled vugs.	1.10	13.70-14.80
8	Limestone, with shaly partings - medium to dark brownish grey; light bluish grey to medium grey weathering; lithographic to finely crystalline; thinly to thickly bedded; commonly intraclastic. Base of second lift at 12.70 m.	1.00	12.70-13.70
7	Silty dolostone - light greenish grey to medium brownish grey; buff to reddish brown weathering; sublithographic to finely crystalline; medium to thickly bedded.	0.75	11.95-12.70
6	Limestone - dark grey; bluish grey to dark grey weathering; oolitic, intraclastic.	0.80	11.15-11.95

Section LO CO-1: (cont.) Cornwall Gravel Company Limited -Macleod, Cornwall
Cornwall Township, Lots 3 to 5, Concession 4
UTM 521800E, 4992800N
Elevation 30.00 m±
See also Goudge 1938, p.195-196 (1.5 m); Hewitt 1964a, p.42 (3.0 m); Hewitt and Vos 1972, p.20 (18.4 m); Derry et al. 1989, p.23-26 (CW-14, 33.4 m)

Gull River Formation (lower member)

5	Limestone - medium to dark brownish grey; light bluish grey to medium dark weathering; lithographic to finely crystalline; thinly to thickly bedded. Base to third lift at 6.65 m.	8.85 m	2.30-11.15 m
4	Silty dolostone - light greenish grey to medium brownish grey buff to reddish brown weathering; sublithographic to finely crystalline; medium to thickly bedded.	0.30	2.00-2.30
3	Limestone - medium to dark brownish grey; light bluish grey to medium grey weathering; lithographic to finely crystalline; thinly to thickly bedded.	0.95	1.05-2.00
2	Silty dolostone - light greenish grey to medium brownish grey; buff to reddish brown weathering; sublithographic to finely crystalline; medium to thickly bedded. Base of fourth lift at 0.65 m.	0.40	0.65-1.05
1	Limestone - medium to dark brownish grey; light bluish grey to medium grey weathering; lithographic to finely crystalline; thinly to thickly bedded.	0.65	0.00-0.65

Section LO CO-2: Permanent Concrete Limited, Cornwall
(previous operator: Gypsum Lime and Alabastine Canada Limited)
Cornwall Township, Lots 25 to 29, Concession 4
UTM 512700E, 4987800N
Elevation 40.00 m±
See also Goudge 1938, p.194 (9.1m); Hewitt and Vos 1972, p.37 (13.4m); Derry et al. 1989, p. 20-22 (CW-12, 24.8 m)

Bobcaygeon Formation (lower member)

7	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish grey weathering; sublithographic to finely crystalline; thickly to massive bedded. Base of first lift at 14.20 m.	4.30 m	14.20-18.50 m

Section LO CO-2: (cont.) Permanent Concrete Limited, Cornwall
(previous operator: Gypsum Lime and Alabastine Canada Limited)
Cornwall Township, Lots 25 to 29, Concession
UTM 512700E, 4987800N
Elevation 40.00 m±
See also Goudge 1938, p.194 (9.1m); Hewitt and Vos 1972, p.37 (13.4m); Derry *et al.* 1989, p. 20-22 (CW-12, 24.8 m)

Gull River Formation (upper member)

6	Limestone, with shaly partings - medium to dark brownish grey; bluish grey to brown weathering; lithographic to finely crystalline; very thinly to thinly bedded.	1.75 m	12.45-14.20 m
5	Limestone, with shaly partings - medium to dark brownish grey; bluish grey to brown weathering; lithographic to finely crystalline; very thinly to thickly bedded; commonly intraclastic. Base of second lift at 4.70 m.	7.75	4.70-12.45
4.	Silty dolostone - light greenish grey; buff to reddish brown weathering; sublithographic to finely crystalline; medium to thickly bedded; intraclastic, calcitic to non-calcitic, calcite-filled vugs, pyrite masses.	1.00	3.70-4.70
3	Limestone, with shaly partings - medium to dark brownish grey; bluish grey to brown weathering; lithographic to finely crystalline; thinly to thickly bedded; commonly intraclastic.	2.60	1.10-3.70
2	Silty dolostone - light greenish grey; buff to reddish brown weathering; sublithographic to finely crystalline; intraclastic.	0.50	0.60-1.10
1	Limestone - dark grey; bluish grey to dark grey weathering; oolitic, intraclastic.	0.60	0.00-0.60

Section LO CO-3: Dibblee Construction Company Limited, Cornwall
Cornwall Township, Lots 21 to 23, Concession 4
UTM 513450E, 4988050N
Elevation 55.00 m±
See also Goudge 1938, p.194-196 (3.0 m); Hewitt 1964a, p.42 (11.0 m); Hewitt and Vos 1972, p.22 (16.5 m); Derry *et al.* 1989, p.22-23 (CW-13, 9.7m)

Bobcaygeon Formation (lower member)

1	Limestone - medium to dark brownish grey; bluish grey to brown weathering; lithographic to finely crystalline; thinly to massive bedded; crinoids, brachiopods, bryozoa, gastropods.	1.70 m	0.00-1.70 m

Gull River Formation (lower and upper members)

No longer exposed.

Section LQ CO-4: A. L. Blair Construction Company Limited, Gravel Hill
Roxborough Township, Lot 9, Concession 4
UTM 509150E, 5007150N
Elevation 100.00 m±
See also Derry et al. 1989, p. 27-28 (CW-16, 4.2 m)

Lindsay Formation (lower member)

1	Limestone, with irregular shaly partings - light to dark brownish grey; bluish grey to brown weatherng; sublithographic to medium crystalline; very thinly to thickly bedded; nodular in places.	4.20 m	0.00-4.20 m

Section LQ CO-5: A. L. Blair Construction Company Limited, Moose Creek
Roxborough Township, Lot 24, Concession 6
UTM 501700E, 5008600N
Elevation 95.00 m±
See also Derry et al. 1989, p. 28 (CW-17, 5.6 m)

Lindsay Formation (lower member)

1	Limestone, with irregular shaly partings - light to dark brownish grey; bluish grey to brown weatherng; sublithographic to medium crystalline; very thinly to thickly bedded; nodular in places.	5.60 m	0.00-5.60 m

Section LQ CO-6: Cruickshank Construction Limited-Glengarry Aggregates and
Concrete Division, Green Valley
Lancaster Township, Lots 29 to 30, Concession 6
UTM 536350E, 5010200N
Elevation 60.00 m±
See also Derry et al. 1989, p. 38-40 (CW-27, 13.75 m)

Bobcaygeon Formation (lower member)

4	Limestone, with shaly partings - brownish grey; light brown to reddish brown weathering; sublithographic to finely crystalline; very thinly to thickly bedded; crinoids, brachiopods, bryozoa, cephalopods, feeding trails, burrows.	1.65 m	6.00-7.65 m
3	Limestone, with irregular shaly partings - medium to dark grey; light grey weathering; sublithographic to finely crystalline; thickly to massive bedded; crinoids, corals.	1.80	4.20-6.00

Gull River Formation (upper member)

2	Limestone - light to medium grey; light bluish grey weathering; lithographic; medium to thickly bedded; crinoids.	0.40	3.80-4.20

Section LO CO-6: (cont.) Cruickshank Construction Limited-Glengarry
Aggregates and Concrete Division, Green Valley
Lancaster Township, Lots 29 to 30, Concession 6
UTM 536350E, 5010200N
Elevation 60.00 m±
See also Derry et al. 1989, p. 38-40 (CW-27, 13.75 m)

Gull River Formation (upper member)

1	Limestone, with shaly partings - brownish grey; light brown to reddish brown weathering; sublithographic to finely crystalline; very thinly to thickly bedded; crinoids, brachiopods, bryozoa, cephalopods, feeding trails, burrows.	3.80 m	0.00-3.80 m

Section AO CO-1: Ontario Hydro, Cornwall
Cornwall Township, Lot 20, Concession 4
UTM 514350E, 4988700N
Elevation 60.00 m±
See also Hewitt 1960, p.80-83 (18.3 m)

Bobcaygeon Formation (lower member) and
Gull River Formation (lower and upper member)

No longer exposed

Section AO CO-2: Roads Resurfacing Company, Apple Hill
Charlottenburg Township, Lot 31, Concession 9
UTM 517400E, 5002750N
Elevation 75.00 m±
See also Goudge 1938, p.78-79 (4.6 m); Hewitt 1964a, p.41 (7.6 m)

Lindsay Formation (lower member)

1	Limestone, with irregular shaly partings - light to medium brownish grey; bluish grey to brown weathering; finely to medium crystalline; very thinly to thickly bedded; nodular in places; intraclastics places; crinoids, brachiopods, corals, burrows.	4.65 m	0.00-4.65 m

Section LO HA-1: Bertrand et Frere Construction Company Ltd-main, L'Orignal
Longueuil Township, Lots 213 to 215
UTM 518550E, 5049050N
Elevation 40.00 m±
See also Goudge 1938, p.154, 156 (3.7 m); Hewitt 1960, p.80 (5.5 m);
Hewitt and Vos 1972, p.15; Derry et al. 1989, p. 30-32 (CW-21, 15.2 m)

Bobcaygeon Formation (upper member)

4	Limestone, with shaly partings - medium grey; brownish grey weathering; finely to medium crystalline; thinly bedded; brachiopods, bryozoa, trilobites, crinoids.	1.60 m	13.60-15.20 m

Section LO HA-1: (cont.) Bertrand et Frere Construction Company Ltd-main, L'Orignal
Longueuil Township, Lots 213 to 215
UTM 518550E, 5049050N
Elevation 40.00 m±
See also Goudge 1938, p.154, 156 (3.7 m); Hewitt 1960, p.80 (5.5 m); Hewitt and Vos 1972, p.15; Derry et al. 1989, p. 30-32 (CW-21, 15.2 m)

Bobcaygeon Formation (upper member)

3	Limestone, with shale interbeds - light to medium grey; dark grey weathering; finely to coarely crystalline; medium bedded; bryozoa, brachiopods, crinoids.	3.00 m	10.60-13.60 m
2	Limestone, with upper and lower shale interbeds 5 cm thick - light grey; dark grey weathering; medium crystalline.	0.40	10.20-10.60
1	Limestone, with shale interbeds up to 10 cm thick - dark grey; dark grey weathering; finely to coarsely crystalline; thinly to medium bedded; bryozoa, brachiopods, crinoids, graptolites, burrows.	10.20	0.00-10.20

Section LO HA-2: Whissell Concrete Products, Hawkesbury
East Hawkesbury Township, Lot 28, Concession 1
UTM 536850E, 5046350N
Elevation 50.00 m±
See also Goudge 1938, p.155-156 (6.1 m); Derry et al. 1989, p. 32-33 (CW-22, 9.5 m)

Rockcliffe Formation (upper member)

2	Limestone - medium grey; brownish grey weathering; coarsely crystalline; massive bedded; stylolites, cross-bedded; brachiopods.	4.50 m	5.00-9.50 m

Rockcliffe Formation (lower member)

1	Quartz sandstone, with dark green shale interbeds up to 10 cm thick - light greenish grey; greenish grey weathering; fine grained; burrows.	5.00	0.00-5.00

Section AO HA-1: Bertrand et Frere Construction Company Limited-north, L'Orignal
Longueuil Township, Lot 241
UTM 517800E, 5050900N
Elevation 50.00 m±
See also Goudge 1938, p.155-156(2.7m); Hewitt and Vos 1972, p.15(5.5m)

Bobcaygeon Formation (upper member)

2	Limestone, with shaly partings - medium grey; brownish grey weathering; finely crystalline; thinly bedded.	2.75 m	1.50-4.25 m

Section AO HA-1: (cont.) Bertrand et Frere Construction Company Limited-north, L'Orignal
Longueuil Township, Lot 241
UTM 517800E, 5050900N
Elevation 50.00 m±
See also Goudge 1938, p.155-156(2.7m); Hewitt and Vos 1972, p.15(5.5m)

Bobcaygeon Formation (upper member)

1	Limestone - medium grey; weathering light grey; finely crystalline; finely bedded.	1.50 m	0.00-1.50 m

Section LO KE-1: Dibblee Construction Company Limited. Stittsville (to south of fault)
Goulbourn Township, Lots 13 and 14, Concession 11
UTM 422650E, 5008400N
Elevation 140.00 m±

Gull River Formation (upper member)

2	Limestone - medium grey; lithographic; thinly to medium bedded; "birdseye" texture.	0.65 m	2.00-2.65 m
1	Limestone - medium to dark grey; finely crystalline; thinly bedded; corals, brachiopods, cephalopods, gastropods, trilobites.	2.00	0.00-2.00

Section LO KE-2: Forbes Building Materials Limited, Hallville
Mountain Township, Lot 8, Concession 8
UTM 460400E, 4989450N
Elevation 90.00 m±
See also Derry et al. 1989, p. 8-9 (CW-1, 8.0 m)

Oxford Formation

2	Dolostone, with shaly partings - light greenish grey to medium brownish grey; buff weathering; finely crystalline; thinly to medium bedded; calcite-filled vugs.	5.00 m	3.00-8.00 m
1	Dolostone - light greenish grey to medium brownish grey; buff weathering; finely crystalline; medium to thickly bedded; calcite-filled vugs.	3.00	0.00-3.00

Section LO KE-3: Thomas Cavanagh Construction Limited, Munster
Goulbourn Township, Lot 11, Concession 8
UTM 423800E, 5004650N
Elevation 120.00 m±
See also Derry *et al.* 1989, p. 57-58 (CP-11, 10.4 m)

Gull River Formation (lower member)

6	Limestone, with silty calcitic dolostone interbeds and shaly partings-medium grey; light grey weathering; lithographic to finely crystalline; thinly to medium bedded.	4.20 m	6.15-10.35 m
5	Silty dolostone - light greenish grey to dark brownish grey; finely crystalline; medium bedded; calcitic in places.	0.80	5.35-6.15
4	Silty dolostone, with shale interbeds - light greenish grey to dark brownish grey; finely crystalline; medium bedded; calcitic in places; burrows.	1.00	4.35-5.35
3	Silty dolostone - light greenish grey to dark brownish grey; finely crystalline; medium bedded; non-calcitic.	0.35	4.00-4.35
2	Limestone, with shaly partings - medium grey; light grey weathering; lithographic to finely crystalline; medium bedded.	3.50	0.50-4.00
1	Silty dolostone - light greenish grey to dark brownish grey; finely crystalline; medium bedded; calcitic.	0.50	0.00-0.50

Section S MA-1: Thousand Island Parkway roadcut, Browns Bay
UTM 435000E, 4926500N
Elevation 85.00 m±
See also Bond and Greggs 1973, p.1150 (18.0 m); Beauchamp 1979

March Formation

4	Sandy dolostone, with interbeds of calcareous quartz sandstone and dolostone - bluish grey; buff weathering; medium crystalline; thinly to medium bedded; calcitic; burrows.	4.70 m	7.70-12.40 m

