ISBN 0-7743-9422-6

THESE TERMS GOVERN YOUR USE OF THIS DOCUMENT

Your use of this Ontario Geological Survey document (the "Content") is governed by the terms set out on this page ("Terms of Use"). By downloading this Content, you (the "User") have accepted, and have agreed to be bound by, the Terms of Use.

Content: This Content is offered by the Province of Ontario's *Ministry of Energy, Northern Development and Mines* (ENDM) as a public service, on an "as-is" basis. Recommendations and statements of opinion expressed in the Content are those of the author or authors and are not to be construed as statement of government policy. You are solely responsible for your use of the Content. You should not rely on the Content for legal advice nor as authoritative in your particular circumstances. Users should verify the accuracy and applicability of any Content before acting on it. ENDM does not guarantee, or make any warranty express or implied, that the Content is current, accurate, complete or reliable. ENDM is not responsible for any damage however caused, which results, directly or indirectly, from your use of the Content. ENDM assumes no legal liability or responsibility for the Content whatsoever.

Links to Other Web Sites: This Content may contain links, to Web sites that are not operated by ENDM. Linked Web sites may not be available in French. ENDM neither endorses nor assumes any responsibility for the safety, accuracy or availability of linked Web sites or the information contained on them. The linked Web sites, their operation and content are the responsibility of the person or entity for which they were created or maintained (the "Owner"). Both your use of a linked Web site, and your right to use or reproduce information or materials from a linked Web site, are subject to the terms of use governing that particular Web site. Any comments or inquiries regarding a linked Web site must be directed to its Owner.

Copyright: Canadian and international intellectual property laws protect the Content. Unless otherwise indicated, copyright is held by the Queen's Printer for Ontario.

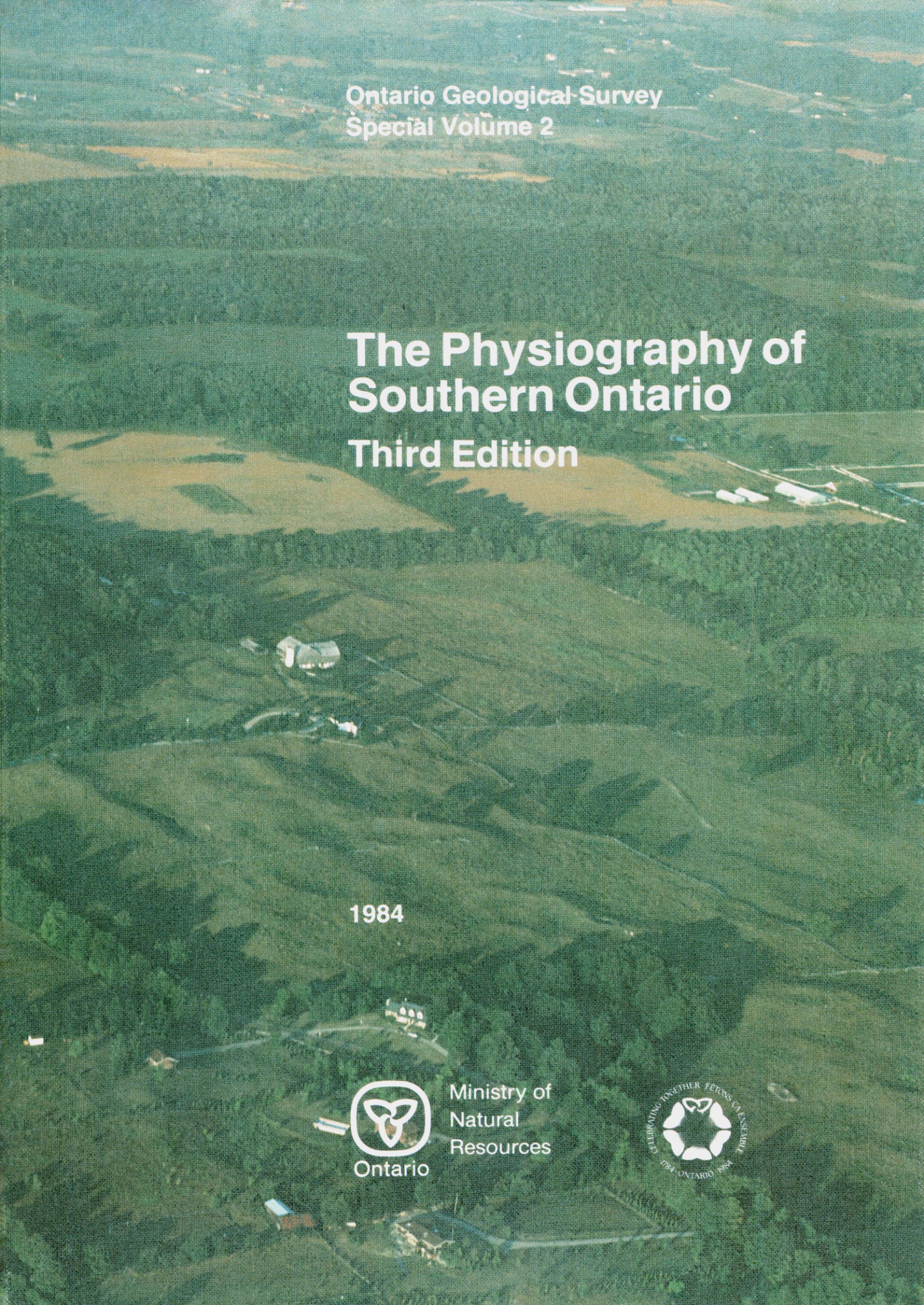
It is recommended that reference to the Content be made in the following form:

Chapman, L.J. and Putnam, D.F. 1984. The Physiography of Southern Ontario; Ontario Geological Survey, Special Volume 2, 270p. Accompanied by Map P.2715 (coloured), scale 1:600 000.

Use and Reproduction of Content: The Content may be used and reproduced only in accordance with applicable intellectual property laws. *Non-commercial* use of unsubstantial excerpts of the Content is permitted provided that appropriate credit is given and Crown copyright is acknowledged. Any substantial reproduction of the Content or any *commercial* use of all or part of the Content is prohibited without the prior written permission of ENDM. Substantial reproduction includes the reproduction of any illustration or figure, such as, but not limited to graphs, charts and maps. Commercial use includes commercial distribution of the Content, the reproduction of multiple copies of the Content for any purpose whether or not commercial, use of the Content in commercial publications, and the creation of value-added products using the Content.

Contact:

FOR FURTHER INFORMATION ON	PLEASE CONTACT:	BY TELEPHONE:	BY E-MAIL:
The Reproduction of the EIP or Content	ENDM Publication Services	Local: (705) 670-5691 Toll-Free: 1-888-415-9845, ext. 5691 (inside Canada, United States)	Pubsales.ndm@ontario.ca
The Purchase of ENDM Publications	ENDM Publication Sales	Local: (705) 670-5691 Toll-Free: 1-888-415-9845, ext. 5691 (inside Canada, United States)	Pubsales.ndm@ontario.ca
Crown Copyright	Queen's Printer	Local: (416) 326-2678 Toll-Free: 1-800-668-9938 (inside Canada, United States)	Copyright@ontario.ca



Ontario Geological Survey
Special Volume 2

The Physiography of Southern Ontario

Third Edition

1984

Ontario
Ministry of
Natural
Resources

Ontario Geological Survey
Special Volume 2

The Physiography of Southern Ontario

Third Edition

by
L.J. Chapman and D.F. Putnam

1984

Ontario
Ministry of Natural Resources
Hon. Alan W. Pope
Minister
John R. Sloan
Deputy Minister

©1984 Government of Ontario
Printed in Ontario, Canada

This report is published with the permission of V.G. Milne, Director, Ontario Geological Survey. Manuscript approved for publication by the Chief, Engineering and Terrain Geology Section, July 9, 1984.

Publications of the Ontario Ministry of Natural Resources are available from the following sources. Orders for publications should be accompanied by cheque or money order payable to the *Treasurer of Ontario.*

Reports, maps (including Maps 2224, 2225, 2226, 2227, 2228 of the *Physiography of Southern Ontario*), and price lists (personal shopping or mail order):

Public Service Centre, Ministry of Natural Resources
Room 1640, Whitney Block, Queen's Park
Toronto, Ontario M7A 1W3

Reports and accompanying maps (personal shopping):

Ontario Government Bookstore
Main Floor, 880 Bay Street
Toronto, Ontario

Reports and accompanying maps (mail order or telephone orders):

Publications Services Section, Ministry of Government Services
5th Floor, 880 Bay Street
Toronto, Ontario M7A 1N8
Telephone (local calls), 965-6015
Toll-free long distance, 1-800-268-7540
Toll-free from Area Code 807, 0-ZENITH-67200

Canadian Cataloguing in Publication Data

Chapman, L.J. (Lyman John), 1908-
The physiography of southern Ontario
(OGS special volume ; 2)

ISBN 0-7743-9422-6

1. Physical geography—Ontario. 2. Geology—Ontario.
I. Putnam, Donald F., 1903-1977. II. Ontario
Geological Survey. III. Title. IV. Series: Ontario
Geological Survey special volume ; 2.

GB132.O5C5 1984 917.13'02 84-093030-5

Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

Parts of this publication may be quoted if credit is given. It is recommended that reference to this report be made in the following form:

Chapman, L.J., and Putnam, D.F.
1984: The Physiography of Southern Ontario; Ontario Geological Survey, Special Volume 2, 270p. Accompanied by Map P.2715 (coloured), scale 1:600 000.

Cover: Aerial view of the Caledon area, southern Ontario (photo courtesy of M.L.T. Stuart).

Critical Reader: W.R. Cowan
Scientific Editor: M.L.T. Stuart

5000-84-Deyell

A MESSAGE FROM THE HONOURABLE ALAN W. POPE ONTARIO MINISTER OF NATURAL RESOURCES

The Ministry of Natural Resources is pleased to present this third, enlarged edition of *The Physiography of Southern Ontario.* I believe this is a significant publication because, for the first time, a physiographic study of all of southern Ontario—including the Georgian Bay-Ottawa Valley region—is now available in a single volume.

In this, our province's bicentennial year, I think it is appropriate that a single, comprehensive edition of L.J. Chapman's and D.F. Putnam's studies of southern Ontario's physiography sould be issued. And we were particularly pleased to have L.J. Chapman continue his work as an author.

The earlier editions of *The Physiography of Southern Ontario* have, for many years, been of value to engineers, scientists, students, and teachers interested in our province's southern physical structure. I know that this edition, like it's predecessors, will be a major reference work.

Special Volume 2
84.08.27

FOREWORD

The publication of this third edition of *The Physiography of Southern Ontario* represents a significant milestone in the history of the study of the glacial deposits of Ontario.