Nepean Formation

3	Quartz sandstone - white to light grey; brown weathering; medium grained; thinly to medium bedded; crossbedded; burrows.	2.00	5.70-7.70

Section S MA-1: Thousand Island Parkway roadcut, Browns Bay
UTM 435000E, 4926500N
Elevation 85.00 m±
See also Bond and Greggs 1973, p. 1150 (18.0 m); Beauchamp 1979

Nepean Formation

2	Quartz-pebble conglomerate, with interbeds up to 50 cm quartz thick of quartz sandstone.	2.00 m	3.70-5.70 m
1	Quartz-pebble conglomerate	3.70	0.00-3.70

Section LO ME-1: G. Tackaberry and Sons Construction Company Limited, Jasper
(previous operator: Brundige Construction Company Limited)
Wohlford Township, Lots 29 and 30, Concession 1
UTM 425950E, 4965800N
Elevation 100.00 m±
See also Goudge 1938, p. 121 (3.0 m); Hewitt 1964a, p. 19-20 (6.1 m);
Rogers 1980, p. 57; Derry et al. 1989, p. 92-93 (BR-9, 11.0 m)

Oxford Formation

1	Dolostone - dark grey; finely crystalline; thinly to medium bedded; calcite-filled vugs.	5.00 m	0.00-5.00 m

Section LO ME-2: Gertrude Ronan, Newbliss
Kitley Township, Lot 13, Concession 3
UTM 422100E, 4961700N
Elevation 120.00 m±
See also Derry et al. 1989, p. 88-89 (BR-6, 10.4 m)

Oxford Formation

5	Dolostone - light grey; light brownish grey weathering; medium crystalline; medium bedded; calcite-filled vugs.	5.80 m	4.60-10.40 m
4	Dolostone, with shaly partings	0.20	4.40-4.60
3	Dolostone - medium grey; finely crystalline; very thinly to thickly bedded.	1.00	3.40-4.40
2	Dolostone, with shaly partings	0.20	3.20-3.40
1	Dolostone - medium grey; finely crystalline; very thinly to thickly bedded.	3.20	0.00-3.20

<u>Section LO ME-3:</u> G. Tackaberry and Sons Construction Co. Limited, Rosedale
Montague Township, Lot 17, Concession 4
UTM 425700E, 4976400N
Elevation 120.00 m±
See also Derry <u>et al.</u> 1989, p. 58 (CP-12, 4.5 m)

March Formation

1	Sandy dolostone - light brownish grey to medium grey; brownish grey weathering; finely to medium crystalline; thinly to medium bedded.	3.40 m	0.00-3.40 m

<u>Section LO ME-4:</u> G. Tackaberry and Sons Construction Co. Ltd., Kilmarnock
Montague Township, Lot 19, Concession 1
UTM 428000E, 4972250N
Elevation 115.00 m±
See also Derry <u>et al.</u> 1989, p. 58-59 (CP-13, 6.0 m)

Oxford Formation

1	Dolostone, with shaly partings - light brownish grey; buff weathering; finely crystalline; medium bedded; calcite-filled vugs.	5.40 m	0.00-5.40 m

<u>Section S ME-1:</u> Highway 16 roadcut, Groveton
UTM 455250E, 4970700N
Elevation 105.00 m±

Oxford Formation

3	Dolostone-light grey; light grey weathering; finely crystalline; calcite-pyrite-filled vugs, chert nodules; stromatolites.	1.20 m	2.85-4.05 m
2	Dolostone - medium grey; medium grey weathering; finely crystalline; thinly bedded; calcite-pyrite-filled vugs, chert nodules.	0.85	2.00-2.85
1	Dolostone - light grey; light grey weathering; finely crystalline; thinly to medium bedded.	2.00	0.00-2.00

<u>Section LO MO-1:</u> Cruickshank Construction Limited, Williamsburgh
Williamsburgh Township, Lot 21, Concession 5
UTM 483900E, 4981950N
Elevation 115.00 m±

Gull River Formation (upper member)

1	Limestone - dark brownish grey; light bluish grey to brown weathering; lithographic to sublithographic; medium to thickly bedded; crinoids, brachiopods, gastropods, burrows.	0.90 m	0.00-0.90 m

Section LO MO-2: Cruickshank Construction Limited, South Mountain
Mountain Township, Lot 11, Concession 2
UTM 466550E, 4982350N
Elevation 80.00 m±
See also Rogers 1980, p.72 (0.3 m)

Oxford Formation

1	Dolostone - medium to dark brownish grey; buff weathering; sublithographic; thickly bedded; calcite-filled vugs.	0.30 m	0.00-0.30 m

Section LO MO-3: Mac Fetterly, Iroquois
Matilda Township, Lots 30 and 31, Concession 1
UTM 473200E, 4963400N
Elevation 60.00 m±
See also Hewitt 1960, p.20-22 (23.8m); Rogers 1980, p.59-60; Derry *et al.* 1989, p. 9-10 (CW-2, 27.6 m)

Oxford Formation

2	Dolostone, with shaly partings - medium to dark grey; buff to light grey weathering; finely to medium crystalline; medium to thickly bedded; calcite-filled vugs at 7.22-12.52 m.	20.40 m	7.22-27.62 m
1	Dolostone -light grey; buff to light grey weathering; sublithographic to finely crystalline; medium to thickly bedded; calcite-filled vugs at 2.42- 5.22 m.	7.22	0.00-7.22

Section AO MO-1: Ontario Ministry of Transportation & Communications-Fisher, Iroquois
Matilda Township, Lot 28 and 29, Concession 1
UTM 473750E, 4963650N
Elevation 80.00 m±
See also Goudge 1938, p.57-59; Rogers 1980, p.71 (3.7 m)

Oxford Formation

1	Dolostone, with shaly partings - dark brownish grey to light greenish grey; buff to reddish brown weathering; finely crystalline; very thinly to thickly bedded; calcite-filled vugs.	2.80 m	0.00-2.80 m

Section AO MO-2: Dean Keyes, South Mountain
Mountain Township, Lot 19, Concession 1
UTM 468200E, 4981700N
Elevation 75.00 m±
See also Rogers 1980, p.72 (2.0 m); Rogers 1981

Rockcliffe Formation (lower member)

1	Quartz sandstone - medium grey; light grey to brown weathering; fine grained; thickly bedded; calcareous.	1.50 m	0.00-1.50 m

Section LQ OT-1: Spratt Sand and Gravel Limited, Huntley
Huntley Township, Lot 2 to 5, Concession 2
UTM 424450E, 5015500N
Elevation 105.00 m±
See also Derry et al. 1989, p. 53-55 (CP-9, 11.3 m)

Bobcaygeon Formation (lower member, unit B)

6	Limestone - light to medium grey; light grey weathering; medium to coarsely crystalline; medium to thickly bedded; stylolites; corals, brachiopods.	4.80 m	6.50-11.30 m
5	Limestone, with shaly partings - dark grey; light bluish grey weathering; sub-lithographic; thinly to medium bedded; brachiopods.	1.30	5.20-6.50
4	Limestone - light to medium grey; light grey weathering; medium to coarsely crystalline; thickly bedded; stylolites, bed up to 5 cm thick of block chert at upper contact; corals brachiopods.	0.50	4.70-5.20
3	Limestone-light grey; light grey weathering; finely crystalline, with medium to coarsely crystalline interbeds up to 5 cm thick; medium bedded; brachipods.	0.25	4.45-4.70
2	Limestone - light to medium grey; light grey weathering; medium to coarsely crystalline; thickly bedded; stylolites; corals, brachipods.	0.35	4.10-4.45
1	Limestone, with shaly partings - dark grey; light bluish grey weathering; sub-lithographic; thinly to medium bedded; brachiopods.	4.10	0.00-4.10

Section LQ OT-2: West Carleton Sand and Gravel Incorporated, Stittsville
Huntley Township, Lots 1 and 2, Concession 4
UTM 424400E, 5012400N
Elevation 120.00 m±
See also Derry et al. 1989, p. 55-57 (CP-10, 10.0 m)

Bobcaygeon Formation (lower member, unit B)

2	Limestone, with shaly partings - light to medium grey; light grey weathering medium crystalline; medium bedded; brachiopods, carols.	6.50 m	4.00-10.50 m

Bobcaybeon Formation (lower member, unit A)

1	Limestone - medium grey; bluish grey weathering; sublithographic to finely crystalline; medium bedded.	4.00	0.00-4.00

Section LO OT-3: H. J. McFarland Construction Company Limited, Fallowfield
Nepean Township, Lots 23 and 24, Concession 5
UTM 436100E, 5013700N
Elevation 80.00 m±
See also Hewitt 1964a, p. 38 (10.9 m); Hewitt and Vos 1972, p. 30-31 (18.9 m); Derry et al. 1989, p. 60-63 (CP-15, 36.2 m)

Bobcaygeon Formation (lower member)

16	Limestone, with shaly partings - medium to dark brownish grey; bluish grey to brown weathering; sublithographic to finely crystalline; very thinly to thickly bedded, brachipods.	3.25 m	32.89-36.15 m
15	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish grey to brown weathering; sublithographic to finely crystalline; very thinly to massive bedded.	2.70	30.19-32.89
	Gull River Formaton (upper member)		
14	Limestone, with shaly partings - dark grey; light bluish grey to dark grey (white at 28.07-28.31 m) weathering; lithographic to finely crystalline; thinly to thickly bedded; intraclastic in places, "birdseye" texture at 28.07-30.19 m; brachiopods, abundant Tetradium at 28.07-30.19 m.	9.21	20.89-30.19
	Gull River Formation (lower member)		
13	Silty dolostone, with shaly partings - medium grey; buff weathering; sublithographic to finely crystalline; thinly to medium bedded.	0.65	20.33-20.98
12	Limestone, with shaly partings - dark grey; bluish grey weathering; lithographic to finely crystalline; thinly to thick bedded.	3.20	17.13-20.33
11	Limestone, with shaly partings - dark grey; bluish grey to dark grey weathering; thinly to thickly bedded; oolitic, intraclastic.	0.55	16.58-17.13
10	Silty dolostone, with shaly partings - greenish grey; buff to reddish brown weathering; sublithographic to finely crystalline; thinly to medium bedded; calcitic in places, intraclastic.	1.15	15.43-16.58
9	Limestone, with shaly partings - dark grey; bluish grey weatherng; lithographic to finely crystalline; thinly to thickly bedded; intraclastic; brachiopods.	2.46	12.97-15.43

Section LQ OT-3: (cont.) H.J. McFarland Construction Co. Ltd, Fallowfield
Nepean Township, Lots 23 and 24, Concession 5
UTM 436100E, 5013700N
Elevation 80.00 m±
See also Hewitt 1964a, p.38 (10.9 m); Hewitt and Vos 1972, p.30-31 (18.9 m); Derry *et al.* 1989, p. 60-63 (CP-15, 36.2 m)

Gull River Formation (lower member)

8	Shale - black.	0.20 m	12.77-12.97 m
7	Limestone, with shaly partings - dark grey; bluish grey weathering; lithographic to sublithographic; medium to thickly bedded; intraclastic.	4.70	8.07-12.77
6	Silty dolostone - medium grey; greenish grey to buff weathering; sublithographic to finely crystalline; medium bedded; calcite-filled vugs.	1.15	6.92-8.07
5	Limestone, with shaly partings - dark grey; bluish grey weathering; lithographic to finely crystalline; medium to thickly bedded.	1.50	5.42-6.92
4	Silty dolostone, with shaly partings - light greenish grey; buff weathering; sublithographic to finely crystalline; medium to thickly bedded; calcite-filled vugs.	1.95	3.47-5.42
3	Limestone, with shaly partings - dark grey; light bluish grey weathering; sublithographic to finely crystalline; medium bedded.	2.10	1.37-3.47
2	Silty dolostone - medium grey; greenish grey weathering; sublithographic to finely crystalline; thinly to medium bedded; non-calcitic.	0.52	0.85-1.37
1	Limestone-dark grey; bluish grey weathering; finely crystalline; medium bedded.	0.85	0.00-0.85

Section LQ OT-4: R.W. Tomlinson Limited, Fallowfield
Nepean Township, Lots 24 and 25, Concession 5
UTM 436050E, 5014250N
Elevation 105.00 m±
See also Rogers 1981; Derry *et al.* 1989, p. 59-60 (CP-14, 10.9 m)

Bobcaygeon Formation (lower member)

3	Limestone, with shaly partings - medium to dark brownish grey; bluish grey to brown weathering; sublithographic to finely crystalline; very thinly to thickly bedded; brachiopods.	3.25 m	7.60-10.85 m

<u>Section LO OT-4:</u> (cont.) R.W. Tomlinson Limited, Fallowfield
Nepean Township, Lots 24 and 25, Concession 5
UTM 436050E, 5014250N
Elevation 105.00 m±
See also Rogers 1981; Derry *et al.* 1989, p. 59-60 (CP-14, 10.9 m)

Bobcaygeon Formation (lower member)

2	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish grey to brown weathering; sublithographic to finely crystalline; very thinly to massive bedded.	2.70 m	4.90-7.60 m

Gull River Formation (upper member)

1	Limestone, with shaly partings - light to dark grey; light bluish grey to dark grey weathering; lithographic to finely crystalline; thinly to thickly bedded.	4.90	0.00-4.90

<u>Section LO OT-5:</u> Dibblee Construction Company Limited, Fallowfield
Nepean Township, Lot 21, Concession 4
UTM 437500E, 5013400N
Elevation 90.00 m±
See also Hewitt 1964a, p.39 (7.6m); Bolton and Liberty 1972, p.23);
Derry *et al.* 1989, p. 63-64 (CP-16, 18.7 m)

Bobcaygeon Formation (lower member)

7	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish grey to brown weathering; sublithographic to finely crystalline; very thinly to massive bedded.	1.50 m	17.22-18.72 m

Gull River Formation (upper member)

6	Limestone, with shaly partings - dark grey; light bluish grey to dark grey (white at 15.10-15.34 m) weathering; lithographic to finely crystalline; thinly to thickly bedded; intraclastic in places, "birdseye" texture at 15.10-17.22 m; brachiopods, abundant <u>Tetradium</u> at 15.10-17.22 m.	7.11	10.11-17.22

Gull River Formation (lower member)

5	Silty dolostone, with shaly partings - medium grey; buff weathering; sublithographic to finely crystalline; thinly to thickly bedded.	0.63	9.48-10.11
4	Limestone, with shaly partings - dark grey; bluish grey weathering; lithographic to finely crystalline; thinly to thickly bedded.	5.32	4.16-9.48

Section LO OT-5: (cont.) Dibblee Construction Company Limited, Fallowfield
Nepean Township, Lot 21, Concession 4
UTM 437500E, 5013400N
Elevation 90.00 m±
See also Hewitt 1964a, p. 39 (7.6m); Bolton and Liberty 1972, p. 23); Derry et al. 1989, p. 63-64 (CP-16, 18.7 m)