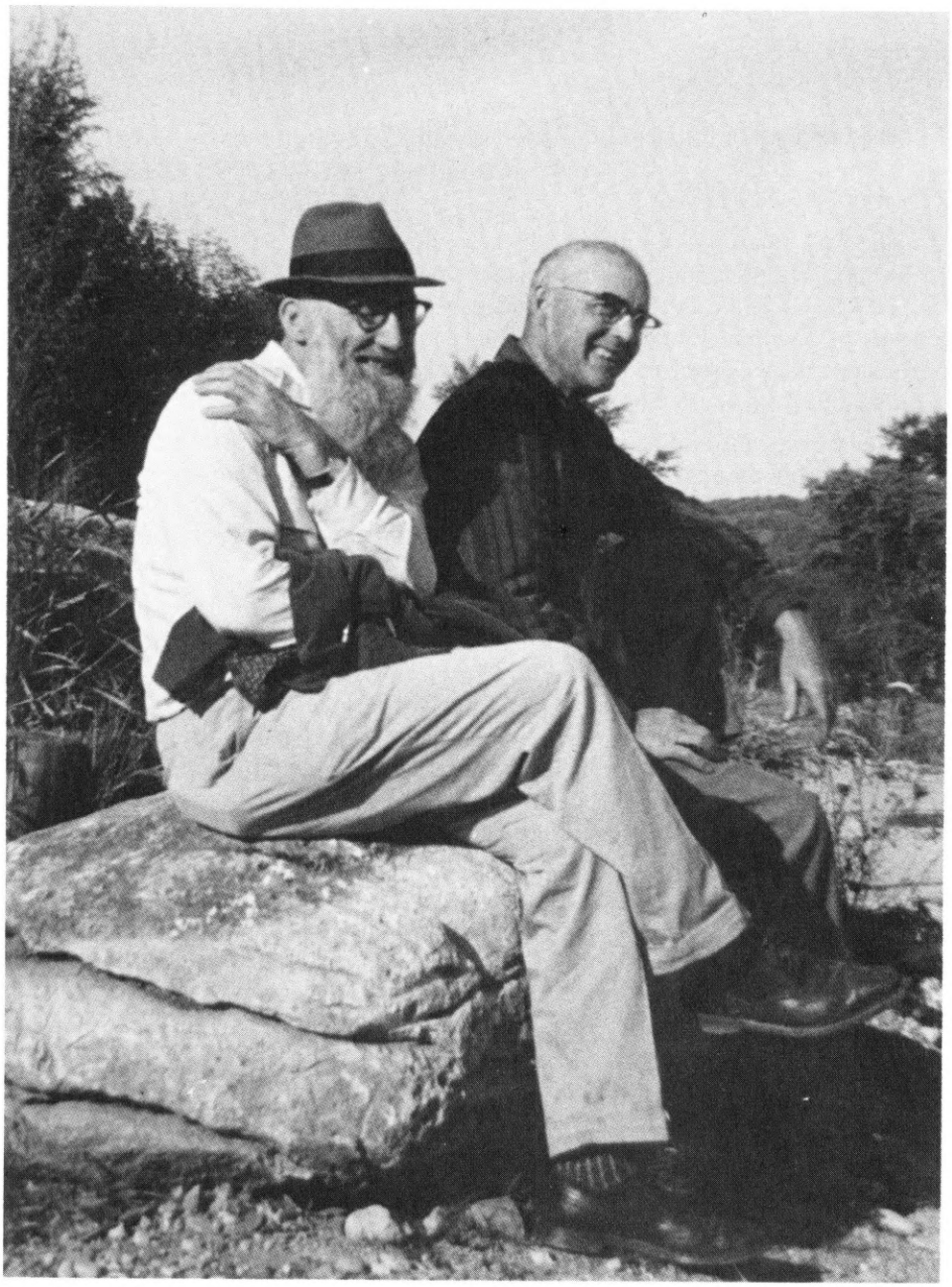
The first edition was published in 1951 at a time when the geological staff of the Ontario Department of Mines (presently the Ontario Geological Survey) and the Geological Survey of Canada started systematic investigations of the glacial deposits of southern Ontario. Their studies were urged on by the need to know more about these deposits to meet the growing demand for developing the ground water supplies and geotechnical studies.

The second edition was published in 1966 at a time when there was an increasing demand for more land-based information for regional planning and locating sand and gravel resources, and just before the Ontario Department of Mines was to considerably increase its staff of Quaternary geology specialists under leadership of the late Dr. Don Hewitt.

The third edition is unique in many respects. The geographic coverage of this edition has been expanded, the text has been extensively revised, and a map at a scale of 1:600 000 has been prepared. This edition comes at a time when most, if not all, of southern Ontario has been mapped at a scale of 1:50 000. Nevertheless, *The Physiography of Southern Ontario* is the only publication which provides an overview of the glacial geology of southern Ontario. The continued use of the book in secondary schools, for college and university courses, and by professional engineers, planners, geographers, geologists, and agriculturalists has led to the publishing of this third edition.

The Ontario Geological Survey is pleased, indeed, to be publishing this third edition and we take pleasure in commending it to the reader.

V.G. Milne
Director
Ontario Geological Survey



The authors, Donald Putnam and Lyman Chapman, in the field, August 1965 (photo courtesy of Donald E. Gislason).

THE AUTHORS

Lyman John Chapman, B.S.A., M.S., worked at the Department of Physiography, Ontario Research Foundation, Toronto, from 1934 until, as Director, he retired in 1973. Donald Fulton Putnam, B.S.A., Ph.D., joined the newly formed Department of Geography, at the University of Toronto, in 1938, and was Chairman of the department from 1952 to 1963.

Both Mr. Chapman and Dr. Putnam (born in 1908 and 1903 respectively) were raised on farms: the former in Ontario near Toronto, and the latter in Nova Scotia, near Truro. Both are graduates of the Ontario Agricultural College, Guelph. Dr. Putnam proceeded with post-graduate studies in botany at Macdonald College, Quebec, and the University of Toronto. Mr. Chapman took post-graduate training in soil science at Michigan State College, and in 1930 and 1931 he worked on soil surveys at Ontario Agricultural College.

Mr. Chapman and Dr. Putnam first worked together in 1934 to investigate a disease of oats which was found to be caused by nematodes invading the roots. From 1935 until about 1947 they spent the greater part of each summer making the survey of landforms and soil-forming materials on which this book is based.

Dr. Putnam and Mr. Chapman have collaborated on a series of articles on the glacial geology, physiography, and soils of Southern Ontario, as well as on a well-known description of its climate. Dr. Putnam has also published various articles on geography, including an account of the climate of the Maritime Provinces, and two texts on the regions of Canada.

For several years, Mr. Chapman directed basic studies of evaporation in Ontario and the application of this information in a scheme of controlled irrigation of forest tree seedlings. His department also carried out studies on the adaptation of crops to soil and climate, particularly for peaches, rice, soybeans, and corn. He has been sought as a scientific consultant on such matters as locating gravel pits, water wells, and the use of soil for special purposes, such as racetracks. In private life, he has been connected with boys' activities, especially hockey, and since 1973 he has owned and operated an apple farm near Thornbury in the Beaver Valley.

Dr. Putnam was well known as a professor who demanded of his students the same clear thinking, precision, and attention to detail that he brought to his own work. He loved to teach and never allowed research or writing to interfere with it. An unparalled leader in field work, he enjoyed leading his students on field trips each year. After his retirement in 1974 from Erindale College, University of Toronto, he continued to be an active lecturer. He was presented with the Coronation Medal in 1953 by Her Majesty the Queen, the Massey Medal in 1969 by the Royal Canadian Geographical Society, and an honourary Doctor of Laws degree from York University in 1974. In 1972, the Canadian Association of Geographers gave him their award for service to the profession of Geography.

After Dr. Putnam's death in 1977, Mr. Chapman's continuing interest in modifying and updating the concepts and statistics included in the second edition of *The Physiography of Southern Ontario* has led to the publication of this, the third edition.

CONTENTS

Page

Preface to the Third Edition xvii
Preface to the Second Edition xix
Preface to the First Edition xxi
Metric Conversion Table xxiv

The Bedrock 1
Broad Warping 1
Faults 2
Erosion of Bedrock 5

Glacial Geology 9
Pre-Wisconsinan Beds 10
Late Wisconsinan Beds 10
Moraines 13
Spillways 15
Drumlins 16
Eskers 17
Glacial Lakes 18
The Recession of the Wisconsinan Glacier 26
Postglacial Developments 41

Surface Features 43
Moraines 43
Interlobate Moraines Built Between the Ontario-Erie and the Georgian Bay and Huron Ice Lobes 43
Orangeville Moraine 43
Waterloo Moraine 44
Blenheim Moraine 44
Leamington Moraine 44
Moraines of the Huron Ice Lobe North of London 44
Milverton Moraine 45
Mitchell Moraine 45
Lucan Moraine 45
Seaforth Moraine 45
Moraines of the Erie Ice Lobe South of London 46
Ingersoll Moraine 46
Westminster Morine 47
St. Thomas Moraine 47
Norwich Moraine 47
Tillsonburg Moraine 47
Sandy Moraines of the Georgian Bay Ice Lobe 47
Saugeen Kame Moraines 47
Wawanosh Moraine 47
Port Huron Moraine System 48
Wyoming Moraine 48
Singhampton Moraine 48
Gibraltar Moraine 49
Paris Moraine 50
Galt Moraine 50
Moraines Behind the Gibraltar and Galt Moraines 51
Banks Moraine 51
Tara Strands 51
Beaver Valley Moraines 51
Vinemount, Niagara Falls, and Fort Erie Moraines 51

Moraines of South-Central Ontario 52
Oak Ridges Moraine 52
Trafalgar Moraine 53
Trenton Moraine 54
Oro Moraine 54
Corn Hill Moraine 54
Edenvale Moraine 54
Mara Moraine 54
Dummer Moraines 54
Eastern Ontario Moraines 55
Georgian Bay-Ottawa Valley Moraines 55
Drumlins 55
Drumlins of the Lake Ontario Ice Lobe 55
Durmlins of the Huron Ice Lobe 56
Drumlins of the Georgian Bay Ice Sheet 56
Drumlins of the Simcoe and Kawartha Lakes Ice Sheet 57
Eastern Ontario Field 57
Eskers 58
Abandoned Shorelines and Lacustrine Sediments 61
The London Correlative of Lake Maumee 62
Lake Whittlesey 62
Lake Arkona 63
Lake Warren 64
Early Lake Algonquin and its Correlatives 68
Lake Algonquin and Lake Nipissing 69
Sarnia to Tobermory 69
Wiarton to Collingwood 71
Nottawasaga Basin 74
Lake Simcoe Basin 76
Lake Nipissing East of Collingwood 76
Manitoulin Island 77
Cockburn and St. Joseph Islands 77
Kirkfield to North Bay 78
Lake Iroquois 78
Champlain Sea 80
Loess (Eolian Silt) 80
Sand and Gravel Deposits 81
River Valleys 84
Northern Georgian Bay Drainage 85
South River 85
French River 85
Magnetawan River 85
Muskoka River 85
Southern Georgian Bay Drainage 86
Severn River 86
Coldwater Creek, Sturgeon River, and other streams 86
Nottawasaga River 86
Beaver River 87
Bighead River 87
Sydenham and Pottawatomi Rivers 88
Disappearing Streams 88
Lake Huron Drainage 89
Sauble River 89
Saugeen River 90
Lucknow (Nine Mile) River 90
Maitland River 91
Bayfield River 92
Ausable River 92