Gull River Formation (lower member)

3	Limestone, with shaly partings - dark grey; bluish grey to dark grey weathering; thinly to thickly bedded; oolitic, intraclastic.	0.55 m	3.61-4.16 m
2	Silty dolostone, with shaly partings - greenish grey; buff to reddish brown weathering; sublithographic to finely crystalline; thinly to medium bedded; calcitic in places, intraclastic.	1.15	2.46-3.61
1	Limestone, with shaly partings - dark grey; bluish grey weathering; lithographic to finely crystalline; thinly to thickly bedded; intraclastic; brachiopods.	2.46	0.00-2.46

Section LO OT-6: George Kennedy, Dunrobin (to north of fault)
Torbolton Township, Lot 1, Concession 5
UTM 422800E, 5031500N
Elevation 60.00 m±
See also Derry et al. 1989, p. 50-51 (CP-6, 5.0 m)

Rockcliffe Formation

2	Quartz sandstone, with dark green shale interbeds - light greenish grey; greenish grey weathering; fine grained; thinly to medium bedded; slightly calcareous.	3.50 m	1.50-5.00 m

Oxford Formation

1	Dolostone - medium grey; buff to reddish brown weathering; sub-lithographic; medium bedded.	1.50	0.00-1.50

Section LO OT-7: Armbro Aggregates, South Gloucester
Gloucester Township, Lots 23 to 25, Concession 5
UTM 455150E, 5016500N
Elevation 85.00 m±
See also Hewitt 1960, p. 24 (2.7m); Hewitt 1964a, p. 26 (6.4m); Hewitt and Vos, 1972, p. 7 (12.8m); Rogers 1980, p. 40-44; Derry et al. 1989, p. 64-67 (CP-17, 27.3 m)

Oxford Formation

12	Dolostone, with shaly partings - brownish grey; greenish grey to buff to reddish brown weathering; finely to medium crystalline; very thinly to thickly bedded; calcite-filled vugs, calcitic.	12.11 m	15.19-27.30 m

Section LQ OT-7: (cont.) Armbro Aggregates, South Gloucester
Gloucester Township, Lots 23 to 25, Concession 5
UTM 455150E, 5016500N
Elevation 85.00 m±
See also Hewitt 1960, p.24 (2.7m); Hewitt 1964a, p.26 (6.4m); Hewitt and Vos, 1972, p.7 (12.8m); Rogers 1980, p.40-44; Derry et al. 1989, p. 64-67 (CP-17, 27.3 m)

March Formation

11	Sandy dolostone - brownish grey; medium grey weathering; fine to coarse grained quartz; calcite-filled vugs, calcitic.	0.38 m	14.81-15.19 m
10	Quartz sandstone - white to light grey; white to reddish brown weathering; very fine to medium grained.	0.29	14.52-14.81
9	Dolostone, with shaly partings - brownish grey; greenish grey to buff weathering; finely to medium crystalline; calcite-filled vugs, calcitic.	0.34	14.18-14.52
8	Quartz sandstone - white to light grey; white to reddish brown weathering; very fine to medium grained.	0.90	13.28-14.18
7	Dolostone, with shaly partings - brownish grey; greenish grey to buff weathering; finely to medium crystalline; medium bedded; calcite-filled vugs, calcitic.	3.15	10.13-13.28
6	Quartz sandstone - white to light grey; white to reddish brown weathering; very fine to medium grained.	0.30	9.83-10.13
5	Dolostone, with shaly partings - light grey; greenish grey weathering; sub-lithographic to finely crystalline; thinly bedded; calcitic.	0.16	9.67-9.83
4	Sandy dolostone - brownish grey; medium grey weathering; fine to coarse grained quartz; calcite-filled vugs, calcitic.	1.10	8.57-9.67
3	Quartz sandstone - white to light grey; white to reddish brown weathering; very fine to medium grained. Top of lower lift at 7.09 m.	1.48	7.09-8.57
2	Sandy dolostone - brownish grey; medium grey weathering; fine to coarse grained quartz; thinly to thickly bedded; calcite-filled vugs, calcitic.	2.79	4.30-7.09
1	Quartz sandstone, with dark calcareous partings - white to light grey; white to reddish brown weathering; very fine to medium grained; thinly to massive bedded; cross bedded in places.	4.30	0.00-4.30

Section LO OT-8: Dibblee Construction Company Limited, South Gloucester
Gloucester Township, Lot 25, Concession 5
UTM 455600E, 5016600N
Elevation 95.00 m±
See also Hewitt 1964a, p.27 (6.1m); Hewitt and Vos 1972, p.10-11 (18.4); Rogers 1980, p.45-48; Derry et al. 1989, p. 67-68 (CP-18, 15.2 m)

	Oxford Formation		
11	Dolostone - medium grey; buff weathering; finely crystalline; thinly bedded.	1.10 m	11.05-12.15 m
10	Dolostone - light grey; light grey weathering; finely crystalline; thinly bedded, intraclastic.	0.80	10.25-11.05
9	Dolostone - medium grey; medium grey weathering; fine crystalline.	0.40	9.85-10.25
8	Dolostone, with shaly partings - light grey; light grey weathering; sublithographic; thinly to medium bedded.	0.55	9.30-9.85
7	Dolostone - medium grey; light medium grey weathering; finely crystalline; medium bedded; calcite-filled vugs.	1.70	7.60-9.30
6	Dolostone, with shaly partings - light to medium grey; medium grey weathering; finely crystalline; thinly bedded; calcite-filled vugs.	3.00	4.60-7.60
	March Formation		
5	Sandy dolostone - brownish grey; medium grey weathering; fine to coarse grained quartz; calcite-filled vugs, calcitic.	0.38	4.22-4.60
4	Quartz sandstone - white to light grey; white to reddish brown weathering; very fine medium grained.	0.29	3.93-4.22
3	Dolostone - with shaly partings - brownish grey; greenish grey to buff weathering; finely to medium crystalline; calcite-filled vugs, calcitic.	0.34	3.59-3.93
2	Quartz sandstone - white to light grey; white to reddish brown weathering; very fine to medium grained.	0.90	2.69-3.59
1	Dolostone, with shaly partings - brownish grey; greenish grey to buff weathering; finely to medium crystalline; medium bedded; calcite-filled vugs, calcitic.	2.69	0.00-2.69

Section LO OT-9: Bertrand Concrete Products Ottawa Inc., South Gloucester
Gloucester Township, Lots 27 and 28, Concession 5
UTM 456200E, 5016050N
Elevation 100.00 m±
See also Hewitt and Vos 1972, p. 8-9 (7.5m); Rogers 1980, p. 51-52; Derry et al. 1989, p. 68-70 (CP-19, 13.5 m)

Oxford Formation

7	Dolostone, with shaly partings - light grey; buff weathering; sublithographic; thinly to medium bedded.	1.50 m	7.30-8.80 m
6	Dolostone - light grey; weathering light green; sublithographic; thinly bedded.	0.90	6.40-7.30
5	Dolostone, with shaly partings - medium grey; medium to dark grey weathering; finely crystalline; medium bedded; calcite-filled vugs.	1.10	5.30-6.40
4	Dolostone - light grey; light grey weathering; finely crystalline; thinly bedded; calcite-filled vugs.	0.90	4.40-5.30
3	Dolostone - dark grey; dark brown to dark grey weathering; finely crystalline; calcite-filled vugs.	1.40	3.00-4.40
2	Dolostone, with shaly partings - light grey; medium grey weathering; finely crystalline; stylolites, calcite-filled vugs.	0.75	2.25-3.00
1	Dolostone, with shaly partings - medium grey; dark grey weathering; finely crystalline; medium to thick bedded; calcite-filled vugs.	2.25	0.00-2.25

Section LO OT-10: George W. Drummond Limited, South Gloucester
Gloucester Township, Lot 28, Concession 6
UTM 457050E, 5016250N
Elevation 95.00 m±
See also Rogers 1980, p. 49-50 (9.9m); Derry et al. 1989, p. 71-73 (CP-20, 11.9 m)

Oxford Formation

7	Dolostone - light grey; buff weathering finely crystalline.	0.25 m	6.50-6.75 m
6	Dolostone, with shaly partings - medium grey; medium to dark grey weathering; finely crystalline; medium bedded; calcite-filled vugs.	2.90	3.60-6.50
5	Dolostone, with shaly partings - medium grey; medium to dark grey weathering; finely crystalline; medium bedded.	1.90	1.70-3.60

Section LO OT-10: (cont.) George W. Drummond Limited, South Gloucester
Gloucester Township, Lot 28, Concession 6
UTM 457050E, 5016250N
Elevation 95.00 m±
See also Rogers 1980, p. 49-50 (9.9m); Derry et al. 1989, p. 71-73 (CP-20, 11.9 m)

March Formation

4	Sandy dolostone-brownish grey; medium grey weathering; fine to coarse grained quartz; calcite-filled vugs, calcitic.	0.38 m	1.32-1.70 m
3	Quartz sandstone - white to light grey; white to reddish brown weathering; very fine to medium grained.	0.29	1.03-1.32
2	Dolostone, with shaly partings - brownish grey; greenish grey to buff weathering; finely to medium crystalline; calcite-filled vugs, calcitic.	0.34	0.69-1.03
1	Quartz sandstone - white to light grey; white to reddish brown weathering; very fine to medium grained.	0.69	0.00-0.69

Section LO OT-11a: Francon Ottawa-Division of Canfarge Limited, Blackburn (to north of fault)
(previous operator: Ottawa Valley Crushed Stone Limited)
Gloucester Township, Lots 12 to 14, Concession 2
UTM 455600E, 5032600N
Elevation 70.00 m±
See also Hewitt 1960, p. 74-77 (26.2 m); Bolton and Liberty 1972, p. 20-21; Derry et al. 1989, p. 74-76 (CP-22 north, 63.3 m)

Bobcaygeon Formation (lower member)

8	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish to brownish grey weathering; sublithographic to finely crystalline; very thinly to massive bedded; nodular beds up to 35 cm thick.	6.80 m	31.45-38.25 m
7	Limestone, with irregular shaly partings - medium to dark grey; bluish grey to buff to reddish brown weathering; sublithographic to finely crystalline; very thinly to massive bedded; crinoids, brachiopods, bryozoa, corals, trilobites.	10.90	20.55-31.45

Gull River Formation (upper member)

6	Limestone, with shaly partings - dark grey; bluish grey weathering; lithographic to sublithographic; very thinly to thickly bedded; "birdseye" texture in places; cephalopods, abundant Tetradium. Base of upper lift at 16.85 m.	6.14	14.41-20.55
5	Limestone - dark grey; bluish grey to dark grey weathering; oolitic.	0.30	14.11-14.41

Section LQ OT-11a: (cont.) Francon Ottawa-Division of Canfarge Limited, Blackburn, (to north of fault)
(previous operator: Ottawa Valley Crushed Stone Limited)
Gloucester Township, Lots 12 to 14, Concession 2
UTM 455600E, 5032600N
Elevation 70.00 m±
See also Hewitt 1960, p.74-77 (26.2 m); Bolton and Liberty 1972, p.20-21; Derry *et al.* 1989, p. 74-76 (CP-22 north, 63.3 m)

Gull River Formation (upper member)

4	Limestone, with shaly partings - dark grey; bluish grey weathering; lithographic to sublithographic; very thinly to thickly bedded; "birdseye" texture in places. Top of lower lift at 13.75 m.	1.76 m	12.35-14.11 m

Gull River Formation (lower member)

3	Silty dolostone - dark brownish grey; buff weathering; finely crystalline; calcitic.	0.40	11.95-12.35
2	Limestone - medium to dark brownish grey; bluish grey weathering; lithographic to finely crystalline; thinly to thickly bedded; dolomitic interbeds up to 40 cm thick, commonly intraclastic; brachiopods, bryozoa.	7.33	4.62-11.95
1	Limestone, with shaly partings and interbeds up to 5 cm thick of finely crystalline silty dolostone - medium to dark brownish grey; bluish grey weathering; lithographic to sublithographic; thinly to thickly bedded; intraclastic in places; "birdseye" texture in places, stylolites brachiopods, gastropods.	4.62	0.00-4.62

Section LQ OT-11b: Francon Ottawa-Division of Canfarge Limited, Blackburn (to south of fault)
(previous operator: Ottawa Valley Crushed Stone Limited)
Gloucester Township, Lots 12 to 14, Concession 2
UTM 455600E, 5032600N
Elevation 50.00 m±
See also Hewitt and Vos 1972, p.23-24 (14.9m); Derry *et al.* 1989, p. 74-76 (CP-22 south, 72.1 m)

Bobcaygeon Formation (upper member)

2	Limestone - medium to dark brownish grey; bluish to brownish grey weathering; sub-lithographic to medium crystalline; thinly to massive bedded; nodules up to 5 cm in diameter of black chert; brachiopods.	30.00 m	25.00-55.00 m

Bobcaygeon Formation (middle member)

1	Limestone, with shaly partings - medium to dark brownish grey; bluish to brownish grey weathering; sublithographic to medium crystalline; thinly to massive bedded; brachiopods.	25.00	0.00-25.00

Section AQ OT-1: Frazer Duntile Limited, Ottawa (Clyde Avenue)
UTM 441500E, 5024300N
Elevation 90.00 m±
See also Goudge 1938, p. 51, 53 (19.8m); Hewitt p.1960, p. 72-74 (21.9m); Barnes 1967, p. 238.