Lake St. Clair Drainage 92
St. Clair River 92
Sydenham River 92
Thames River 93
Lake Erie Drainage 94
Kettle Creek 94
Catfish Creek 94
Big Otter Creek 95
Big Creek 95
Grand River and Tributaries 95
Western Lake Ontario Drainage 98
Niagara River 99
Welland River 99
Scarp-face drainage 99
Dundas Valley 101
Northern Lake Ontario Drainage 102
Credit River 102
Etobicoke Creek 103
Humber and Don Rivers 103
Ganaraska River 104
Trent River 104
Moira River 105
Salmon River 105
Napanee River 106
St. Lawrence Valley Drainage 106
Cataraqui and Gananoque Rivers 106
Raisin River 106
Ottawa Valley Drainage 106
South Nation River 106
Rideau River 107
Mississippi River 108
Madawaska River 108
Bonnechère River 109
Muskrat River 109
Indian River 109
Petawawa River 109
Barron River 110
Mattawa River 110
Ottawa River 110
The Significance of Southern Ontario Streams 111

Physiographic Regions 113
1 Niagara Escarpment 114
Land Use and Settlement 119
2 Beaver Valley 122
3 Bighead Valley 124
4 Cape Rich Steps 126
5 Horseshoe Moraines 127
Land Use and Settlement 128
6 Flamborough Plain 129
7 Dundalk Till Plain 130
Land Use and Settlement 132
8 Stratford Till Plain 133
Land Use and Settlement 134
9 Hillsburgh Sandhills 135
10 Waterloo Hills 136
Land Use and Settlement 137

11 Guelph Drumlin Field 137
Land Use and Settlement 138
12 Teeswater Drumlin Field 139
Land Use and Settlement 140
13 Arran Drumlin Field 141
Land Use and Settlement 143
14 Oxford Till Plain 143
Land Use and Settlement 144
15 Mount Elgin Ridges 144
16 Caradoc Sand Plains and London Annex 146
17 Ekfrid Clay Plain 146
18 Bothwell Sand Plain 147
19 St. Clair Clay Plains 147
Essex Clay Plain 147
Lambton Clay Plain 149
Chatham Flats 150
St. Clair Delta 151
20 Pelee Island 151
21 Erie Spits 153
22 Norfolk Sand Plain 153
23 Haldimand Clay Plain 156
Land Use and Settlement 158
24 Saugeen Clay Plain 159
Land Use and Settlement 160
25 Huron Slope 160
26 Huron Fringe 161
27 Bruce Peninsula 162
Land Use and Settlement 162
28 Manitoulin Island 163
Land Use and Settlement 165
29 St. Joseph and Cockburn Islands 166
30 Oak Ridges Moraine 166
31 Peterborough Drumlin Field 169
Land Use and Settlement 171
32 South Slope 172
Land Use and Settlement 174
33 Peel Plain 174
Land Use and Settlement 175
34 Schomberg Clay Plains 176
Land Use and Settlement 177
35 Simcoe Lowlands 177
Nottawasaga Basin 178
Lake Simcoe Basin 181
36 Simcoe Uplands 182
37 Carden Plain 184
38 Dummer Moraines 185
Land Use and Settlement 185
39 Napanee Plain 186
Land Use and Settlement 187
40 Prince Edward Peninsula 188
Land Use and Settlement 189
41 Iroquois Plain 190
Niagara Fruit Belt 190
Ontario Lakehead 191
Hamilton to Toronto 191
Toronto 192
Scarborough 193

Scarborough to Newcastle 193
Newcastle to Trenton 194
Trent Embayment 195
Geographical Significance of the Iroquois Plain 195
42 Leeds Knobs and Flats 196
Land Use and Settlement 196
43 Smiths Falls Limestone Plain 196
Land Use and Settlement 197
44 Edwardsburg Sand Plain 200
45 North Gower Drumlin Field 200
46 Glengarry Till Plain 201
Land Use and Settlement 203
47 Winchester Clay Plain 203
Land Use and Settlement 204
48 Lancaster Flats 205
49 Ottawa Valley Clay Plains 205
50 Russell and Prescott Sand Plains 208
51 Muskrat Lake Ridges 210
52 Petawawa Sand Plain 210
53 Algonquin Highlands 211
Soils 211
Agriculture 213
Mining 213
Forestry 213
Recreation 214
54 Georgian Bay Fringe 214
55 The Number 11 Strip 214

Summary 217

Appendix A: Quaternary Geology reports and maps published for Southern Ontario by the Ontario Geological Survey and the Geological Survey of Canada 221
Appendix B: Aggregate Resource Inventory Reports for Southern Ontario published by the Ontario Geological Survey 225
Appendix C: Ontaro Soil Survey reports and maps published by Canada Department of Agriculture 228
Appendix D: Counties, districts, and regional and district municipalities in Southern Ontario, and a list of present locations of former municipalities in Southern Ontario 229
Glossary 235
References 239
Index 245

TABLES

1. Soil profile of the Dumfries series 128
2. Soil profile of the Honeywood loam 131
3. Soil profile of the Waterloo sandy loam 137
4. Population of the Bruce Peninsula, 1981 163
5. Population of Manitoulin Island, 1981 165
6. Population of the South slope, eastern part, 1981 174
7. Population of a representative area of the Napanee plain, 1981 187
8. Population of Prince Edward County, 1981 190
9. Population of the central part of the Smiths Falls plain, 1981 199
10. Population of Stormont and Glengarry Counties, 1981 203
11. Soil profile of the North Gower clay loam 204
12. Population of Dundas County, 1981 204

FIGURES

1. Bedrock geology of Southern Ontario 2
2. Sketch of the bedrock topography of Southern Ontario 3
3. Locations of faults in Southern Ontario 4
4. Physiographic sketch of the Ottawa-Bonnechère Graben 4
5. Moraines of Southern Ontario 13
6. Texture curves of tills from 12 widely distributed drumlins 15
7. Drumlin fields of Southern Ontario 16
8. Eskers in Southern Ontario 19
9. Sequence of former lakes of the Huron and Erie basins 21
10. Former shorelines in Southern Ontario 22
11a. The recession of the Wisconsinan glacier, showing the early ice positions at the Orangeville and Waterloo Moraines 29
11b. Huron lobe at the Milverton Moraine 30
11c. Overriding of the Milverton Moraine by the Georgian Bay lobe 30
11d. Huron lobe at the Mitchell Moraine 31
11e. Huron lobe at the Seaforth Moraine, and Ontario-Erie lobe at the St. Thomas Moraine 31
11f. Position of the ice fronts at the Port Huron Moraine system, during the early stage of Lake Whittlesey 32
11g. Late stage of Lake Whittlesey, first separation of the Ontario-Erie lobe and Lake Simcoe-Kawartha Lakes lobe 32
11h. Ice position at the Banks Moraine, during the time of Lake Warren 33
11i. Lake Lundy and Lake Peel 33
11j. Early Lake Algonquin and Lakes Dresden and Dunnville 34
11k. Lake Iroquois 34
11l. Main Algonquin beach stage and the Champlain Sea 35
11m. Champlain Sea and the Fossmill stage of Lake Algonquin 35
11n. Lake Stanley stage and the formation of the Ottawa delta during the initial stage of the North Bay outlet 36
11o. Nipissing Great Lakes and drainage down the Ottawa Valley, St. Clair River, and via Chicago 36
12. Physiographic sketch of the channels through the sandy delta, east of Ottawa 41
13. Sketch map showing the parts of the Oak Ridges Moraine 52
14. A section of the Palmerston map sheet (NTS 40 P/15), on which the contours intermittently outline an esker 60
15. Profiles of warped shorelines of former glacial Lakes Whittlesey, Warren, Algonquin, and Iroquois, the Champlain Sea, and postglacial Lake Nipissing 62
16. The distribution of deleterious components in gravel in Southern Ontario ... 82
17. Profile showing elevations along the Nottawasaga River and its tributaries .. 87
18. Sketch showing the dissection near Port Stanley, on the north shore of Lake Erie 95
19. The 55 physiographic regions of Southern Ontario 113
20. Block diagram of the Blue Mountain, south of Collingwood 117
21. Block diagram of the Beaver Valley 122
22. Block diagram of the Cape Rich foreland 126
23. Soil profiles for the Huron clay loam, Perth clay loam, and Brookston clay loam 134
24. Physiographic sketch of Manitoulin Island 164
25. Map showing the several different parts of the Simcoe lowlands 178
26. Generalized map of the surficial deposits of Toronto 192
27. Block diagram illustrating the structure of the rock knobs and clay flats of Leeds County (part of the United Counties of Leeds and Grenville 196
28. Russell and Prescott sand plains 209
29. Diagram illustrating the shallow soil over bedrock, typical of the Algonquin highlands 211