Bobcaygeon Formation (lower member)

2	Limestone - medium to dark grey; light grey weathering; lithographic to finely crystalline; medium to thickly bedded.	5.10 m	4.70-9.80 m

Gull River Formation (upper member)

1	Limestone, with shaly partings - medium grey; light grey weathering; finely crystalline; thinly to medium bedded.	4.70	0.00-4.70

Section AQ OT-2: Campeau Corporation, Ottawa (McCarthy Road)
(previous operator: Dibblee Construction Company Limited)
UTM 447600E, 5022100N
Elevation 80.00 m±
See also Hewitt 1960, p.77-79 (20.1m)

Bobcaygeon Formation (lower member)

13	Limestone, with undulating shaly partings - dark grey; brownish grey weathering; finely crystalline; thinly to thickly bedded; lenses and nodules of dark chert at 18.17 m.	4.00 m	16.87-20.87 m

Gull River Formation (upper member)

12	Limestone - medium to dark grey; light grey weathering; lithographic to sublithographic; thinly to medium bedded; stylolites; abundant *Tetradium* at 16.37-16.87 m.	2.00	14.87-16.87
11	Limestone - medium to dark grey, light grey weathering; lithographic; medium bedded.	1.05	13.82-14.87
10	Limestone - medium to dark grey; light grey weathering; lithographic to finely crystalline; medium bedded; oolitic and intraclastic in places.	2.90	10.92-13.82
9	Limestone, with shaly partings - light grey; light grey to brownish grey weathering; lithographic to finely crystalline; thinly bedded.	1.10	9.82-10.92
8	Limestone, with shaly partings - medium grey; brownish grey weathering; sublithographic; medium bedded.	1.80	8.02-9.82

Section AQ OT-2: (cont.) Campeau Corporation, Ottawa (McCarthy Road)
(previous operator: Dibblee Construction Company Limited)
UTM 447600E, 5022100N
Elevation 80.00 m±
See also Hewitt 1960, p. 77-79 (20.1m)

Gull River Formation (lower member)

7	Silty dolostone, with shaly partings - greenish grey; buff weathering; sub-lithographic to finely crystalline; thinly to medium bedded.	0.40 m	7.62-8.02 m
6	Limestone, with shaly partings - medium grey; light grey weathering; lithographic; thinly to medium bedded; oolitic and intraclastic in places; cephalopods,. brachiopods.	2.90	4.72-7.62
5	Silty dolostone, with shaly partings - greenish grey; light green weathering; sublithographic to finely crystalline; thinly bedded.	1.40	3.32-4.72
4	Limestone - medium to dark grey; light grey weathering; sublithographic to finely crystalline; intraclastic.	1.47	1.85-3.32
3	Limestone, with shaly partings - medium to dark grey; light grey weathering; finely crystalline; thinly to medium bedded; intraclastic.	0.95	0.90-1.85
2	Limestone - medium to dark grey; light grey weathering; lithographic to sublithographic.	0.50	0.40-0.90
1	Limestone - medium grey; light grey weathering; sublithographic; oolitic.	0.40	0.00-0.40

Section AQ OT-3: D. Grandmaitre Limited Ottawa (Montreal Road)
UTM 450800E, 5032450N
Elevation 100.00 m±
See also Hewitt 1960, p. 80-81 (12.2m)

Bobcaygeon Formation (upper member)

No longer exposed

Section AQ OT-4: Minto Construction Limited, Orleans
(previous operator: Frazer Duntile Limited)
Gloucester Township, Lot 2, Concession 1
UTM 458750E, 5036400N
Elevation 50.00 m±
See also Hewitt 1964a, p. 40 (7.6m); Hewitt and Vos 1972, p. 25

Bobcaygeon Formation (middle member)

1	Limestone, with shaly partings - medium to dark grey; bluish grey to buff to reddish brown weathering; sublithographic to finely crystalline; medium to thickly bedded; brachiopods, cephalopods, colonian corals.	8.80 m	0.00-8.80 m

Section AO OT-5: Campbell, Nepean
Nepean Township, Lot 3, Concession 2
UTM 431750E, 5018800N
Elevation 105.00 m±
See also Hewitt 1964b, p. 17

Nepean Formation

No longer exposed.

Section AO OT-6: Tillson, Nepean,
Nepean Township, Lot 6, Concession 2
UTM 432450E, 5019400N
Elevation 100.00 m±
See also Hewitt 1964b, p. 18

Nepean Formation

No longer exposed.

Section AO OT-7: Nepean (Corkstown Road)
Nepean Township, Lot 6, Concession 1
UTM 432200E, 5020000N
Elevation 105.00 m±
See also Hewitt 1964b, p. 17-18 (3.0m)

Nepean Formation

1	Quartz sandstone - white, white to reddish brown weathering; fine to medium grained; thinly to massive bedded; ripple marks, non-calcareous.	1.75 m	0.00-1.75 m

Section AO OT-8: T. Sidney Kirby Company Ltd, Ottawa (St. Laurent Blvd)
UTM 448500E, 5032500N
Elevation 65.00 m±
See also Goudge 1938, p. 52-54 (10.4m); Uyeno 1974, p. 21-22 (10.3m)

Bobcaygeon Formation (upper member)

2	Limestone - light grey; bluish grey weathering; medium crystalline; medium to thickly bedded; stylolites, cross-bedded; corals, bryozoa, brachiopods.	6.00 m	2.60-8.60 m

Bobcaygeon Formation (middle member)

1	Limestone, with shaly partings - medium to dark grey; light bluish grey weathering; sublithographic to finely crystalline; very thinly to medium bedded; intra-clastic in places; beds and lenses up to 5 cm thick of black chert.	2.60	0.00-2.60

Section AO OT-9: Laurentian Stone Company Limited, Ottawa (Montreal Road)
UTM 451400E, 5032400N
Elevation 100.00 m±
See also Goudge 1938, p. 54-57 (8.2m); Uyeno 1974, p. 21 (6.7m)

Bobcaygeon Formation (upper member)

No longer exposed.

Section AO OT-10: Ottawa (Mooney's Bay)
UTM 445750E, 5023950N
Elevation 85.00 m±
See also Wilson 1956a, p. 28-29; Uyeno 1974, p. 21 (12.1m).

Bobcaygeon Formation (upper member)

No longer exposed.

Section S OT-1: roadcut, Harwood Plains (to north of fault)
UTM 425550E, 5025500N
Elevation 75.00 m±

March Formation

6	Quartz sandstone - white; white to reddish brown weathering; medium to coarse grained; medium to thickly bedded; non-calcareous; burrows.	2.26 m	3.77-6.03 m
5	Dolostone, with sandy dolostone interbeds - very thinly to thinly bedded.	0.29	3.48-3.77
4	Quartz sandstone - white; white to reddish brown weathering; medium to coarse grained; thinly to thickly bedded; non-calcareous.	0.88	2.60-3.48
3	Dolostone - light to dark grey; buff to medium grey weathering; finely crystalline; thinly to medium bedded; gastropods.	0.60	2.00-2.60
2	Sandy dolostone - light to medium grey buff to reddish brown weathering; medium to coarse grained quartz; medium to thickly bedded.	0.90	1.10-2.00
1	Quartz sandstone - white; white to buff weathering; medium to coarse grained (one very coarse grained bed less than 1 cm thick); thickly bedded; slightly calcareous in places.	1.10	0.00-1.10

Section S OT-2: roadcut, Harwood Plains
UTM 426500E, 5026400N
Elevation 65.00 m±

Oxford Formation

4	Dolstone - medium grey; buff to reddish brown weathering; fine crystalline; thinly bedded; stromatolites.	0.40 m	3.20-3.60 m
3	Dolostone, with shaly interbeds up to 10 cm thick containing glauconite and dendrites - light to dark grey; buff to reddish brown weathering; sublithographic to finely crystalline; medium to thickly bedded; calcite-filled vugs.	2.05	1.15-3.20

Section S OT-2: (cont.) roadcut, Harwood Plains
UTM 426500E, 5026400N
Elevation 65.00 m±

Oxford Formation

2	Dolostone, with sandy interbeds up to 3 cm thick-medium grey; buff to reddish brown weathering; finely crystalline; medium bedded.	0.58	0.57-1.15

March Formation

1	Sandy dolostone - light brownish grey; buff weathering; medium to coarse grained quartz; medium bedded.	0.57	0.00-0.57

Section S OT-3: roadcut, Nepean (Queensway)
UTM 432450E, 5019700N
Elevation 100.00 m±
See also Greggs and Bond 1972 (6.9m), 1977; Brand and Rust 1977a (6.8m), 1977b

March Formation

6	Sandy dolostone-light brownish grey; light grey to buff weathering; medium to coarse grained quartz; calcitic, glauconitc, dolostone intraclasts.	0.35 m	6.35-6.70 m

Nepean Formation

5	Quartz sandstone - white; white to reddish brown weathering; fine to medium grained; very thinly to medium bedded; calcareous, ripple marks, crossbedded; burrows.	1.30	5.05-6.35
4	Quartz sandstone - white to dark grey; white to reddish brown weathering; fine to medium grained; thinly to medium bedded; calcareous.	0.92	4.13-5.05
3	Quartz sandstone - white; white to reddish brown weathering; coarse grained; thinly to medium bedded calcareous, crossbedded, recessive.	0.34	3.79-4.13
2	Quartz sandstone - white to dark grey, white to reddish brown weathering; fine to medium grained; very thinly to medium bedded; calcareous in places.	1.21	2.58-3.79
1	Quartz sandstone, white; white to reddish brown weathering; fine to medium grained; thinly to massive bedded; calcareous in places, crossbedded.	2.58	0.00-2.58

Section S OT-4: cliff, Ottawa, (Saint Laurent Blvd.)
UTM 449300E, 5032050N
Elevation 65.00 m±

Lindsay Formation (upper member)

5	Black shale, with interbed of finely crystalline limestone 10 cm thick.	0.45 m	6.55-7.00 m

Lindsay Formation (lower member)

4	Limestone - medium to dark grey; light bluish grey weathering; sublithographic to finely crystalline; thinly to medium bedded; nodular; crinoids, brachiopods.	2.85	3.70-6.55

Lindsay Formation (lower member)

3	Limestone - medium to dark grey; light bluish grey weathering; sublithographic to finely crystalline; thinly bedded; recessive, nodular; brachiopods.	0.75	2.95-3.70
2	Limestone - medium to dark grey; light bluish grey weathering; sublithographic to finely crystalline; medium to thickly bedded; nodular; crinoids, brachiopods.	0.85	2.10-2.95
1	Limestone - medium grey; light bluish grey weathering; finely crystalline; thinly bedded; nodular; brachiopods.	2.10	0.00-2.10

Section S OT-5a: rivercut, Ottawa (Prince of Wales Falls, Hog's Back Park, Northeast bank of Rideau River) (fault block B in Figure 5)
UTM 445500E, 5024200N
Elevation 60.00 m±
See also Raymond 1911, p. 190-191 (16.4m); Vollrath 1962, p. 19-25 (18.7m)

Gull River Formation (lower member)

10	Silty dolostone, with interbeds of limestone up to 10 cm thick-greenish grey; light brown weathering; finely crystalline; thinly to thickly bedded.	1.70 m	15.95-17.65 m
9	Limestone - light grey; bluish grey weathering; sublithographic to finely crystalline; medium bedded.	0.15	15.80-15.95
8	Silty dolostone with interbeds of shale up to 10 cm thick - greenish grey; light brown weathering; finely crystalline; thinly to thickly bedded.	2.00	13.80-15.80
7	Limestone, with dolomitic mottling - light grey; bluish grey weathering; sublithographic to finely crystalline; thinly to thickly bedded; ripply marks at 12.08 m.	2.15	11.65-13.80

Section S OT-5a: rivercut, Ottawa (Prince of Wales Falls, Hog's Back Park, Northeast bank of Rideau River) (fault block B in Figure 5)
UTM 445500E, 5024200N
Elevation 60.00 m±
See also Raymond 1911, p.190-191 (16.4m); Vollrath 1962, p.19-25 (18.7m)

	Shadow Lake Formation		
6	Silty dolostone, with thin interbeds of fine grained (coarse grained in places) quartz sandstone - greenish grey; light brown weathering; finely crystalline; very thinly to thickly bedded.	2.45 m	9.20-11.65 m
	Rockcliffe Formation (upper member)		
5	Interbedded calcitic silty dolostone and dark green shale, with interbeds of limestone up to 10 cm thick and thin interbeds of coarse grained quartz sandstone - very thinly to medium bedded; ripply marks at 5.65 m.	5.30	3.90-9.20
4	Quartz sandstone, with dark green shaly partings - light green; fine grained (coarse grained, 3.71-3.77 m); very thinly to thickly bedded; calcareous.	1.45	2.45-3.90
3	Shale - dark green; very thinly bedded.	0.45	2.00-2.45
2	Quartz sandstone - dark grey; coarse grained; thickly bedded.	0.35	1.65-2.00
1	Quartz sandstone, with dark green shale partings - light green; fine grained; very thinly to thickly bedded; calcareous.	1.65	0.00-1.65

Section S OT-5b: rivercut, Ottawa (Prince of Wales Falls, Hog's Back Park, northeast bank of Rideau River) (fault block C in Figure 5)
UTM 445500E, 5024200N
Elevation 65.00 m±
See also Raymond 1911, p.192 (13.5m)

	Gull River Formation (lower member)		
6	Limestone - medium to dark brownish grey; bluish grey weathering; lithographic to sublithographic; very thinly to thickly bedded; stromatolites.	1.00 m	12.50-13.50 m
5	Quartz sandstone - light greenish grey; reddish brown weathering; fine grained; thinly to thickly bedded; calcareous.	1.20	11.30-12.50
4	Limestone, with interbedded shale - dark brownish grey; bluish grey weathering; sublithographic; very thinly to thinly bedded.	0.45	10.85-11.30

Section S OT-5b: rivercut, Ottawa (Prince of Wales Falls, Hog's Back Park, northeast bank of Rideau River) (fault block C in Figure 5)
UTM 445500E, 5024200N
Elevation 65.00 m±
See also Raymond 1911, p. 192 (13.5m)

Gull River Formation (lower member)

3	Silty dolostone - light greenish grey to dark brownish grey; buff to reddish brown weathering; finely to medium crystalline; very thinly to massive bedded; calcitic; burrows.	1.40 m	9.45-10.85 m
2	Limestone, with interbedded shale - dark brownish grey; bluish to brownish grey weathering; sublithographic to finely crystalline; very thinly to thinly bedded.	1.45	8.00-9.45
1	Silty dolostone, with interbedded shale - light greenish grey to dark brownish grey; buff to reddish brown weathering; sublithographic to medium crystalline; very thinly to massive bedded; calcitic; burrows.	8.00	0.00-8.00

Section S OT-6: cliff, Ottawa (Rideau Falls)
UTM 445350E, 5031700N
Elevation 40.00 m±

Lindsay Formation (lower member)

2	Limestone - dark grey; bluish grey to light brown weathering; sublithographic to finely crystalline; thinly to thickly bedded; nodular; brachiopods.	5.85 m	2.30-8.15 m

Verulam Formation

1	Limestone, with shale interbeds up to 15 cm thick - light to dark grey; bluish grey weathering; finely to medium crystalline; very thinly to medium bedded; intraclastic; brachiopods, bryozoa, crinoids.	2.30	2.30-8.15

Section S OT-7: cliff, Ottawa (Rockcliffe Park)
UTM 446900E, 5033500N
Elevation 60.00 m±

Rockcliffe Formation (lower member)

5	Quartz sandstone, with dark green shale interbeds-light greenish grey; greenish grey weathering; fine grained; very thinly to thinly bedded; non-calcareous.	3.00 m	3.30-6.30 m
4	Quartz sandstone - light greenish grey; greenish grey weathering; fine grained; very thinly to medium bedded; non-calcareous.	0.95	2.35-3.30

<u>Section S OT-7:</u> (cont.) cliff, Ottawa (Rockcliffe Park)
UTM 446900E, 5033500N
Elevation 60.00 m±

Rockcliffe Formation (lower member)

3	Quartz sandstone - greenish grey; buff to reddish brown weathering; coarse to very coarse grained; calcareous.	0.10 m	2.25-2.35 m
2	Quartz sandstone, with dark green shale interbeds - light greenish grey; greenish grey weathering; fine grained; very thinly to thickly bedded; non-calcareous.	1.35	0.90-2.25
1	Quartz sandstone - light greenish grey; greenish grey weathering; fine grained; very thinly to thickly bedded; non-calcareous.	0.90	0.00-0.90

<u>Section S OT-8:</u> roadcut, Ottawa (Victoria Island)
UTM 443900E, 5029600N
Elevation 45.00 m±

Verulam Formation

1	Limestone, with shale interbeds - medium grey; light grey weathering; sub-lithographic to coarsely crystalline; thinly to medium bedded; ripple marks; burrows, crinoids, brachiopods trilobites, gastropods, bryozoa.	2.20 m	0.00-2.20 m

<u>Section S OT-9:</u> roadcut, Rothwell Heights
UTM 451700E, 5033850N
Elevation 55.00 m±

Rockcliffe Formation (lower member)

4	Quartz sandstone-light grey; light greenish grey weathering; fine grained; very thinly to thickly bedded; non-calcareous.	2.67 m	1.13-3.80 m
3	Quartz sandstone, with dark green micaceous shale interbeds - light grey; light greenish grey weathering; fine grained; non-calcareous, crossbedded.	0.23	0.90-1.13
2	Quartz -pebble conglomerate -medium grey; medium grey weathering; very thinly to medium bedded.	0.65	0.25-0.90

Oxford Formation

1	Dolostone - medium to dark grey; buff to reddish brown weathering; sublithographic; thinly bedded; calcitic.	0.25	0.00-0.25

Section S OT-10: cliff, Ottawa (CFB Rockcliffe)
UTM 450850E, 5033380N
Elevation 55.00 m±

Rockcliffe Formation (upper member)

19	Quartz sandstone, with shaly partings and interbeds up to 25 cm thick of sublithographic limestone and sandy limestone - light grey; greenish grey weathering; fine grained; calcareous.	1.35 m	19.05-20.40 m
18	Silty dolostone - light grey; reddish brown weathering; finely crystalline; calcitic, conchoidal fractures.	0.70	18.35-19.05
17	Quartz sandstone, with shaly partings-light grey; greenish grey weathering; fine grained; very thinly bedded; calcareous.	0.15	18.20-18.35
16	Silty dolostone - light grey; reddish brown weathering; fine crystalline; calcitic, conchoidal fractures.	0.30	17.90-18.20
15	Quartz sandstone, with shaly partings-light grey; greenish grey weathering; fine grained; very thinly bedded; calcareous.	0.30	17.60-17.90
14	Silty dolostone-light grey; reddish brown weathering; finely crystalline; calcitic.	0.07	17.35-17.60
13	Shale - green.	0.30	17.23-17.35
12	Siltstone, with shaly partings - medium to dark grey; greenish buff weathering.	0.60	16.63-17.23
11	Shale, with interbeds up to 5 cm thick of silty dolostone - dark grey.	2.50	14.13-16.63
10	Silty dolostone - light grey; reddish brown weathering; finely crystalline; non-calcitic.	0.15	13.98-14.13
9	Quartz sandstone, with shaly partings - light grey; greenish grey weathering; fine grained; calcareous.	0.16	13.82-13.98
8	Shale - dark grey	0.44	13.38-13.82
7	Quartz sandstone - light grey; greenish grey weathering; coarse to very coarse grained; calcareous; crossbedded.	0.18	13.20-13.38
6	Quartz sandstone, with dark green shale interbeds - light grey; light greenish grey weathering; fine grained; very thinly to thickly bedded; non-calcareous, cross-bedded.	2.20	11.00-13.20

Section S OT-10: (cont.) cliff, Ottawa (CFB Rockcliffe)
UTM 450850E 5033850N
Elevation 55.00 m±

Rockcliffe Formation (upper member)

5	Silty dolostone - medium grey; brown weathering; fine crystalline; non-calcitic, conchoidal fractures.	0.70 m	10.30-11.00 m

Rockcliffe Formation (lower member)

4	Shale - dark gren.	1.80	8.50-10.30
3	Quartz sandstone - light grey; greenish grey weathering; coarse to very coarse grained; calcareous.	0.20	8.30-8.50
2	Shale - dark green.	0.30	8.00-8.30
1	Quartz sandstone, with dark green shale interbeds-light grey; light greenish grey weathering; fine grained; very thinly to thickly bedded; non-calcareous, crossbedded.	8.00	0.00-8.00

Section S OT-11a: roadcut, Cyrville (Highway 417) (to north of fault)
UTM 452000E, 5029700N
Elevation 65.00 m±

Billings Formation

1	Shale - black; cephalopods; inarticulate brachiopods, graptolites.	10.00 m	0.00-10.00 m

Section S OT-11b: roadcut, Cyrville (Highway 417) (to south of fault)
UTM 452000E, 5029700N
Elevation 65.00 m±

Carlsbad Formation

1	Siltstone, with interbeds of silty bioclastic limestone and shale - medium grey to greenish grey; very thinly to thinly bedded; abundant crinoids, brachiopods, bryozoa.	3.50 m	0.00-3.50 m

Section LO PE-1: O. Shirley and Son, Smith's Falls
South Elmsley Township, Lots 9 and 10, Concession 3
UTM 416450E, 4968150N
Elevation 120.00 m±
See also Goudge 1938, p.120 (1.2m); Rogers 1980, p.68-69 (7.4m);
Derry et al. 1989, p. 87-88 (BR-4, 11.0 m)

March Formation

1	Sandy dolostone, with interbeds of dolostone and calcareous quartz sandstone-medium to coarse grained quartz; medium bedded; calcite-filled vugs.	11.00 m	0.00-11.00 m

Section LQ PE-2: G. Tackaberry & Sons Construction Company Ltd., Newbliss
Kitley Township, Lots 14 to 16, Concession 3
UTM 420700E, 4961800N
Elevation 120.00 m±
See also Derry et al. 1989, p. 88 (BR-5, 8.0 m)

Oxford Formation

2	Dolostone - light grey to light brownish grey; light grey to light brown weathering; finely to medium crystalline; medium bedded.	2.50 m	1.60-4.10 m
1	Dolostone - medium grey; medium grey weathering; finely to medium crystalline; medium bedded; calcite-filled vugs.	1.60	0.00-1.60

Section LQ PE-3: Ivan and Donald Wills, Mill Pond
South Burgess Township, Lot 6, Concessions 2 and 3
UTM 406300E, 4957800N
Elevation 125.00 m±

Covey Hill Formation

7	Boulder conglomerate, with matrix of well rounded, poorly sorted, coarse grained quartz sand.	5.00 m	8.00-13.00 m
6	Quartz sandstone, with pebbles - medium brown; medium bedded; poorly sorted.	1.00	7.00-8.00
5	Quartz sandstone with pebbles and cobbles - green; very poorly sorted.	2.30	4.70-7.00
4	Covered interval.	1.00	3.70-4.70
3	Quartz-pebble conglomerate - medium brown; thinly bedded; poorly sorted.	0.80	2.90-3.70
2	Quartz-pebble conglomerate - brown; massive; rounded to angular clasts.	1.70	1.20-2.90
1	Conglomerate - reddish brown; massive.	1.20	0.00-1.20

Section LQ PE-4: Dibblee Construction Company Limited, Smith's Falls
Montague Township, Lots 27 and 28, Concession 5
UTM 419800E, 4974800N
Elevation 130.00 m±
See also Goudge 1938, p. 118; Hewitt 1964b, p. 19 (4.6m); Rogers 1980, p. 63; Derry et al. 1989, p. 52-53 (CP-8, 5.2 m)

March Formation

6	Sandy dolostone - light grey to light brownish grey; light brownish grey weathering; finely crystalline; medium to coarse grained well rounded quartz; thinly to medium bedded; calcite-filled vugs; gastropods.	2.30 m	2.85-5.15 m

Section LQ PE-4: (cont) Dibblee Construction Company Limited, Smith's Falls
Montague Township, Lots 27 and 28, Concession 5
UTM 419800E, 4974800N
Elevation 130.00 m±
See also Goudge 1938, p. 118; Hewitt 1964b, p. 19 (4.6m); Rogers 1980, p. 63; Derry et al. 1989, p. 52-53 (CP-8, 5.2 m)

March Formation

5	Quartz sandstone-light grey to light green weathering; medium grained; medium bedded; well rounded, well sorted, calcareous.	0.45 m	2.40-2.85 m
4	Sandy dolostone - light grey; light brownish grey weathering; finely crystalline; coarse grained well rounded quartz; thinly bedded.	0.55	1.85-2.40
3	Covered interval. Base of first lift at 1.50 m.	0.35	1.50-1.85
2	Sandy dolostone - light brown to light brownish grey; light brownish grey weathering; finely crystalline; medium to coarse gravel well rounded quartz; thin to medium bedded; calcite-filled vugs.	0.80	0.70-1.50
1	Dolostone - medium grey; light to medium grey weathering; finely crystalline; thin bedded; calcite-filled vugs.	0.70	0.00-0.70

Section AQ PE-1: Oliver, Perth
North Elmsley Township, Lot 27, Concession 9
UTM 402800E, 4970850N
Elevation 140.00 m±
See also Rogers 1980, p. 70 (2.0m)

Nepean Formation

1	Quartz sandstone - light grey; reddish brown weathering; medium grained; massive; well rounded, well sorted, non-calcareous.	2.00 m	0.00-2.00 m

Section AQ PE-2: Ontario Building Materials Limited, Smith's Falls
Montague Township, Lot 29, Concession 5
UTM 419200E, 4974100N
Elevation 125.00 m±
See also Hewitt 1963, p. 23 (3.0m)

March Formation

3	Quartz sandstone-light grey, reddish brown weathering; medium grained; medium bedded; well rounded, well sorted, non-calcareous.	1.50 m	1.00-2.50 m
2	Sandy dolostone - light brownish grey; finely crystalline; medium to coarse grained well rounded quartz.	0.40	0.60-1.00

<u>Section AQ PE-2:</u> (cont.) Ontario Building Materials Limited, Smith's Falls
Montague Township, Lot 29, Concession 5
UTM 419200E, 4974100N
Elevation 125.00 m±
See also Hewitt 1963, p. 23 (3.0m)

March Formation

1	Quartz sandstone-light grey; reddish brown weathering; medium grained; thickly bedded; well rounded, well sorted, non-calcareous.	0.60 m	0.00-0.60 m

<u>Section AQ PE-3:</u> Hughes, Perth
North Elmsley Township, Lot 26, Concession 7
UTM 405700E, 4967300N
Elevation 135.00 m±
See also Hewitt 1964b, p. 16 (1.3m)

Nepean Formation

1	Quartz sandstone - white; light brown weathering; medium grained medium bedded; well rounded; well sorted, noncalcareous, crossbedded; burrows (<u>Skolithos</u>).	1.30 m	0.00-1.30 m

<u>Section AQ PE-4:</u> Wilson, Perth
Bathurst Township, Lot 16, Concession 1
UTM 395600E, 4967500N
Elevation 145.00 m±
See also Hewitt 1964b, p. 17 (0.6m)

Nepean Formation

No longer exposed

<u>Section LO RU-1:</u> Laurent Leblanc, Navan
Cumberland Township, Lots 7 to 9, Concession 6
UTM 469750E, 5031500N
Elevation 95.00 m±
See also Derry <u>et al.</u> 1989, p. 77 (CP-23, 21.0 m)

Lindsay Formation (lower member)

1	Limestone, with shale interbeds up to 5 cm thick-medium grey; light brownish grey weathering; finely to medium crystalline; thinly to medium bedded crossbedded, intraclastic, nodular in places; brachiopods, crinoids, trilobites, corals, feeding trails.	15.50 m	0.00-15.50 m

Section LO RU-2: Corporation of Clarence Township, Canaan
Clarence Township, Lot 11, Concession 11
UTM 477550E, 5033200N
Elevation 75.00 m±
See also Hewitt 1964a, p. 40 (13.7m); Derry *et al.* 1989, p. 16-17 (CW-7, 17.0 m)

Lindsay Formation (lower member)

2	Limestone - light to medium grey; light brown weathering; medium to coarsely crystalline; thinly bedded, nodular.	2.00 m	15.00-17.00 m
1	Limestone, with shale interbeds - medium brownish grey; light brownish grey weathering; finely to coarsely crystalline; thinly to medium bedded; gastropods, brachiopods, trilobites, crinoids, bryozoa.	15.00	0.00-15.00

Section LO RU-3: Bertrand et Frere Construction Company Limited, Sarsfield
Cumberland Township, Lot 12, Concession 3
UTM 474300E, 5031100N
Elevation 80.00 m±
See also Derry *et al.* 1989, p. 77-78 (CP-24, 13.0 m)

Lindsay Formation (lower member)

1	Limestone, with shale interbeds up to 5 cm thick - light to medium grey; light brown weathering; finely to medium crystalline; thinly to medium bedded; nodular intraclastic in places; brachiopods, corals, crinoids.	12.00 m	0.00-12.00 m

Section LO RU-4: Canada Brick, Russell
Russell Township, Lots 18 and 19, Concession 3 and 4
UTM 471000E, 5016100N
Elevation 70.00 m±
See also Guillet 1967, p.76-78 (4.6m)

Queenston Formation

1	Siltstone - predominantly red, with light greenish grey colour occurring in reduction spots and along joints and bedding planes; very thinly to thickly bedded; slightly calcareous, crossbedded, desiccation cracks, ripple marks.	9.15 m	0.00-9.15 m

Section LQ RU-5: A. L. Blair Construction Company Limited, Embrun
(to north of fault)
Russell Township, Lots 6 and 7, Concession 8
UTM 479100E, 5012600N
Elevation 55.00 m±
See also Derry et al. 1989, p. 14-15 (CW-5, 12.0 m)

Bobcaygeon Formation (middle member)

1	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish grey to brown weathering; sublithographic to finely crystalline; thinly to massive bedded; corals, gastropods, brachiopods, bryozoa, crinoids.	12.00 m	0.00-12.00 m

Section LQ RU-6: Dibblee Construction Company Limited, Embrun
Russell Township, Lot 9, Concession 10
UTM 481300E, 5015800N
Elevation 75.00 m±
See also Derry et al. 1989, p. 15-16 (CW-6, 6.0 m)

Lindsay Formation (lower member)

1	Limestone, with shale interbeds up to 5 cm thick - medium to dark brownish grey; bluish grey to brown weathering; finely to medium crystalline; very thinly to thickly bedded; intraclastic, nodular in places; brachiopods, crinoids, gastropods, cephalopods, corals, feeding trails.	3.30 m	0.00-3.30 m