30. Mean annual precipitation for Southern Ontario 212

PHOTOGRAPHS

1. Niagara Escarpment, Collingwood 6
2. Striae on limestone, near Lion's Head, on the Bruce Peninsula 10
3. Drumlin near Bradford 11
4. Fluting on a drumlin east of Peterborough 11
5. Aerial view of a fluted till plain southeast of Palmerston 12
6. Kame at Glen Ross on the Trent River 14
7. Dummer Moraine near Erinsville, Lennox and Addington County 14
8. Stream gravel near Arkona, Lambton County 15
9. A drumlin landscape 17
10. Esker ridge near Chesley, Elderslie Township 18
11. Pit face in the esker near Chesley, Elderslie Township 18
12. Air photo of an esker southwest of Atwood, Perth County 20
13. Rounded pebbles typical of beach gravels 21
14. Abandoned marine beach strands near Carleton Place 22
15. A present-day gravel beach at Chartwell Point on Lake Ontario 23
16. Varved clay, Holland Landing 23
17. Stream-cut bluff near Vinette, United Counties of Prescott and Russell 40
18. Clay till moraine south of Woodstock 46
19. Wyoming Moraine near Hensall, Huron County 48
20. Kame moraine at the head of the Beaver Valley near Flesherton 49
21. Spillway at Violet Hill, Dufferin County 50
22. The Oak Ridges Moraine in Albion Township 53
23. An island in Rice Lake with the typical drumlin form 58
24. Oblique aerial view of an esker near Jessopville, Dufferin County 59
25. Ripple pattern in the Lake Warren plain northeast of Goderich 66
26. Varved clay over till, on the Peel plain 67
27. Air photo showing the crecentic pattern of blow-outs on the sand plain near Hepworth, Bruce County 71
28. Close-up of dune sands near Hepworth, Bruce County 71
29. Air photo of little moraines west of Owen Sound 72
30. Beach of Lake Algonquin near Hogg, north of Owen Sound 73
31. Flat lake plain delta of the Bighead River, Grey County 74
32. Air photo of the area just west of Collingwood 75
33. Algonquin bluff near Waverley, Simcoe County 76
34. Boulder beach on a till ridge near Greenfield, Glengarry County 80
35. Marine clay, Carlsbad Springs, east of Ottawa 81
36. Wind-blown silt with glacial till below, Cramahe Township, Northumberland County 81
37. Hoggs Falls on the Boyne River in the Beaver Valley 88
38. Hepworth Creek, an example of a disappearing stream 89
39. Luther Dam on the Grand River 96
40. Elora Gorge 97
41. Niagara Falls 100
42. Niagara Gorge 100
43. Webster's Falls on Spencer Creek, near the Town of Dundas 102
44. Shallow valley of the South Nation River near Cass Bridge, Dundas County 107
45. Badly gullied hillside north of Georgetown on shale of the Queenston Formation 115
46. Terraces of outwash sand on the Niagara Escarpment at Dunn Hill, Hockley Valley 116
47. The Niagara Escarpment at Lion's Head, Bruce Peninsula 118
48. Stacks on Flowerpot Island near the tip of the Bruce Peninsula 119
49. Lake Algonquin boulder beach located along the south shore of Georgian Bay near Thornbury 123

50. Typical "whaleback" drumlin form south of Meaford 125
51. Oblique aerial view of the Dundalk plain west of Shelburne, showing numerous swamps 130
52. Dundalk plain, East Garafraxa Township 133
53. The Baden hills, west of Kitchener 136
54. Glacial till, Wroxeter, Bruce County 140
55. Vertical air photo of the Gould Lake area in Amabel Township, Bruce County 142
56. Air photo showing sandy knolls on the sand plain west of Glencoe, Middlesex County 148
57. Air photo showing lack of sandy knolls on the sand plain west of Glencoe, Middlesex County 148
58. Soybeans growing on the Chatham flats 151
59. Soybeans growing on the level clay loam of Pelee Island 152
60. A pheasant hunter on the blackish soil of Pelee Island 153
61. Onion field on muck at Point Pelee 154
62. Tobacco farm at Cathcart, west of Brantford 155
63. A field of winter wheat on the Haldimand clay plain near Caistorville 158
64. Exposure of varved clay near Chesley, Bruce County 159
65. Fissure in dolostone, Bruce Peninsula 162
66. Flutings in bedrock, Grimsthorpe, Manitoulin Island 164
67. Oblique aerial photograph of the Oak Ridges Moraine 167
68. Oblique aerial photograph of a drumlin near Lake Scugog 169
69. Gullied till plain north of Bowmanville, Regional Municipality of Durham 173
70. Faintly undulating to level clay plain on the Peel plain 175
71. Minesing flats 179
72. Aerial view of the Holland Marsh 182
73. Rolling till plain of the Simcoe uplands, Medonte Township 183
74. Shallow soil on limestone, Carden plain 184
75. Shallow soil on limestone, near Napanee 186
76. Nodular limestone of the Lindsay Formation 188
77. Sand dunes in Prince Edward County on the shore of Lake Ontario 190
78. Scarborough Bluffs 193
79. Granite knobs and clay flats near Gananoque 197
80. Marine beach deposits of limestone shingles on the Smiths Falls limestone plain 198
81. Farmsteads consisting of several log buildings are common on the limestone plains of eastern Ontario 199
82. Boulder pavement near Maxville, Glengarry County 202
83. Stone wagon, near Vankleek Hill, northern Glengarry County 202
84. Level clay plain of the Champlain Sea floor, Barr Line, Renfrew County ... 206
85. Stream-cut bluff, east of Ottawa 207
86. Shallow layer of till over granitic bedrock, southwestern Algonquin Provincial Park 211

MAP

(Back Pocket)

Map P.2715 (coloured) – Physiography of Southern Ontario.
Scale 1:600 000.

PREFACE TO THE THIRD EDITION

It is now over 30 years since *The Physiography of Southern Ontario* was first printed. At the outset it was intended mainly to provide a basis needed for the classification, mapping, and description of soils. However, various other practical applications have been served. Engineers who must consider soil as foundation material for highways and buildings found it immediately useful. Hydrologists, seeking well water and, increasingly in recent years those concerned with seepage of pollutants, have used it as a starting reference. We have assisted in selecting routes for pipelines. Exploration for gravel and sand, for foundry sand, clay suitable for glazed tile, and even stone-free sandy loam for racetracks may also be mentioned. The text and maps are a standard reference for the teaching of physical geography. The third edition will serve to keep the information available for these purposes. Most of the data have been updated using agricultural information from the 1981 census, and recent population, hydrology, and climatology statistics. I would like to acknowledge the work of the following people who were instrumental in this regard: Mr. Nicholas Roller, Senior Statistician, Economics Branch, Ontario Ministry of Agriculture and Food, Toronto; Mr. Peter Gryniewski, Supervisor, Streamflow Forecast Centre, Conservation Authorities and Water Management Branch, Lands and Waters Group, Ontario Ministry of Natural Resources, Toronto; Mr. John M. Spratt, Hydraulic Studies and Testing Engineer, Hydraulic Studies and Development Department, Ontario Hydro, Toronto; and staff of Atmospheric Environment Service, Environment Canada, Toronto.

The two previous editions dealt only with the agricultural area underlain by sedimentary limestones and shales, most of it having a deep, soil overburden. This was the area surveyed up to that time. Since that time the pre-dominantly forested regions extending to North Bay have been surveyed. In this text North Bay is the dividing point between Southern and Northern Ontario, and so this edition deals with all of the Province south of North Bay. Southern Ontario is in turn subdivided into two: 1) the area underlain by Precambrian bedrock of the Canadian Shield, which is based on "The Physiography of the Georgian Bay-Ottawa Valley area of Southern Ontario" (Chapman 1975) and its inclusion has resulted in the addition of three more physiographic regions: the Georgian Bay fringe, the Highway 11 strip, and the Algonquin highlands; and 2) the south part which is underlain by the softer Paleozic bedrock.

Also, this third edition is accompanied by an updated physiographic map (Map P.2715) with a scale of 1:600 000, a more useful size of wall map. The four miles to one inch maps (Maps 2224, 2225, 2226, 2227, and 2228) have been reprinted and can be ordered from:

Public Service Centre, Ministry of Natural Resources
Room 1640, Whitney Block, Queen's Park
Toronto, Ontario M7A 1W3

During the last 17 years further studies by several geologists have resulted in a few changes in glacial history and some of these are included in this edition. However, we do not intend to deal in any detail with the stratigraphy and age of the buried Pleistocene deposits even though this topic has received considerable attention during this same period.

My able partner and dear friend Dr. Donald Putnam died on February 23, 1977. Without his inspiration and competence this work would have been less complete.

The Department of Physiography, Ontario Research Foundation, which supported this survey was discontinued upon my retirement in 1973. It is fitting and satisfying that the decision to update, review, and publish the text a third time was made in cooperation with the Engineering and Terrain Geology Section, Ontario

Geological Survey, Ontario Ministry of Natural Resources. I would like to acknowledge the support of Dr. Owen L. White and Mrs. Gertrude M. Scott. In particular, the patient and thorough, diligent work of Mrs. Mary-Lynne T. Stuart, the scientific editor, in updating the statistics in the chapter *Physiographic Regions* and her editorial advice are greatly appreciated. The comments of Dr. W.R. Cowan, the critical reader, have been most helpful as well. I would also like to thank Renate Simon and Mrs. Monika Sutton, for their able assistance, Mrs. Donna Day for drafting the figures and Mr. Lyell McKinnon for proofreading the manuscript and preparing the index.

Lyman Chapman
Delta Farm
R.R. #1, Thornbury

PREFACE TO THE SECOND EDITION

The second edition of *The Physiography of Southern Ontario* is due to the steady and increasing demand for the book. It provides an opportunity to make some changes and additions in the light of studies made since 1950. The interpretations of glacial history at several stages have been altered. Some information on the composition of the glacial tills, clays, sands, and gravels is now available. Statistics have been brought up to date and regional descriptions improved. However, the text has not been changed greatly.

The large maps are the same and so regrettably include a sprinkling of cartographic errors. A generalized, smaller map is included with this edition. Being less cumbersome than the four large map sheets it should aid the reader and be convenient to carry when travelling. It was prepared for the Atlas of Canada and is used here through the courtesy of the Geographical Branch, Canada Department of Mines and Technical Surveys.

The writers wish to express their thanks to Mr. T.D. Jarvis and Dr. H.B. Speakman for their encouragement and support particularly from 1934 to 1950 during the course of the survey. Professor F.F. Morwick and Dr. O.M. McConkey of the Ontario Agricultural College, gave much valuable help. We owe a great deal to Miss Maynard Grange of the Foundation for her editorial advice and to Miss Eleanor Harman and the editorial staff of the University Press. The fine co-operation of the Geographical Branch, Canada Department of Mines and Technical Surveys has made possible the inclusion of the small coloured physiographic map with this edition. Finally we are grateful for the continued support of the Ontario Research Foundation and the financial support of the Ontario Government.

We hope that this book will continue to serve as a technical reference and also to be enjoyed by all those interested in the landscape.

L.J.C.
D.F.P.

PREFACE TO THE FIRST EDITION

This is a description of the surface of Southern Ontario. It deals with the major features controlled by the underlying rock structures and in particular describes the local land forms composed of unconsolidated materials. It is accompanied by four coloured maps upon which the classification and distribution of these land forms is shown. The map and report constitute the results of field work carried on since 1934, under the auspices of the Ontario Research Foundation.

Southern Ontario, for the purposes of this discussion, is the agriculturally developed portion of the Province which, for the most part, lies to the south of the Canadian Shield, including the southwestern peninsular area bounded by the Great Lakes together with the lowland between the Ottawa and St. Lawrence rivers. It is underlain chiefly by stratified limestones and shales of Palaeozoic age, the original horizontal attitude of which has been but little disturbed. The limestone boundary is not strictly adhered to, however, because certain areas underlain by Precambrian rocks are included, notably some outcrops in Frontenac, Leeds, and Renfrew counties and adjacent areas floored by deep clay deposits. Included also is Manitoulin Island, because it is composed of flat plains of Palaeozoic rocks, even though it is usually thought of as part of northern Ontario.