Section AQ TH-1: Stewart, Rockland
Clarence Township, Lots B and C, Concession 9
UTM 477000E, 5041500N
Elevation 50.00 m±
See also Wilson 1921, p.26 (26.1m); Goudge 1938, p.180, 182 (22.9m); Barnes 1968, p.170; Derry et al. 1989, p. 17-18 (CW-8, 29.75 m)

Bobcaygeon Formation (lower member)

4	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish to brownish grey weathering; sublithographic to finely crystalline; very thinly to massive bedded; nodular beds up to 30 cm thick.	11.10 m	18.65-29.75 m
3	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish to brownish grey weathering; sub-lithographic to finely crystalline; very thinly to massive bedded; brachiopods, bryozoa, cephalopods, gastropods. Base of upper lift at 10.25 m.	8.40	10.25-18.65

Section AQ TH-1: (cont.) Stewart, Rockland
Clarence Township, Lots B and C, Concession 9
UTM 477000E, 5041500N
Elevation 50.00 m±
See also Wilson 1921, p.26 (26.1m); Goudge 1938, p.180, 182 (22.9m); Barnes 1968, p.170; Derry et al. 1989, p. 17-18 (CW-8, 29.75 m)

Gull River Formation (upper member)

2	Limestone, with shaly partings - medium brownish grey; bluish grey weathering; lithographic to sublithographic; very thinly to thickly bedded; oolitic and intraclastic at 3.90-4.75 m, "birdseye" texture at 4.75-10.25 m; abundant *Tetradium* at 4.75-10.25 m.	7.85 m	2.40-10.25 m

Gull River Formation (lower member)

1	Limestone, with interbeds up to 80 cm thick of finely crystalline silty dolostone - medium brownish grey; bluish to brownish grey weathering; lithographic to finely crystalline; very thinly to medium bedded; commonly intraclastic.	2.40	0.00-2.40

Section AQ TH-2: Cumberland (Highway 17) (to north of fault)
Cumberland Township, Lot 25, first concession from the Ottawa River
UTM 463900E, 5039900N
Elevation 25.00 m±
See also Bolton and Liberty 1972, p.20

Rockcliffe Formation (lower member)

2	Quartz sandstone, with shale interbeds - light greenish grey; greenish grey weathring; fine grained.	10.00 m	10.00-20.00 m

Oxford Formation

1	Dolostone, with shaly partings - light grey; buff weathering; finely crystalline; medium bedded.	10.00	0.00-10.00

Section LQ WE-1: Arriscraft Corporation, Philipsville
Bastard Township, Lots 26 to 27, Concession 7
UTM 407450E, 4941600N
Elevation 135.00 m±

Nepean Formation

1	Quartz sandstone - white; medium grained; thinly bedded; well sorted, well rounded, non-calcareous, crossbedded.	2.00 m	0.00-2.00 m

Section LQ WE-2: G. Tackaberry & Sons Construction Company Limited, Harlem
(previous operator: Brundige Construction Company Limited)
Bastard Township, Lot 15, Concession 6
UTM 411200E, 4946700N
Elevation 140.00 m±
See also Hewitt 1964a, p. 20 (3.4m); Rogers 1980, p. 58; Derry et al. 1989, p. 86-87 (BR-2, 3.7 m)

March Formation

6	Sandy dolostone - light brownish grey; light brownish grey weathering; finely crystalline; fine grained quartz; medium bedded; calcite-filled vugs.	2.10 m	1.55-3.65 m
5	Dolostone - very thinly bedded.	0.25	1.30-1.55
4	Quartz sandstone - green to light grey; coarse grained; slightly calcareous.	0.20	1.10-1.30
3	Dolostone, with minor coarse grained quartz - light brown; light brown to medium grey weathering; finely crystalline; very thinly to thinly bedded.	0.80	0.30-1.10
2	Covered interval.	0.25	0.05-0.30
1	Sandy dolostone - light brown to grey; coarse grained well rounded quartz.	0.05	0.00-0.05

Section LQ WE-3: G. Tackaberry & Sons Construction Company Limited, Newboyne
Bastard Township, Lot 6, Concession 5
UTM 414050E, 4951050N
Elevation 140.00 m±
See also Derry et al. 1989, p. 87 (BR-3, 3.8 m)

March Formation

4	Sandy dolostone - light brownish grey; light brownish grey weathering; finely crystalline; medium grained quartz; medium bedded; calcite-filled vugs.	3.00 m	0.80-3.80 m
3	Quartz sandstone - green; very coarse grained; medium bedded; calcareous.	0.30	0.50-0.80
2	Covered interval.	0.45	0.05-0.50
1	Dolostone -light grey to light brown; light brown weathering; fine crystalline.	0.05	0.00-0.05

<u>Section LQ WE-4:</u> G. Tackaberry & Sons Construction Co. Ltd., Sheldon Corners
Rear of Yonge and Escott Township, Lots 21 and 22, Concession 10
UTM 419750E, 4943800N
Elevation 130.00m±

March Formation

5	Sandy dolostone - light brown to light brownish grey; light brownish grey; weathering; finely crystalline; coarse grained quartz; medium bedded.	5.80 m	2.50-8.30 m
4	Quartz sandstone - white to light brown; light brown weathering; medium to coarse grained; medium to thickly beds; calcareous.	0.80	1.70-2.50
3	Dolostone, with minor coarse grained quartz- dark grey; medium grey weathering; finely crysalline; thinly bedded.	0.80	0.90-1.70
2	Sandy dolostone -light grey; light brownish grey weathering; finely crystallline; fine grained quartz; thickly bedded, calcite-filled vugs.	0.30	0.60-0.90
1	Sandy dolostone -light grey; light greenish brown weathering; finely crystalline; coarse grained quartz; thickly bedded.	0.60	0.00-0.60

<u>Section LQ WE-5:</u> Canfarge Limited, Forfar
Bastard Township, Lots 29 to 30, Concession 4
UTM 403400E, 4943900N
Elevation 130.00 m±

Nepean Formation

1	Quartz sandstone - white to light brown; light grey to reddish brown weathering; medium grained; thinly bedded; well sorted, well rounded, non-calcareous; burrows (<u>Skolithos</u>).	2.50 m	0.00-2.50 m

<u>Section LQ WE-6:</u> Griffin Brothers Gananoque Limited, Westport
North Crosby Township, Lot 12, Concession 7
UTM 387650E, 4947350N
Elevation 145.00 m±

Gull River Formation (lower member)

3	Silty dolostone, with lithographic lime- stone interbeds up to 35 cm thick and shaly partings and interbeds up to 10 cm thick - light greenish grey grey to dark brownish grey; buff to reddish brown weathering; finely to medium crystalline; thinly to thickly bedded; calcitic to non- calcitic; calcite-filled vugs, conchoidal fractures, sulphate molds in lithographic limestone at 12.18-12.40 m and 12.66-12.90 m.	9.93 m	6.77-16.70 m

Section LQ WE-6: (cont.) Griffin Brothers Gananoque Limited, Westport
North Crosby Township, Lot 12, Concession 7
UTM 387650E, 4947350N
Elevation 145.00 m±

Gull River Formation (lower member)

2	Limestone, with dolomitic mottling and silty dolostone interbeds up to 25 cm thick - medium to dark grey; light to medium grey weathering; lithographic to finely crystalline; thinly to thickly bedded; dolostone intraclasts at base, oolitic at 2.18-2.35 m, 3.57-3.75 m, and 3.96-4.32 m, gypsum nodules at 5.57-6.20 m; brachiopods.	4.77 m	2.00-6.77 m
1	Silty dolostone, with shaly partings - light greenish grey; buff weathering; finely crystalline; thinly to thickly bedded; slightly calcitic, conchoidal features; brachiopods.	2.00	0.00-2.00

Section S WE-1: roadcut, Philipsville
UTM 409500E, 4943350N
Elevation 125.00 m±

March Formation

8	Sandy dolostone, with interbeds of calcareous quartz sandstone - light to medium grey; finely crystalline; medium grained quartz; calcite-filled vugs; burrows, gastropods.	1.65 m	5.00-6.65 m
7	Quartz sandstone - white to light green to light brown; fine to medium grained; medium bedded; non-calcareous; burrows.	1.80	3.20-5.00
6	Sandy dolostone - light grey to light brownish grey; finely crystalline; medium grained quartz; calcite-filled vugs.	0.10	3.10-3.20

Nepean Formation

5	Quartz sandstone - white t light green; fine grained; non-calcareous; burrows.	0.95	2.15-3.10
4	Quartz sandstone - light to medium grey; medium grained; medium bedded; calcareous.	0.35	1.80-2.15
3	Quartz sandstone - white; medium grained; medium bedded; non-calcareous; burrows (*Skolithos*).	1.00	0.80-1.80
2	Quartz sandstone - light grey; medium grained; medium bedded; well sorted, well rounded, calcareous.	0.20	0.60-0.80

Section S WE-1: (cont.) roadcut, Philipsville
UTM 409500E, 4943350N
Elevation 125.00 m±

Nepean Formation

1	Quartz sandstone - white; medium grained; thickly bedded; well sorted, well rounded, non-calcareous.	0.60 m	0.00-0.60 m

Section LO WI-1: Cruickshank Construction Limited, Winchester Springs
Williamsburgh Township, Lots 31 and 31, Concession 7
UTM 478700E, 4983150N
Elevation 70.00 m±
See also Goudge 1938, p.58-59 (1.6m); Hewitt and vos 1972, p.20-21 (6.1m); Derry et al. 1989, p.10-11 (CW-3, 14.15 m)

Gull River Formation (lower member)

5	Silty dolostone, with interbeds of lithographic to finely crystalline limestone and shaly partings - light to dark brownish grey, and light to medium greenish grey; buff to reddish brown weathering; sublithographic to finely crystalline; thinly to thickly bedded; calcitic to non-calcitic, calcite-filled vugs, conchoidal fractures, intraclastic in places.	4.85 m	9.30-14.15 m
4	Quartz sandstone - light grey; light to medium greenish grey weathering; fine to coarse grained; calcareous; burrows.	0.20	9.20-9.30
3	Silty dolostone, with interbeds of lithographic to finely crystalline limestone and shaly partings - light to dark brownish grey, and light to medium greenish grey; buff to reddish brown weathering; sublithographic to finely crystalline; thinly to thickly bedded; calcitic to non-calcitic, calcite-filled vugs, conchoidal fractures; intraclastic in places; pyritized cephalopods.	8.75	0.35-9.10
2	Limestone - medium grey; bluish grey to dark grey weathering; oolitic, intraclastic.	0.25	0.10-0.35
1	Silty dolostone, with shaly partings - medium to dark brownish grey; buff to reddish brown weathering; sublithographic to finely crystalline; calcitic; burrows.	0.10	0.00-0.10

<u>Section LQ WI-2:</u> Dibblee Construction Company Limited, Winchester Springs
Williamsburgh Township, Lot 33, Concession 7
UTM 478100E, 4982850N
Elevation 80.00 m±
See also Hewitt and Vos 1972, p.23 (3.0m)

Gull River Formation (lower member)

1	Silty dolostone, with interbeds of lithographic to finely crystalline limestone and shaly partings - light to dark brownish grey, and light to medium greenish grey; buff to reddish brown weathering; sublithographic to finely crystalline; thinly to thickly bedded; calcitic to non-calcitic, calcite-filled vugs, conchoidal fractures, intraclastic in places; trilobites.	4.25 m	0.00-4.25 m

<u>Section LQ WI-3:</u> A.L. Blair Construction Company Limited, St. Albert
(previous operator: Silvertone Black Marble Quarries Limited)
Finch Township, Lots 7 and 8, Concession 12
UTM 483900E, 5008850N
Elevation 65.00 m±
See also Goudge 1938, p.191-193, 195 (4.6m); Hewitt 1964a, p.41 (3.0m); Hewitt and Vos 1972, p.15 (5.5m); Derry <u>et al.</u> 1989, p. 11-14 (CW-4, 14.9 m)

Bobcaygeon Formation (middle member)

2	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish grey to brown weathering; sublithographic to finely crystalline; very thinly to thickly bedded; nodular in places; crinoids, brachiopods.	5.90 m	4.60-10.50 m

Bobcaygeon Formation (lower member)

1	Limestone, with irregular shaly partings - medium to dark brownish grey; bluish to brownish grey weathering; sublithographic to finely crystalline; very thinly to thickly bedded.	4.60	0.00-4.60

<u>Section LQ WI-4:</u> A.L. Blair Construction Company Limited, Osnabruck
Osnabruck Township, Lot 27, Concession 5
UTM 495600E, 4986750N
Elevation 90.00 m±
See also Derry <u>et al.</u> 1989, p. 19-20 (CW-11, 3.0 m)

Verulam Formation

1	Limestone, with irregular shaly partings -light to dark brownish grey; bluish grey to brown weathering; sublithographic to medium crystalline; thinly to medium bedded; brachiopods; bryozoa, crinoids.	3.00 m	0.00-3.00 m

Section LO WI-4: A. L. Blair Construction Company Limited, Finch
Finch Township, Lot 23, Concession 3
UTM 498250E, 5001700N
Elevation 90.00 m±

Lindsay Formation (lower member)

1	Limestone, with irregular shaly partings -medium to dark brownish grey; bluish grey to brown weatherng; sublithographic to medium crystalline; thinly to thickly bedded; intraclastic in places; crinoids, brachiopods, corals, burrows.	4.50 m	0.00-4.50 m

Section LO WI-6: Cornwall Gravel Company Limited, Chesterville
Winchester Township, Lots 17 and 18, Concession 1
UTM 483350E, 4991100N
Elevation 80.00 m±

Gull River Formation (lower member)

2	Limestone - dark grey; bluish grey to brown weathering; lithographic; thinly to thickly bedded; stromatolites.	0.70 m	0.70-1.40 m
1	Sandy dolostone- light greenish grey; buff to reddish brown weathering; fine grained quartz; very thinly to medium bedded; calcitic.	0.70	0.00-0.70

Section AO WI-1: Dibblee Construction Company Limited, Durham Wells
Williamsburgh Township, Lot 4, Concession 4
UTM 490900E, 4983800N
Elevation 90.00 m±
See also Hewitt 1960, p.82-84 (10.7m)

Gull River Formation (lower member)

1	Limestone, with shaly partings - medium to dark brownish grey; bluish grey weathering; sublithographic; very thinly to medium bedded.	0.50 m	0.00-0.50 m

APPENDIX 2 - DRILLHOLE LOGS

The drillhole logs (see below) are in geographical order (from west to east, in north-south strips) according to the map area in which the drillholes occur, abbreviated as follows:

AR (Arnprior, 31F/8)
CA (Carleton Place, 31F/1)
PE (Perth, 31C/16)
WE (Westport, 31C/9)
OT (Ottawa, 31G/5)
KE (Kemptville, 31G/4)
ME (Merrickville, 31B/13)
BR (Brockville, 31B/12)
RU (Russell, 31G/6)
WI (Winchester, 31G/3)
MO (Morrisburg, 31B/14)
HA (Hawkesbury, 31G/10
AL (Alexandria, 31G/7)
CO (Cornwall, 31G/2) and
VA (Vaudreuil, 31G/8).