Southern Ontario is an area of modest relief. The lowest land along the Ottawa River is barely 150 feet above sea level, while the highest points on the Blue Mountain south of Collingwood just fail to reach 1,800 feet above sea level. These occur on a rocky ridge near the village of Singhampton.

It is a glaciated region. In four successive cold periods of the Pleistocene, vast masses of ice moved across it, scouring the bedrock, breaking and pulverizing the dislodged pieces, [and] overriding and moulding the resultant debris. The Palaeozoic limestones, sandstones, and shales were fairly easily eroded and, except in a few well-known marginal areas, the deep overburden stands in striking contrast to the scanty, discontinuous, sandy mantle on the harder rocks of the Canadian Shield. The depth of the overburden, the gentle slopes, and the high content of limestone and clay are responsible for the development of some highly productive and durable soils. It is no accident that these 30,000 square miles, or 19,000,000 acres, produce 95 per cent of the agricultural wealth of the Province and one-quarter of that of the whole dominion.

Physiographic research has not received the attention in Canada that it deserves. Only one regional study has appeared heretofore, J.W. Goldthwait's masterly *Physiography of Nova Scotia*, which was published in 1924. It has been a source of inspiration to the present writers. While most of the facts herein assembled are the result of our own field work, full use was made of the reports of previous investigators. Information about the bedrock is largely due to the long continued efforts of the Geological Survey of Canada, supplemented by the special studies of outside geologists. Among those to whom we are most indebted are A.W.G. Wilson, M.Y. Williams, C.L. Stauffer, M.E. Wilson, A.E. Wilson, J.F. Caley, and G.M. Kay. Investigation of the Pleistocene deposits has not received the same continued emphasis as the bedrock. However, there have been a number of outstanding individual contributors to the knowledge of surface geology in Ontario, among whom might be mentioned [are] J.W. Spencer, G.K. Gilbert, A.L. Fairchild, F. Leverett, F.B. Taylor, A.P. Coleman, J.W. Goldthwait, W.A. Johnson, G.M. Stanley, R.E. Deane, C.P. Gravenor, A. Dreimanis, A.K. Watt, P.F. Karrow, N.R. Gadd, and C.I. Dell. It is notable that many of these are American geologists whose work in the adjoining states led them to see the need for having supplementary Canadian data.

The sorting of the highly variable surface deposits of a glaciated area is in itself a worthy task, but in this instance it was undertaken as part of a wider objective. Interested in climate and soils and their effects on crops, the writers studied the

landforms and geological materials because this information throws some light on the character of the soils and their distribution. Since the acceptance of the profile as the basis of classification, efforts to establish soils studies as an independent science have led to an undue minimizing of the geological materials as a factor in soil formation. Especially in recently glaciated areas the characteristics of the parent materials are of primary importance. The distribution pattern of these soils is complex, and in order to have a clear mental picture of it the glacial history must be known.

It is perhaps in order to say a few words about the way in which our physiographic survey was carried on. The field mapping was done on a scale of one inch to a mile. Contoured sheets of the National Topographic Series were used, and in areas where these were not available county road maps produced by the Ontario Department of Highways were used instead. In such areas, elevations were checked by the use of aneroid barometers. Later, much detail was obtained by reference to aerial photographs as they became available.

As can be seen by reference to our preliminary publications, Southern Ontario was regarded as being composed of three physiographic divisions, eastern, south-central, and southwestern Ontario and each was undertaken as a project, the central region first, then eastern Ontario, and eventually the much larger district west of the Niagara escarpment.

Traversing was done by automobile and in most sections all of the traversable east-west roads of the Province were covered systematically as well as many north-south ones. Before this was done, however, several weeks were spent in preliminary reconnaissance in each section, and afterwards a great deal of checking in the field was necessary during the final drafting of the master maps. Since the roads of the Province are, on the average, about one mile apart it means that observations have been made along two sides of every square mile in the area. Occasionally when it was felt any particular block was not sufficiently visible from the road, foot traverses were made. In certain areas considerable walking was necessary because of poor roads. A few aeroplane flights, also, were made to assist in the interpretation of aerial photographs and to take photographs for illustrations.

When vertical aerial photographs are viewed under a stereoscope all the prominent landforms stand out and can be mapped. Escarpments in the bedrock, most of the moraines and the spillways associated can be identified in this way, as can drumlins, eskers, and the higher abandoned shorecliffs of the glacial lakes. The pattern exhibited by the photographs also serves as a guide. Even faint relief can produce a definite pattern, giving clues to the topography that would be missed on a ground survey. For instance, those till plains which are faintly drumlinized (fluted) show up in uniform colours broken by dark parallel streaks. Undrumlinized till plains exhibit a marbled pattern similar to that of till moraines. Aerial photography is undoubtedly the finest aid to geographic investigation which has been developed, and it is unfortunate that good vertical photographs were not available for all of Southern Ontario when the survey was being made.

The map (in four parts) accompanying this book is the first reasonably accurate presentation of the surface features of Southern Ontario. The base is derived from the old "Geographical Series," on the scale of 1:250,000, published by the Dominion of Canada Department of the Interior. It lacks many of the cartographical improvements of the National Topographic Series, but complete base maps of the latter were not available.

We feel impelled to caution our readers that the map deals in landforms only. It is not a generalized soils map, although several factors basic to a classification of soils may be inferred from it. The report describes these landforms and their composition, and is not meant as a complete account of Pleistocene geology. The various substages of the Wisconsin glaciation as they apply in this region are not discussed, and neither are their ages, partly because these are indefinite and contentious at present. It leaves untouched the lower beds of the drift, the classification of which would require a painstaking study of local stratigraphy.

Although we believe the map to be reasonably detailed for the scale used, we must point out that it is a broad scale generalization. The glacio-fluvial classification of land forms was made as simple as possible without obscuring all important distinctions. Terminal moraines, for instance, are differentiated according to whether they consist chiefly of glacio-fluvial sands and gravels or of till. Of course, there are many cases of association of the two types; small kames are common along all till-moraines, and kame-moraines have inclusions of sandy till and even of boulder clay. In association with the moraines a network of abandoned glacial drainage channels encircles the high ground west of the escarpment. Practically all of these have been mapped with the aid of aerial photographs; hence their positions are accurately charted. Each, however, is a complex system in itself involving steep-cut bluffs, terraces, meander scrolls, and long swamps which cannot be shown on the scale employed. On the other hand many minor details can be shown. The outlines of the drumlins are definite enough to show whether they are oval or of a more attenuated shape. Among the drumlins a few short eskers have been missed, but the mapping of the main eskers is nearly complete. Along the ancient shorelines a distinction is made between cliffs and beaches, and such features as wave-built gravel bars are shown wherever possible, regardless of whether they are referable to any of the established water levels. However, in some places parallel beaches marking successive water levels lie so close together that it is impossible to show them all individually on a map of this scale. The lacustrine plains are separated into two main categories: the sandy deltas and shore terraces, and the clay plains. There is also a separate category for those areas in which a shallow lacustrine clay serves to modify a till plain. The limestone plains with little or no drift enjoy a separate category, as does also the shallow drift over shale. The slopes of the Niagara escarpment, however, are mapped without distinguishing its component rock formations. Finally, the locations of the larger peat bogs are mapped since they, in themselves, are distinctive landscape types. Thus, altogether fifteen landform categories have been differentiated and find cartographic expression upon the master map.

The stream valleys do not appear on the map, except in so far as they are indicated by the streams themselves, but they are discussed. One full section deals with the relation of the rivers to the pre-existing land forms, and the nature of the dissection produced to date. In some cases a few facts are included about the amount and reliability of the stream flow and other attributes of the larger rivers.

We might well have contented ourselves with this analytical result since it provides the maximum detail available from the survey. However, analysis is only half of the geographic process. The other half is the preparation of a much simpler map dividing the area into convenient divisions each having distinctive characteristics. Moreover, the fact that such regions can be named appeals to most people. For instance we have noticed that the Peel plain has personality because it has a name by which it can be set apart from other clay plains in Southern Ontario. Some boundaries are not so distinctive as others and some geographer may feel obliged to shift them. Also, some of the names which we have applied may not stick and more apt ones will be found. In spite of these shortcomings we have identified, named, and described fifty-two minor natural regions which may be recognized in Southern Ontario.

Conversion Factors for Measurements in Ontario Geological Survey Publications

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

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

1 ounce (troy)/ton (short)	20.0	pennyweights/ton (short)
1 pennyweight/ton (short)	0.05	ounce (troy)/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 cooperation with the Coal Association of Canada.

THE BEDROCK

The physiography of Ontario south of North Bay (herein denoted as Southern Ontario) falls naturally into two parts on the basis of the bedrock. The north part (generally north of the Kawartha Lakes) is characterized by knobs and ridges of granite and other rocks of Precambrian age. It is part of the Canadian Shield which covers a vast area in Canada and provides a stable foundation in this part of the continent. The softer, sedimentary limestones, shales, and sandstones in the south part overlie the more ancient Precambrian bedrock. They originated as marine sediments of marl, clay, and sand, and are the oldest rocks to harbour the pretrified remains of saltwater organisms. Since these organisms are some of the most primitive animals and plants, the rocks are called Paleozoic. The great thickness of these beds indicates a long period of inundation while these sediments accumulated. The sediments in time became cemented under the pressure of overlying strata to form solid rocks. Finally, this part of the continent rose above sea level. The beds of limestones, dolostones, shales, and sandstones overlap each other and appear as concentric belts as shown in Figure 1. However, being relatively soft and easily eroded these rocks yielded a good deal of material to the glaciers when they advanced over this area. As a result there is usually a thick mantle of soil materials covering the bedrock. These materials, deposited by the glaciers during Pleistocene time, form the bulk of the surface landforms.

In the north part, which in this monograph we will call the Canadian Shield or Georgian Bay-Ottawa Valley region, the Precambrian bedrock is within the Grenville Province, distinguished by the presence of certain metasedimentary and metavolcanic rocks. About two-thirds of the rocks are granites, generally granite-gneisses. Next in extent are the metasediments including crystalline limestone, quartzite, and amphibolite and paragneiss, these respectively being from the metamorphism of limestone, sandstone, and various limy and sandy shales. Commonly associated with the granites are syenites and nepheline syenites. There are scattered occurrences of volcanics.

During their long history, these rocks have suffered much folding, then have been greatly worn down by erosion. The series of northwest-trending ridges around the Muskoka Lakes originated through the differential erosion of folded rocks. Another example of this type of erosion is found between Lake Nipissing and Burk's Falls where a series of north-trending broad ridges are separated by intervening troughs.

Included in the region are small areas of Paleozoic limestone which are remnants of deposits that at one time formed an extensive and, perhaps, continuous overlay on the Precambrian rocks. Some of these outliers are near the southern border. Others occur in protected depressions, commonly in downfaulted positions. They are also present in the crater near Brent, a circular depression attributed to the impact of a meteor, and in the basin of Cedar Lake. Similarly, there is Paleozoic limestone in the basin of Skeleton Lake.

BROAD WARPING

In the Georgian Bay-Ottawa Valley region the bedrock has been warped to form broad arches in two directions. One extends northwestward from the Adirondack area, crossing the St. Lawrence River at the Thousand Islands, and is responsible for the appearance on the surface of Precambrian granite knobs which are buried to the east and west by younger sedimentary rocks. Called the Frontenac Axis, it extends toward Algonquin Provincial Park

and divides drainage flowing toward Lake Ontario from that flowing to the Ottawa River. The second and a much larger upwarping is the Algonquin Arch. It extends northeastward from Chatham forming the upland south of Collingwood and continues to the upland in and around Algonquin Provincial Park. Together they give the region its dome-shaped build.

From the shore of Georgian Bay which stands at 580 feet above sea level (a.s.l.) the land rises to over 1,800 feet. A point west of Booth Lake has an altitude of 1,925 feet a.s.l.; a few points are over 1,800 feet and some sizeable areas stand above 1,600 feet. On the eastern flank, the land descends irregularly to below 600 feet a.s.l. at the edge of the Ottawa Valley and eastern Ontario lowland. Overall, the land slopes from the centre toward the borders at about 10 feet per mile.

In the south the sedimentary rock strata, which were originally horizontal, have been faintly but noticeably warped. Owing to pressure changes within the earth, broad domes were pushed up in the Adirondacks, Algonquin Provincial Park, and Wisconsin, while between them appeared basins in Michigan, New York, and the Ottawa Valley. The broad arch running from the Dundalk area southwestward has been related by some geologists to the Algonquin Park dome (Kay 1942) and to the Cincinnati Arch which underlies Essex County. The main elements of the bedrock topography and structure are illustrated by Figure 2.

This broad arch of the rocks, from Windsor to Dundalk and beyond, is responsible for the highest part of the Niagara Escarpment south of Collingwood. There, the cuesta stands about 1,000 feet above the lowland to the east while it rises only 350 feet above Lake Ontario between Hamilton and Niagara Falls. In other words, the brow of the cuesta is over 1,700 feet a.s.l. near Singhampton but slopes down to 600 feet on the Niagara Peninsula and to less than 800 feet on the Bruce Peninsula. The "build" of southwestern Ontario is due to these two bedrock structures, the Dundalk (Algonquin) Arch and the Niagara Escarpment.

In the vicinity of the Bay of Quinte the rocks were further wrinkled so as to form three broad steps rising eastward (Kay 1942). However, after this topography was cut by river valleys running southwestward and later planed by the glaciers, very little of this rise-and-trend remains.

FAULTS

Apart from the Ottawa Valley there are no major faults or dislocations due to breaking of the Paleozoic bedrock in Southern Ontario. This lack of faults carries with it the comforting implication of a free-

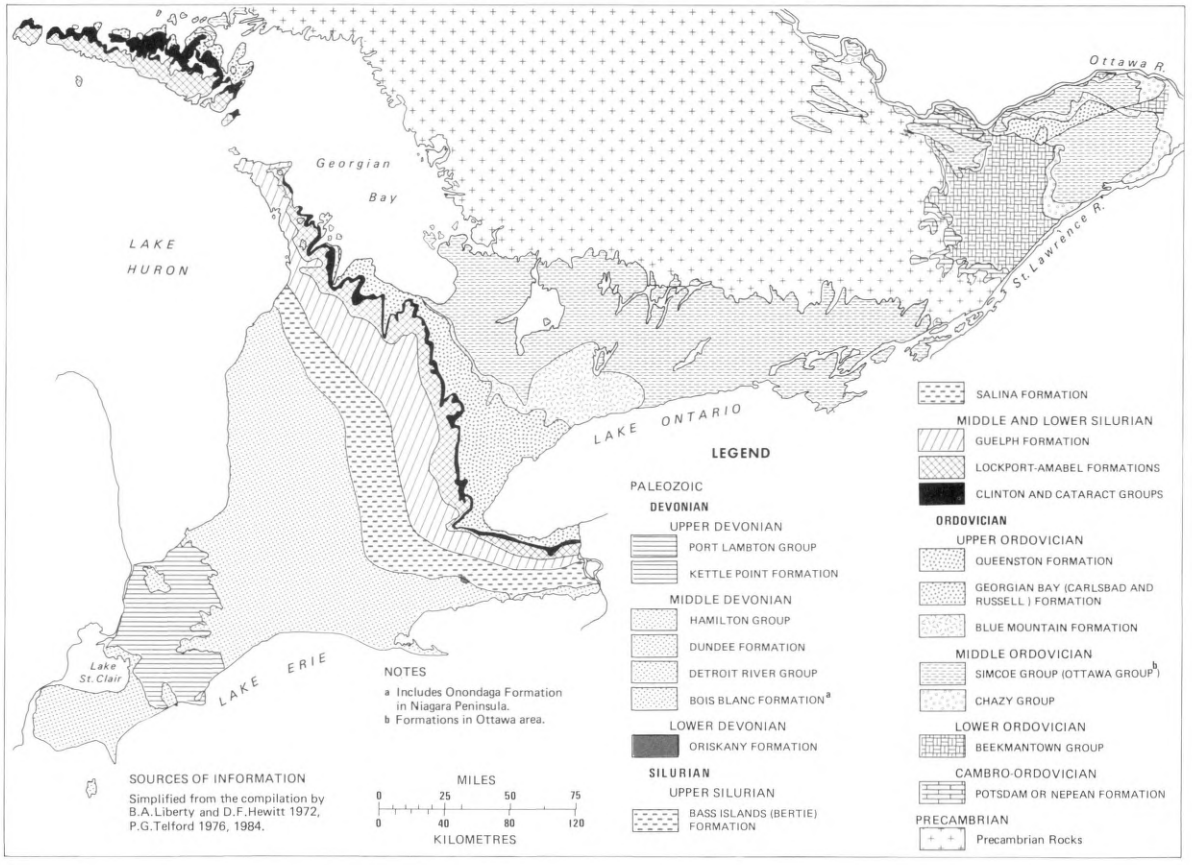


Figure 1. Bedrock geology of Southern Ontario.

dom from earthquakes. The mild earthquake of the summer of 1943, which centred at Cornwall, was a fresh reminder of the instability of the bedrock in the Ottawa-St. Lawrence Lowlands. The locations of the main faults in the area are represented in Figure 3, according to the mapping of Wilson *et al.* (1941), Kay (1942), and Ayres *et al.* (1971).

The Ottawa basin is bounded on the west by the Frontenac Axis, visibly expressed in the Thousand Islands, where the Precambrian rocks appear on the surface, with the overlying limestones appearing to the east and west. Many of the Thousand Islands are granite knobs. The basin is sharply bounded on the north, just beyond the Ottawa River, by the edge of the Canadian Shield which rises abruptly to a height of about 1,000 feet. This is the result of faulting, the block to the south having dropped down so as to place the overlying sedimentary rocks in a protected position where they escaped the full forces of erosion. This downdropped block is bounded on the south and west by faults, and is tilted toward the west. The southern boundary is easily seen as a bluff facing the northeast which crosses the City of Gloucester from Ottawa to the village of Russell. Farther east another fault is buried under clay and sand; it appears in the northeastern part of the United Counties of Stormont, Dundas, and Glengarry, but is not conspicuous. West of Ottawa the main fault passes through the hamlet of Hazeldean and forms the northern flank of the Carp River valley. Along this fault, Precambrian outliers overlook the sedimentary rocks of the Ottawa Group of the lowland; prominent also is the ridge of sandstone of the Nepean Formation from which so much fine building stone has come to the City of Ottawa.

In Renfrew County there are prominent scarps on both sides of the Ottawa Valley, the southwestern one lying south of Calabogie Lake, Mount St. Patrick, and Lake Clear. Thus a block 35 miles in width is down-dropped forming what has been called the Ottawa-Bonnechère Graben (Kay 1942). A sketch of the topography is shown in Figure 4. Within it are several minor breaks. There are three south-facing escarpments bounding blocks that are tilted toward the north, and in each case Paleozoic limestones are preserved on their northern flanks.

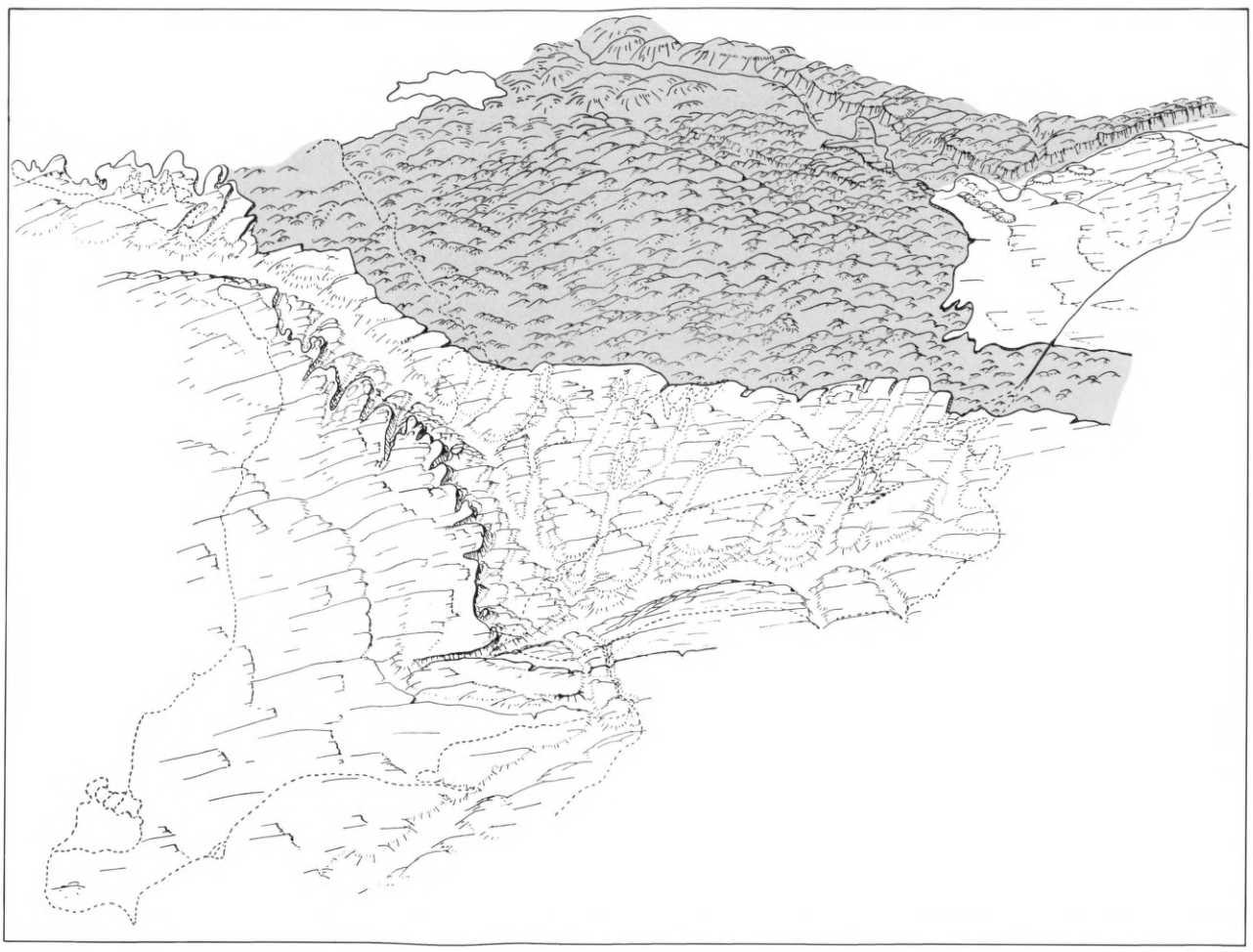


Figure 2. Sketch of the bedrock topography of Southern Ontario. The part of Southern Ontario underlain by Precambrian bedrock is shaded. The south part, which is underlain by the softer Paleozoic limestones and shales has been left unshaded.