The drillholes for each map area are separated, and numbered in sequence, according to whether they refer to holes drilled by an Ontario government ministry (GDH) or to other holes (DH) (DH OT-11, DH OT-12, and GDH WE-4 are out of order at the end of the appendix). The depth, elevation, and UTM grid co-ordinates, all in metres, are given for each drillhole. Most Ontario government drill holes are relatively shallow (less than 30 metres); except for these, only holes drilled to a depth of greater than 30 metres are included.

The first column in each log refers to the depth to the top of a specific stratigraphic unit, the second column to the elevation of the top of the unit, and the third column to the thickness of the unit. The "+" symbol indicates that the entire thickness of the unit does not occur in the intersection.

The following drillhole tabulation indicates the name of each hole and reference material available (see also Ontario Ministry of Natural Resources oil and gas well summary cards, Petroleum Resources Section, London, Ontario). The logs for holes DH RU-1 to -5 and DH RU-7 to -22 are not included since they were all drilled in the vicinity of DH RU-6, which was drilled to a greater depth than the other holes. Abbreviations used in the tabulation are a follows:

MNDM (OGS), Ministry of Northern Development and Mines (Ontario Geological Survey)

MNR (ER), Ministry of Natural Resources (Eastern Region);

MTO, Ministry of Transportation;

MOE, Ministry of the Environment;

GSC, Geological Survey of Canada;

DMTS, Department of Mines and Technical Surveys; and

CGC, Consumer's Gas Company.

Hole Number	Hole Name	References
GDH AL-1	MTO Alexandria 134	Rogers 1981
DH AL-1	GSC McCrimmon	this study
DH AL-2	CGS 12023	well summary card only
DH AL-3	Imperial Laggan	this study
DH AL-4	Alexandria	well summary card only
DH AL-5	Fournier	well summary card only
GDH AR-1	MTO Arnprior 111	Rogers 1981
GDH BR-1	MNR (ER) Leeds D	Powell & Klugman 1979
GDH BR-2	MNR (ER) Leeds E	Powell & Klugman 1979
GDH BR-3	MTO Brockville 117	Rogers 1981
GDH BR-4	MTO Brockville 39	Rogers 1981
GDH BR-5	MTO Brockville 130	Rogers 1981
GDH BR-6	MTO Brockville 127	Rogers 1980, p. 54-55
GDH CA-1	MNR (ER) Lanark C	Powell & Klugman 1979, Rogers 1980, p. 38
GDH CA-2	MNR (ER) Lanark D	Powell & Klugman 1979
GDH CA-3	MTO Carleton Place 28	Magni 1982
GDH CA-4	MTO Carleton Place 81	Rogers 1981
DH CO-1	Cornwall Gravel	this study
DH CO-2	Ontario Hydro 791	Hewitt 1960, p. 82-83
GDH HA-1	MOE Alfred	McKenna 1980
DH HA-1	Larouche	well summary card only
GDH KE-1	MTO Kemptville 9	Rogers 1981
GDH ME-1	MTO Merrickville 23	Rogers 1981
GDH ME-2	MTO Merrickville 7	Rogers 1981
GDH MO-1	MTO Morrisburg 135	Rogers 1981
GDH MO-2	MTO Morrisburg 6	Rogers 1981
DH MO-1	Dames and Moore RH1	Dames & Moore Consulting Engineers 1974, Rogers 1980, p. 59
DH MO-2	Dames and Moore RH2	Dames & Moore Consulting Engineers 1974
DH MO-3	Dames and Moore RH3	Dames & Moore Consulting Engineers 1974 Bond & Greggs 1976, p. 22
GDH OT-1	MNR (ER) Ottawa-Carleton A	Powell & Klugman 1979
GDH OT-2	MNDM (OGS) SIS 9	Johnson, Russell & Telford 1983, p. 34-35
GDH OT-3	MTO Ottawa 72	Rogers 1980, p. 40-44
GDH OT-4	MTO Ottawa 70	Rogers 1980, p. 45-48
GDH OT-5	MTO Ottawa 67	Rogers 1980, p. 51-52
GDH OT-6	MTO Ottawa 155	Rogers 1980, p. 49-50
DH OT-1	Davidson	well summary card only
DH OT-2	Lord Elgin Hotel	well summary card only
DH OT-3	Dundonald Park	well summary card only
DH OT-4	Booth	well summary card only
DH OT-5	GSC Lebreton	this study
DH OT-6	DMTS Ottawa	well summary card only
DH OT-6	Ramsayville	well summary card only
DH OT-8	Union Station	well summary card only
DH OT-9	Zellers	well summary card only
DH OT-10	Canada Cement	HEWITT 1960, P. 76-77

DH OT-11	GSC Billings Bridge	this study
DH OT-12	Tomlinson	this study
GDH PE-1	MNR (ER) Lanark A	Powell & Klugman 1979
GDH PE-2	MNR (ER) Lanark B	Powell & Klugman 1979
GDH PE-3	MNR (ER) Lanark E	Powell & Klugman 1979
GDH RU-1	MNDM (OGS) SIS 10	Johnson, Russell & Telford 1983, p. 34-36
DH RU-1 TO 5	CGC 12022, 12417, 16050 to 16052	well summary card only
DH RU-6	CGC 16306	well summary card only
DH RU-7 TO 22	CGC 16307 to 16322	well summary card only
DH RU-23	Ottawa Dairy	well summary card only
DH RU-24	GSC Russell	this study
DH RU-25	Standard Oil Vars	well summary card only
DH RU-26	Standard Oil Carlsbad Springs	well summary card only
GDH VA-1	MTC Vaudreuil 28	Rogers 1981
GDH WE-1	MNR (ER) Leeds A	Powell & Klugman 1979
GDH WE-2	MNR (ER) Leeds B	Powell & Klugman 1979
GDH WE-3	MNR (ER) Leeds C	Powell & Klugman 1979
GDH WE-4	MTC Westport 34	this study
GDH WI-1	MTC Winchester 113	Rogers 1981
DH WI-1	Nestle Jackson	well summary card only
DH WI-2	Dames and Moore RH4	Dames & Moore Consulting Engineers 1974, Bond & Greggs 1976, p. 21-22
DH WI-3	Dames and Moore RH5	Dames & Moore Consulting Engineers 1974

Drill core stored in government core libraries has been examined an used for reference purposes. The drill core for DH AL-1 (GSC McCrimmon), DH AL-3 (Imperial Laggan), DH OT-5 (GSC Lebreton), DH OT-11 (GSC Billings Bridge), and DH RU-24 (GSC Russell) is at the Geological Survey of Canada's Ottawa facility. The drill core for GDH OT-2 (OGS SIS 9) and GDH RU-1 (OGS SIS 10) is at the Ontario Geological Survey's Toronto facility. The drill core for GDH BR-4 (MTO Brockville 39), GDH BR-5 (MTO Brockville 130), GDH CA-4 (MTO Carleton Place 81), GDH OT-4 (MTO Ottawa 70), GDH OT-5 (MTO Ottawa 67), GDH OT-6 (MTO Ottawa 155), and GDH WE-4 (MTO Westport 34) is at the Ontario Ministry of Northern Development and Mines' Tweed facility; and the drill core for the DH MO-1, DH WI-2, and DH WI-3 (Dames and Moore RH1, RH4, and RH5, respectively) is at the Ontario Ministry of Natural Resources' Petroleum Resources Laboratory in London. Thicknesses determined for stratigraphic units in the reference drillholes have been used to estimate thicknesses in some of the other drillholes for which the available information is less reliable; the "e" symbol in some of the logs indicates that the figure is an estimate.

Hole Number	GDH AR-1			GDH CA-1			GDH CA-2			GDH CA-3		
Depth (m)	9.1			41.8			22.0			10.4		
Elevation (m) UTM (m)	135.0± 409830E, 5014410N			137.2 410600E, 5001770N			121.9 403640E, 5010320N			135.0± 413100E, 4994650N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings												
Lindsay upper lower												
Verulam												
Bobcaygeon upper middle lower												
Gull River upper lower												
Shadow Lake												
Rockcliffe upper lower												
Oxford				0.0	137.2	1.8+						
March				1.8	135.4	6.9				0.0	135.0	9.2+
Nepean	0.0	135.0	9.1+	8.7	128.5	31.1	0.0	121.9	20.1+	9.2	125.8	1.2+
Covey Hill				39.8	97.4	0.0	20.1	101.8	0.0			
Precambrian				39.8	97.4		20.1	101.8				

Hole Number	GDH CA-4			GDH PE-1			GDH PE-2			GDH PE-3		
Depth (m)	14.0			5.2			14.9			72.5		
Elevation (m) UTM (m)	136.6 410370E, 5001680N			137.2 395410E, 4969070N			135.6 397420E, 4969480N			129.5 414080E, 4972690N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings												
Lindsay upper lower												
Verulam												
Bobcaygeon upper middle lower												
Gull River upper lower												
Shadow Lake												
Rockcliffe upper lower												
Oxford	0.0	136.6	2.3+									
March	2.3	134.3	6.6							0.0	129.5	34.4+
Nepean	8.9	127.7	5.1+	0.0	137.2	4.0+	0.0	135.6	13.7+	34.4	95.1	34.4+
Covey Hill				4.0	133.2	0.0	13.7	121.9	0.0	71.3	58.2	0.0
Precambrian				4.0	133.2		13.7	121.9		71.3	58.2	

Hole Number	GDH WE-1			GDH WE-2			GDH WE-3			GDH OT-1		
Depth (m)	22.9			23.5			15.2			12.2		
Elevation (m) UTM (m)	121.9 407130E, 4940690N			143.3 404390E, 4941180N			131.7 399100E, 4948080N			91.4 421770E, 5026260N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings												
Lindsay upper lower												
Verulam												
Bobcaygeon upper middle lower												
Gull River upper lower												
Shadow Lake												
Rockcliffe upper lower												
Oxford												
March												
Nepean	0.0	121.9	20.3+	0.0	143.3	22.6+	0.0	131.7	12.2+	0.0	91.4	9.1+
Covey Hill	20.3	101.6	0.0	22.6	120.7	0.0	12.2	119.5	0.0	9.1	82.3	0.0
Precambrian	20.3	101.6		22.6	120.7		12.2	119.5		9.1	82.3	

Hole Number	GDH OT-2			GDH OT-3			GDH OT-4			GDH OT-5		
Depth (m)	98.2			15.8			14.6			9.1		
Elevation (m) UTM (m)	66.6 454150E, 5027430N			95.7 454920E, 5016560N			97.8 455140E, 5016340N			97.9 456330E, 5015970N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad	7.0	59.6	67.9+									
Billings	74.9	-8.3	23.3+									
Lindsay upper lower												
Verulam												
Bobcaygeon upper middle lower												
Gull River upper lower												
Shadow Lake												
Rockcliffe upper lower												
Oxford							0.0	97.8	0.3+	0.0	97.9	3.1+
March				0.0	95.7	9.4+	0.3	97.5	14.3+	3.1	94.8	6.0+
Nepean				9.4	86.3	6.4+						
Covey Hill												
Precambrian												

Hole Number	GDH OT-6			DH OT-1			DH OT-2			DH OT-3		
Depth (m)	7.6			149.4			404.8			420.6		
Elevation (m) UTM (m)	95.2 456640E, 5016100N			110.0± 446590E, 5018850N			76.2 445730E, 5029640N			86.9 445110E, 5028830N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings							19.8	56.4	12.0+e	3.0	83.9	1.3+e
Lindsay												
upper							31.8e	44.4e	10.8e	4.3e	82.6e	10.8e
lower							42.6e	33.6e	21.9e	15.1e	71.8e	21.9e
Verulam							64.5e	11.7e	39.7e	37.0e	49.9e	39.7e
Bobcaygeon												
upper							104.2e	-28.0e	27.5e	76.7e	10.2e	27.5e
middle							131.7e	-55.5e	23.4e	104.2e	-17.3e	23.4e
lower							155.1e	-78.9e	29.0e	127.6e	-40.7e	29.0e
Gull River												
upper							184.1e	-107.9e	11.6e	156.6e	-69.7e	11.6e
lower							195.7e	-119.5e	42.3e	168.2e	-81.3e	42.3e
Shadow Lake							238.0e	-161.8e	2.5e	210.5e	-123.6e	2.5e
Rockcliffe												
upper							240.5e	-164.3e	7.0e	213.0e	-126.1e	7.0e
lower							247.5e	-171.3e	45.1e	220.0e	-133.1e	45.1e
Oxford				18.9	91.1	39.7e	292.6	-216.4	62.2e	265.1	-178.2	62.2e
March	0.0	95.2	7.6+	58.6e	51.4e	17.6e	354.8e	-278.6e	17.6e	327.3e	-240.4e	17.6e
Nepean				76.2	33.8	60.4e	372.4e	-296.2e	32.4+e	344.9e	-258.0e	60.4e
Covey Hill				136.6e	-26.6e	6.7e				405.3e	-311.4e	12.9e
Precambrian				143.3	-33.3					418.2	-331.3	

Hole Number	DH OT-4			DH OT-5			DH OT-6			DH OT-7		
Depth (m)	295.7			442.3			602.0			531.6		
Elevation (m) UTM (m)	60.0± 443670E, 5029520N			75.0± 444910E, 5027480N			83.8 444070E, 5026700N			80.0± 457300E, 5022250N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad										62.3	17.7	9.3+e
Billings										71.6e	8.4e	62.0e
Lindsay upper										133.6e	-53.6e	10.8e
Lindsay lower										144.4e	-64.4e	21.9e
Verulam	7.7	52.3	20.3+e	1.8	73.2	31.1+				166.3e	-86.3e	39.7e
Bobcaygeon upper	28.0e	32.0e	27.5e	32.9	42.1	27.5				206.0e	-126.0e	27.5e
Bobcaygeon middle	55.5e	4.5e	23.4e	60.4	14.6	23.4				233.5e	-153.5e	23.4e
Bobcaygeon lower	78.9e	-18.9e	29.0e	83.8	-8.8	29.0	13.7	70.1	7.0+e	256.9e	-176.9e	29.0e
Gull River upper	107.9e	-47.9e	11.6e	112.8	-37.8	11.6	20.7e	63.1e	11.6e	285.9e	-205.9e	11.6e
Gull River lower	119.5e	-59.5e	42.3e	124.4	-49.4	42.3	32.3e	51.5e	42.3e	297.5e	-217.5e	42.3e
Shadow Lake	161.8e	-101.8e	2.5e	166.7	-91.7	2.5	74.6e	9.2e	2.5e	339.8e	-259.8e	2.5e
Rockcliffe upper	164.3e	-104.3e	7.0e	169.2	-94.2	7.0	77.1e	6.7e	7.0e	342.3e	-262.3e	7.0e
Rockcliffe lower	171.3e	-111.3e	45.1e	176.2	-101.2	45.1	84.1e	-0.3e	45.1e	349.3e	-269.3e	45.1e
Oxford	216.4	-156.4	62.2e	221.3	-146.3	62.2	129.2	-45.4	62.2e	349.4	-314.4	62.2e
March	278.6e	-218.6e	17.1+e	283.5	-208.5	17.6	191.4e	-107.6e	17.6e	456.6e	-376.6e	17.6e
Nepean				301.1	-226.1	60.4	209.0	-125.2	30.9e	474.2e	-394.2e	54.4+e
Covey Hill				361.5	-286.5	8.8	239.9e	-156.1e	0.0e			
Precambrian				370.3	-295.3		239.9	-156.1				