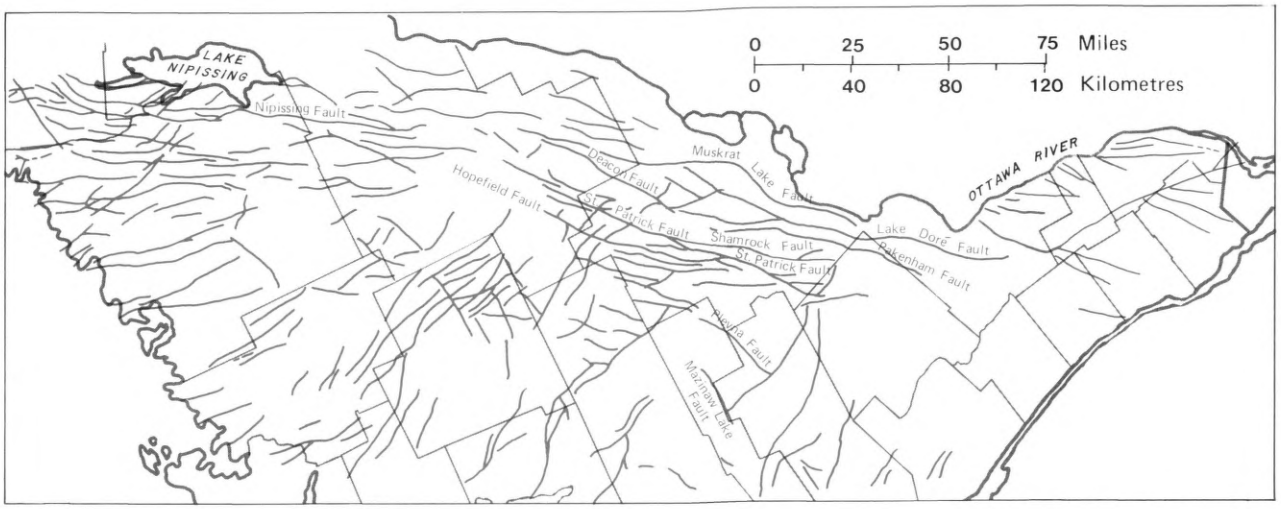


Figure 3. Locations of faults in Southern Ontario.

These are the Muskrat scarp along the northeast side of Muskrat Lake, the Doré scarp extending from Lake Doré past Renfrew toward Arnprior, and the series which can be seen intermittently along the north side of the Bonnechère River upstream from Northcote Station, and northeast of Golden and Round Lakes. Farther south in Renfrew the main area of farmland is confined roughly by the Pakenham Fault whose north-facing scarp can be traced from near Eganville to Pakenham. A few miles southwest two parallel scarps face south and north respectively, while between them enough soil material accumulated to encourage the settlements of Mount St. Patrick, Dacre, and Lake Clear.

The alternate strips of good and poor land in the Ottawa Valley are due to the shallow sandy drift or rock outcrop on the brows of all these scarps and the deep drift in the depressions.

In the Georgian Bay-Ottawa Valley region the evidence of faulting is widespread but faults with measurable vertical displacement are most common in the eastern and far northern parts of the region. In Figure 3, most of the major faults and enough of the smaller ones to show a pattern are mapped. The latter may not always form prominent scarps but have produced visible surface lineaments and clearly affect the courses of streams.

Kay (1942) mentioned some of the faults which have such important effects on the physiography of

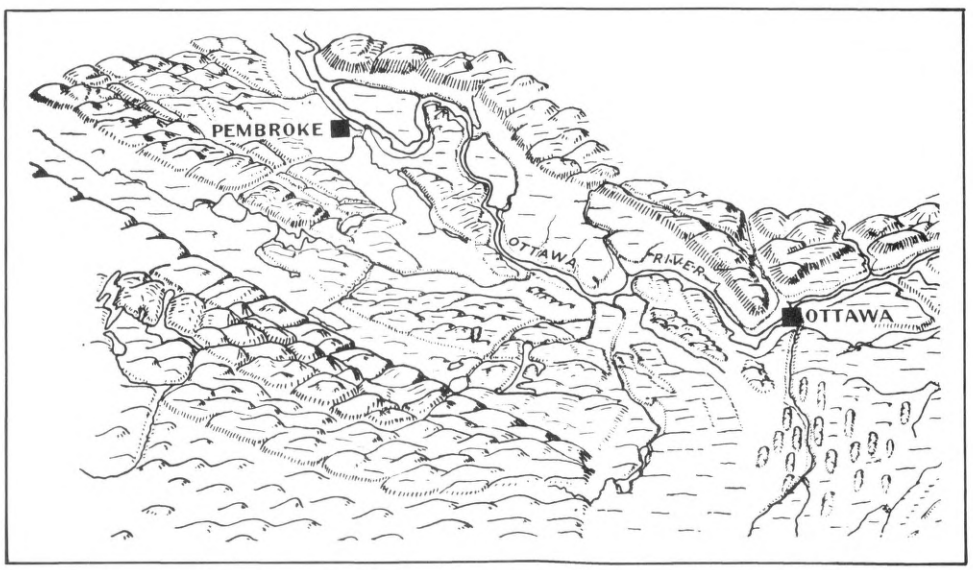


Figure 4. Physiographic sketch of the Ottawa-Bonnechère Graben.

Renfrew County and adjacent areas. He described and named 15 faults in the area and there are others as shown in Figure 3. Kay did not recognize any faults in line with the monocline which he described north of Belleville. However, Ayres *et al.* (1971) show a series of them trending northeast all over the southern part of the region under discussion. The faults named by Kay have a northwest alignment and determine the course of the Ottawa River in this section and affect the whole eastern side of the area. The western part is marked by a different set of smaller faults having a general westerly trend and which shows up as straight narrow valleys commonly followed by streams, or, in places, occupied by long narrow lakes; for example, the Still, Key, and Pickerel Rivers, and Lakes Caribou and Noganosh.

Within the Georgian Bay-Ottawa Valley region the most prominent topographic break is provided by the St. Patrick fault-line scarp. It is a continuous northeast-facing scarp about 85 miles long. The highest section is west of Lake Clear where it rises from below 800 feet a.s.l. to above 1,600 feet in two places. The lowland or graben between this fault and the Coulonge Fault, which forms the abrupt edge of the Laurentian uplands of Quebec is due to a great downfaulted block of rock. This block is itself broken by three faults each showing up as southwest-facing scarps up to 400 feet high. Between them the rocks are tilted toward the northeast and Paleozoic limestones are preserved in the depressions. The Coulonge Fault scarp extends to Mattawa, then westward on the north side of the Mattawa Valley and Lake Nipissing. Under water in the Lake Nipissing basin, Paleozoic limestone is preserved in the depression south of the fault scarp and another small area occurs west of Nipissing village. From Lake Nipissing to Mattawa there is a lowland area partly floored by clay. From Mattawa to Chalk River there is only a narrow valley, but below there the lowland widens out into the main part of the Ottawa-Bonnechère Graben. Apart from the one just mentioned, the most definite fault line west of Chalk River is the valley followed by the Canadian National Railway through Lake Traverse, and Radiant, Cedar, Cauchon, Mink, and Kioshkokwi Lakes.

Above the St. Patrick scarp stand the Madawaska Highlands, their southwestern boundary being along another (Plevna) fault with a southwest-facing scarp. Thus the Madawaska Highlands are based on an upraised block of rock. The Plevna scarp is about 300 feet high at the maximum but it is indefinite in other places. Within these highlands the Madawaska River follows a depression along a fault line through the southern corner of Griffith and Matawatchan Township. The Hopefield Fault is marked by a valley with bluffs of rock on the south side.

The highest part of the region astride the west ern boundary of Algonquin Provincial Park drops off abruptly on the east along a fault. The area northeast of Dorset should also be mentioned because of a series of northeast-trending faults reflected in the pattern of streams and lakes.

The major faults of the region are from Precambrian to Cretaceous in age and minor seismicity is associated with these structures. However, no severe earthquakes have been centred here in the last 160 years.

EROSION OF BEDROCK

In addition to warping and faulting, there is a third method of fashioning the contour of the bedrock surface—by erosion, chiefly by running water. Before the advent of the glacial periods the Paleozoic rocks of this area had been subjected for about 250 million (Ma) to stream erosion which transported clay and sand to the sea. The surfaces of the more easily eroded rocks, such as the shales, were lowered, leaving the harder dolostone or limestone to form uplands. Particularly in the large basin centred in Michigan, the various rock formations are found in concentric belts with the strata dipping toward the centre; that is, toward the southwest in Ontario. This resulted in the development of curved lowlands bounded inwardly by escarpments. Known as cuesta and vale topography, it is common in England, northern France, and several other parts of the world.

Before glaciation, judging by the relief on similar rocks in Kentucky and Pennsylvania just outside the glaciated area, there were deep V-shaped valleys on the harder limestones and more rounded topography in areas of softer rocks.

There can be no doubt that the master rivers of preglacial times followed the lowlands, while tributaries led into them. Drainage from the upper Great Lakes area passed through the Georgian Bay depression and continued directly toward Toronto, where it met a stream in the Lake Ontario basin. From there its course is not known definitely. It probably flowed eastward, as the concepts of Spencer (1881) and Grabau (1901), that the Dundas Valley extends to the Erie basin, have never been confirmed.