Hole Number	DH OT-8			DH OT-9			DH OT-10			GDH KE-1		
Depth (m)	330.7			128.0			61.0			9.1		
Elevation (m) UTM (m)	65.0± 445780E, 5030100N			70.1 439930E, 5024500N			108.0 455750E, 5033170N			100.0± 460600E, 4989400N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings												
Lindsay												
upper												
lower	9.1	55.9	3.5+e									
Verulam	12.6e	52.4e	39.7e									
Bobcaygeon												
upper	52.3e	12.7e	27.5e									
middle	79.8e	-14.8e	23.4e									
lower	103.2e	-38.2e	29.0e				0.0	108.0	16.2+			
Gull River												
upper	132.2e	-67.2e	11.6e				16.2	91.8	7.6			
lower	143.8e	-78.8e	42.3e	3.1	67.0	18.8+e	23.8	84.2	37.2+			
Shadow Lake	186.1e	-121.1e	2.5e	21.9e	48.2e	2.5e						
Rockcliffe												
upper	188.6e	-123.6e	7.0e	24.4	45.7	7.0e						
lower	195.6e	-130.6e	45.1e	31.4e	38.7e	26.5e						
Oxford	240.7	-175.7	62.2e	57.9	12.2	64.9				0.0	100.0	9.1+
March	302.9e	-237.9e	17.6e	122.8	-52.7	5.2+						
Nepean	320.5e	-255.5e	10.2+e									
Covey Hill												
Precambrian												

Hole Number	GDH ME-1			GDH ME-2			GDH BR-1			GDH BR-2		
Depth (m)	9.1			8.0			16.2			29.0		
Elevation (m) UTM (m)	105.0± 451960E, 4980340N			105.0± 457490E, 4958970N			114.3 437210E, 4937770N			102.7 436610E, 4934400N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings												
Lindsay upper lower												
Verulam												
Bobcaygeon upper middle lower												
Gull River upper lower												
Shadow Lake												
Rockcliffe upper lower												
Oxford	0.0	105.0	9.1+	0.0	105.0	5.8+						
March				5.8	99.2	0.0	0.0	114.3	9.4+			
Nepean				5.8	99.2	0.0	9.4	104.9	6.8+	0.0	102.7	26.7+
Covey Hill				5.8	99.2	0.0				26.7	76.0	0.0
Precambrian				5.8	99.2					26.7	76.0	

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Hole Number	GDH BR-3			GDH BR-4			GDH BR-5			GDH BR-6		
Depth (m)	9.1			20.4			18.3			10.7		
Elevation (m) UTM (m)	115.0± 450500E, 4948180N			95.0± 447430E, 4939850N			110.0± 447340E, 4940830N			95.0± 436840E, 4929270N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings												
Lindsay upper lower												
Verulam												
Bobcaygeon upper middle lower												
Gull River upper lower												
Shadow Lake												
Rockcliffe upper lower												
Oxford	0.0	115.0	7.9+				0.0	110.0	4.9+			
March	7.9	107.1	1.2+	0.0	95.0	20.4+	4.9	105.1	13.4+	0.9	94.1	5.8+
Nepean										6.7	88.3	3.4
Covey Hill										10.1	84.9	0.0
Precambrian										10.1	84.9	

Hole Number	GDH RU-1			DH RU-6			DH RU-23			DH RU-24		
Depth (m)	51.8			896.1			387.1			835.1		
Elevation (m)	81.4			76.2			71.6			76.5		
UTM (m)	472220E, 5028360N			464970E, 5014820N			471690E, 5012030N			469400E, 5017600N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston				1.5	74.7	49.7+				14.0	62.5	13.0+
Carlsbad				51.2	25.0	186.9e	24.3	47.3	131.1+	27.0	49.5	186.9
Billings	16.8	64.6	18.2+	238.1e	-161.9e	62.0e	155.4	-83.8	62.0e	213.9	-137.4	62.0
Lindsay												
upper	35.0	46.4	7.7	300.1e	-223.9e	10.8e	217.4e	-145.8e	10.8e	275.9	-199.4	10.8
lower	42.7	38.7	9.1+	310.9e	-234.7e	21.9e	228.2e	-156.6e	21.9e	286.7	-210.2	21.9
Verulam				332.8e	-256.6e	39.7e	250.1e	-178.5e	39.7e	308.6	-232.1	39.7
Bobcaygeon												
upper				372.5e	-296.3e	37.8e	289.8e	-218.2e	37.8e	348.3	-271.8	37.8
middle				410.3e	-334.1e	25.1e	327.6e	-256.0e	25.1e	386.1	-309.6	25.1
lower				435.4e	-359.2e	20.4e	352.7e	-281.1e	20.4e	411.2	-334.7	20.4
Gull River												
upper				455.8e	-379.6e	8.8e	373.1e	-301.5e	8.8e	431.6	-355.1	8.8
lower				464.6e	-388.4e	62.6	381.9e	-310.3e	5.2+e	440.4	-363.9	62.6
Shadow Lake				527.2e	-451.0e	2.8e				503.0	-426.5	2.8
Rockcliffe												
upper				530.0e	-453.8e	12.7e				505.8	-429.3	12.7
lower				542.7e	-466.5e	35.2e				518.5	-442.0	35.2
Oxford				577.9e	-501.7e	102.1e				553.7	-477.2	102.1
March				680.0e	-603.8e	20.1e				655.8	-579.3	20.1
Nepean				700.1e	-623.9e	171.6e				675.9	-599.4	159.3+
Covey Hill				871.7e	-795.5e	0.0e						
Precambrian				871.7	-795.5							

Hole Number	DH RU-25			DH RU-26			GDH WI-1			DH WI-1		
Depth (m)	304.8			585.2			10.8			239.3		
Elevation (m) UTM (m)	73.2 468860E, 5020450N			70.1 464660E, 5023020N			90.0± 461470E, 4990150N			75.0± 481690E, 4994690N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad	33.4	39.8	150.3+e	27.4	42.7	114.4+e						
Billings	183.7e	-110.5e	62.0e	141.8e	-71.7e	62.0e						
Lindsay												
upper	245.7e	-172.5e	10.8e	203.8e	-133.7e	10.8e						
lower	256.5e	-183.3e	21.9e	214.6e	-144.5e	21.9e						
Verulam	278.4e	-205.2e	26.4+e	236.5e	-166.4e	39.7e						
Bobcaygeon												
upper				276.2e	-206.1e	37.8e						
middle				314.0e	-243.9e	25.1e						
lower				339.1e	-269.0e	20.4e						
Gull River												
upper				359.5e	-289.4e	8.8e						
lower				368.3e	-298.2e	62.6e				9.2	65.8	3.3+e
Shadow Lake				430.9e	-360.8e	2.8e				12.5e	62.5e	2.8e
Rockcliffe												
upper				433.7e	-363.6e	12.7e				15.3	59.7	24.3
lower				446.4e	-376.3e	35.2e				39.6	35.4	35.1
Oxford				481.6	-411.5	100.6	1.5	93.5	9.3+	74.7	0.3	164.6+
March				582.2	-512.1	3.0+						
Nepean												
Covey Hill												
Precambrian												

Hole Number	DH WI-2			DH WI-3			GDH MO-1			GDH MO-2		
Depth (m)	228.3			94.2			9.1			12.2		
Elevation (m) UTM (m)	73.2 474220E, 4984780N			73.2 478270E, 4987480N			85.0± 470630E, 4964880N			75.0± 468720E, 4981830N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings												
Lindsay												
upper												
lower												
Verulam												
Bobcaygeon												
upper												
middle												
lower												
Gull River												
upper												
lower												
Shadow Lake												
Rockcliffe												
upper				12.8	60.4	9.5+						
lower	10.4	62.8	31.7+	22.3	50.9	35.6				0.0	75.0	3.4+
Oxford	42.1	31.1	169.5	57.9	15.3	36.3+	0.0	85.0	9.1+	3.4	71.6	8.8+
March	211.6	-138.4	16.7+									
Nepean												
Covey Hill												
Precambrian												

Hole Number	DH MO-1			DH MO-2			DH MO-3			GDH HA-1		
Depth (m)	209.4			167.3			153.3			480.1		
Elevation (m) UTM (m)	87.5 473430E, 4963340N			81.7 474070E, 4963030N			76.5 473790E, 4962820N			55.8 509500E, 5044120N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings												
Lindsay												
upper												
lower										3.0	52.8	24.6+
Verulam										27.6	28.2	65.4
Bobcaygeon												
upper										93.0	-37.2	14.7
middle										107.7	-51.9	22.4
lower										130.1	-74.3	14.1
Gull River												
upper										144.2	-88.4	8.2
lower										152.4	-96.6	33.9
Shadow Lake										186.3	-130.5	2.6
Rockcliffe												
upper										188.9	-133.1	65.9
lower										254.8	-199.0	59.0
Oxford	3.3	84.2	109.4+	8.5	73.2	105.5+	12.8	63.7	108.8+	313.8	-258.0	129.1
March	112.7	-25.2	35.3	114.0	-32.3	33.5	121.6	-45.1	31.7+	442.9	-387.1	26.3
Nepean	148.0	-60.5	45.3	147.5	-65.8	19.8+				469.2	-413.4	10.9+
Covey Hill	193.3	-105.8	0.0									
Precambrian	193.3	-105.8										

Hole Number	DH HA-1			GDH AL-1			DH AL-1			DH AL-2		
Depth (m)	304.8			9.1			556.3			618.4		
Elevation (m) UTM (m)	51.2 514360E, 5042560N			65.0± 523390E, 5030340N			75.0± 520050E, 5029850N			81.1 520250E, 5030920N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings	22.8	28.4	56.7+									
Lindsay												
upper	79.5	-28.3	10.8e									
lower	90.3e	-39.1e	21.9e									
Verulam	112.2e	-61.0e	65.4e									
Bobcaygeon												
upper	177.6e	-126.4e	14.7e									
middle	192.3e	-141.1e	22.4e									
lower	214.7e	-163.5e	14.1e									
Gull River												
upper	228.8e	-177.6e	8.2e									
lower	237.0e	-185.8e	33.9e									
Shadow Lake	270.9e	-219.7e	2.6e									
Rockcliffe												
upper												
lower	273.5e	-222.3e	31.3+e	0.0	65.0	9.1+	14.0	61.0	22.9+e	17.1	64.0	12.2+
Oxford							36.9e	38.1e	197.5e	29.3	51.8	197.5e
March							234.4	-159.4	63.1	226.8e	-145.7	63.1e
Nepean							297.5	-222.5	258.8+	289.9e	-208.8e	325.5e
Covey Hill										615.4e	-534.3e	0.0e
Precambrian										615.4e	-534.3	

Hole Number	DH AL-3			DH AL-4			DH AL-5			DH CO-1		
Depth (m)	692.5			240.8			304.8			24.1		
Elevation (m) UTM (m)	93.3 521150E, 5026300N			85.0± 528540E, 5017320N			55.0± 504680E, 5033250N			30.0± 519830E, 4992000N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad							30.5	24.5	113.2+e			
Billings							143.7e	-88.7e	62.0e			
Lindsay												
upper							205.7	-150.7	9.2			
lower				0.0	85.0	12.3+e	214.9	-159.9	21.9e			
Verulam				12.3e	72.7e	65.4e	236.8e	-181.8e	65.4e			
Bobcaygeon												
upper				77.7e	7.3e	14.7e	302.2e	-247.2e	2.6+e			
middle				92.4e	-7.4e	22.4e						
lower				114.8e	-29.8e	14.1e						
Gull River												
upper				128.9e	-43.9e	8.2e						
lower				137.1e	-52.1e	33.9e				0.0	30.0	24.1+
Shadow Lake				171.0e	-86.0e	2.6e						
Rockcliffe												
upper	9.1	84.2	58.9+	173.6	-88.6	67.2+						
lower	68.0	25.3	53.9									
Oxford	121.9	-28.6	197.5									
March	319.4	-226.1	63.7									
Nepean	383.1	-289.8	309.4+									
Covey Hill												
Precambrian												

Hole Number	DH CO-2			GDH VA-1			DH OT-11			DH OT-12		
Depth (m)	39.0			9.1			281.3			32.1		
Elevation (m) UTM (m)	65.0± 514160E, 4989000N			70.0± 543730E, 5031080N			80.0± 447360E, 5025840N			126.0 435730E, 5014140N		
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings							5.5	74.5	32.5+			
Lindsay												
upper							38.0	42.0	5.3			
lower							43.3	36.7	19.7			
Verulam							63.0	17.0	32.0			
Bobcaygeon												
upper							95.0	-15.0	37.2			
middle							132.2	-52.2	26.3			
lower	7.3	57.7	5.2+				158.5	-78.5	23.8	0.0	150.0	4.6+
Gull River												
upper	12.5	52.5	8.8				182.3	-102.3	12.5	14.7	111.3	8.7
lower	21.3	43.7	17.7+				194.8	-114.8	41.8	23.4	102.6	7.1+
Shadow Lake							236.6	-156.6	2.6			
Rockcliffe												
upper							239.2	-159.2	12.4			
lower							251.6	-171.6	29.7+			
Oxford												
March												
Nepean				0.0	70.0	9.1+						
Covey Hill												
Precambrian												

Hole Number	GDH WE-4											
Depth (m)	32.1											
Elevation (m) UTM (m)	150.0± 387780E, 4947450N											
	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)	Top (m)	Elevation of top (m)	Thickness (m)
Queenston												
Carlsbad												
Billings												
Lindsay upper lower												
Verulam												
Bobcaygeon upper middle lower												
Gull River upper lower	 0.0	 150.0	 4.6+									
Shadow Lake	4.6	145.4	2.8									
Rockcliffe upper lower	 7.4 8.9	 142.6 141.1	 1.5 0.0									
Oxford	8.9	141.1	3.8									
March	12.7	137.3	8.9									
Nepean	21.6	128.4	10.5+									
Covey Hill												
Precambrian												

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.