By far the greatest topographic break produced by differential erosion of harder and softer rock in Ontario is the Niagara Escarpment. It rises in New York near Rochester, skirts Lake Ontario to Hamilton, and then passes north to Collingwood (Photo 1). The Blue Mountain south of Georgian Bay, the Bruce Peninsula, and Manitoulin Island with its neighbours to the west constitute its extension in Ontario. Thence, it crosses the upper peninsula of Michigan and swings southward along the margin of

that lake. It forms the Door Peninsula in Wisconsin but disappears west of Chicago. Thus, it partly encircles the Lake Michigan basin into which the beds dip at the rate of 20 feet or more to the mile.

The only deep preglacial river valleys in the bedrock to be seen in the whole area are found along the Niagara Escarpment. The Dundas Valley, running west from the tip of Lake Ontario, is one of the longest, measuring 10 miles to the point where it becomes filled with drift. The Forks of the Credit, the Hockley Valley, and the Devil's Glen are well known for their scenic beauty, while the Mad, Pine, Noisy, and Pretty Rivers all flow through notches in the escarpment south of Collingwood. The Beaver Valley, extending 30 miles from Thornbury to Flesherton, is the best example of all. Kimberley village in the narrow upper reach of the valley sits 500 feet below the rim. Nearer Georgian Bay the valley suddenly broadens into Collingwood Township to the east, and it is this section that has gained a reputation for fine farms and Northern Spy apples. The broad valley drained by the Bighead River which empties at Meaford resembles the lower part of the Beaver Valley, but lacks the long extension into the heart of the upland. On the Bruce Peninsula the two important valleys are below the level of Georgian Bay, affording Owen Sound and Wiarton excellent harbours. All of these valleys have been rounded to a U-shape by glaciers and have received coatings of till of variable depths.

Although the Niagara Escarpment is outstanding, another escarpment, the Onondaga, crosses the Niagara Peninsula from Fort Erie to Hagersville, beyond which it is buried by drift. Capped by limestone, it confines a lowland worn in the Salina Formation consisting of limestone, shale, and sandstone interbedded. The Onondaga Escarpment is not very high in Ontario, and several sections east of Hagersville lie buried under the clay of Haldimand and Welland. Another scarp appears at the edge of the Gull River Formation overlooking the border of the Canadian Shield. Seldom more than 50 feet high, it occasionally rises to 75 feet. The Kawartha Lakes and a series of smaller lakes are found in the depression in front of this escarpment. Low scarps appear also in the Lindsay Formation, notably north of Lindsay and Peterborough. In the smaller Ottawa basin the cuesta-form relief is not appreciably developed.

The amount of erosion accomplished by the great Pleistocene glaciers is not subject to accurate measurement. Some measure of the depth of planing can be obtained by noting the depth of the drift which is the end-product of glacial erosion, and south of the Canadian Shield this averages between 75 and 100 feet. Most active erosion of the bedrock occurred on the brows of the escarpments and along the lowland routes taken by the principal streams of ice. The basins of Lakes Ontario, Huron, and Superior extend to below sea level; as such scooping-out

OGS 10 652

Photo 1. Niagara Escarpment, Collingwood, with the "Blue Mountain Peaks" ski run visible in the background. Photo courtesy of M.B. McLeod.

could not have been the work of a river, it is attributed to the glaciers, although this is a subject of some debate.

In those sections north of Lake Ontario where there is little or no overburden the limestones have been planed off, eliminating most of the valleys, but a series of shallow valleys running southward still remain to mark the sites of bigger preglacial river valleys.

The region to the north, underlain by Precambrian bedrock, presents a distinctly different type of relief. When viewed broadly the skyline is generally even. Such a peneplain is the result of subaerial erosion of rocks over a long period, in this case in pre-Paleozoic time (Kay 1942). There are some monadnocks of more resistant rocks standing up above the general level.

Locally, the surface is quite rough with a relief generally of 50 feet to 200 feet but here and there up to 500 feet. The rock knobs are irregular in outline except in a few areas where there are fairly straight, parallel ridges. The valleys between these knobs and ridges do not have a dendritic drainage pattern because of the structural control. The knobs and ridges themselves are rounded, and the bedrock surfaces are smoothed and, where protected by a covering of soil, commonly show polished surfaces with parallel scratches or striae which were made by the overriding glaciers. The numerous swamps and lakes generally occupy bedrock basins, most of which must be attributed to glacial erosion. Thus the relief is dominated by bedrock forms which were fashioned by a long period of subaerial erosion followed by a very much shorter but quite significant period of erosion by glacial ice.

GLACIAL GEOLOGY

The unconsolidated materials on the bedrock in an intensely glaciated area such as Southern Ontario consist mainly of the following: sheets of till laid down directly by the ice; glaciofluvial deposits, i.e. sand and gravel deposited by streams of water draining from the melting glacier; and the clays, silts, and sands deposited in lakes which existed during the recession of the glacier. As a rule the glaciofluvial and outwash deposits overlie the till, and the lacustrine deposits in turn overlie the aforementioned types of deposits. Where they occur, the alluvium of present streams and the beaches of present lakes are uppermost and, of course, are still in the process of being deposited. They are postglacial deposits, as are the peat or muck in wet depressions, and they will be dealt with briefly in this monograph, the main emphasis being on the deposits of the last ice age, i.e. Pleistocene deposits.

Map P.2715 (back pocket) and the four inches to one mile maps (Map Numbers 2224, 2225, 2226, 2227, and 2228; *see* page ii) are important components of this monograph. The text was written assuming that the reader will have one or more of these maps at hand for reference. Our mapping is unavoidably less accurate in the Georgian Bay-Ottawa Valley region than in the south because of the sparse road network. Also, air photo interpretation is more difficult because of the forest cover.

It was stated earlier that the overall structure of Southern Ontario is mainly due to the bedrock. The notable exception is the massive ridge of glacial drift (called the Oak Ridges Moraine) trending east through the counties north of Lake Ontario. It forms the drainage divide south of Lake Scugog and Rice Lake, and extends from the Niagara Escarpment in the Town of Caledon to the Trent Valley. At its deepest, in King Township, there is 600 to 800 feet of overburden piled on the bedrock. A bore hole, which penetrated 203 m (665 feet) of drift before reaching bedrock, revealed 160 m (525 feet) of lacustrine sediments and only 34 m (112 feet) of tills, the remaining sediments being fluvial and ice-contact stratified drift (Sado *et al.* 1983; Sado *et al.* in preparation). The surface deposits are mostly sand and gravel, but dense, compact till sometimes appears in deep road cuts and gullies within 30 or 40 feet of the surface. In Uxbridge Township thick beds of lacustrine clay and silt are often found under the surface sands. Similarly, lacustrine silts are found under the upper units of sand and gravel south of Rice Lake. However, the structure of this moraine is largely unknown. From its great bulk it is surmised that the earlier glaciers may have been responsible for the core and that the earlier glaciers followed the same routes as the last one in this area.

Subsurface, older till sheets are well exposed in Lake Erie shorecliffs, Scarborough Bluffs, and other places. However, apart from noting their contribution to the material in the upper deposits, we do not intend to discuss the various till sheets and their ages. It is enough in this volume to concentrate on the landforms and soil materials on the surface, leaving Pleistocene stratigraphy to others.

During the retreat of the last glacier, extensive lowland areas were submerged in glacial lakes for a time. These areas are now clay or sand plains. Any earlier episode of the Wisconsinan glaciation also may have been attended by glacial lakes during its retreat. The last glacier overrode the older beds of sand and clay. Apart from the shaley tills, the clayey tills are mostly due to the overriding and incorporation of older clays of earlier glacial events. The brown clay till found in a broad belt east and south of Lake Huron is one example. The heavy till of the Niagara Peninsula is another. The overridden clays are compacted and the strata are often contorted.

Sands and gravels, when overridden and incorporated by the glacier were redeposited as sandy till. The till between Lake Simcoe and Georgian Bay is of this type. Sandy till on the surface of the sandy ridge in northern Oro Township indicates that this is an overridden kame moraine. Sandy till on the surface of the sandhills in the Waterloo area might also be regarded similarly.

PRE-WISCONSINAN BEDS

The last glaciation in Ontario is called the Wisconsinan. The previous glaciation is referred to as the Illinoian, and the unglaciated period in between is termed the Sangamon. Pre-Wisconsinan glacial drift has been identified in Ohio and other states to the west but it is rarely seen in Ontario. The glacial beds, formerly considered to be Pre-Wisconsinan in age, at Scarborough Bluffs and other widely distributed lower beds in Ontario have come to be classified as Wisconsinan. At Toronto, only the thin layer of till on the bedrock at the former Don Valley Brickyard (Watt 1954), the lower till seen in an excavation at the railroad marshalling yards south of Maple, and till in a gully beside the Canadian National Railway south of Woodbridge (White 1975) are Pre-Wisconsinan, probably Illinoian. Pre-Wisconsinan interglacial deposits that may be related to the Sangamon are also located at the former Don Valley Brickyard. These deposits contain fossil materials which indicate climatic conditions warmer than at present. Some of the lower tills present in the Plum Point-Port Talbot area along Lake Erie and at the Scarborough Bluffs are now dated as Early Wisconsinan (Dreimanis and Karrow 1972). Generally, Pre-Wisconsinan deposits are very rare and may be disregarded when describing the surface features.

LATE WISCONSINAN BEDS

The last glacier to cover Southern Ontario was responsible for depositing the soil materials and shaping the landforms as they exist today. This monograph is the product of a systematic examination and mapping of the surface drift. The interpretation in terms of the last glacier's retreat is soon to be discussed and a few main points about the qualities of the materials will be given. But, before beginning that story, it may be in order to introduce the features from which it is pieced together and to give a bird's-eye view of their distribution.

The forward motion of the glacier produced two types of markings which point out the alignment, and sometimes the direction, of movement. They are scratches (striae) on the bedrock surface (Photo 2), and mouldings of the surface of the till sheet (drumlins, flutings). The striae and polished surfaces are not retained on soft rock such as shale or on the harder, coarse-grained, Precambrian rocks, otherwise they are usually visible on rock surfaces. They are best preserved on rocks covered with some drift where scaling off of the surface by frost action has been prevented. These markings can only be seen where the bedrock is exposed as it often is on the Canadian Shield. In the south, where the bedrock is generally buried, the alignment of drumlins and flutings indicate the direction of glacial movement.

As the continental glacial ice masses accumulated and advanced, they eroded the bedrock. Soil and rock were carried forward, mixed together, and milled. The resulting rocky grist is a heterogeneous mass of boulders, stones, and pebbles in a sand, silt, and clay matrix, known as till. It is not regularly stratified as are sediments deposited in running and standing water. Layers of till in the overburden provide prime evidence of glaciation, especially when the till contains some rocks other than the local bedrock; these foreign rocks are called glacial erratics.

On the Canadian Shield the covering of drift on the bedrock is generally shallow and scattered exposures of bare rock are usually visible. On Map 2228 the areas having very shallow drift and numerous outcrops of bare rock are shown separately from those with thicker overburden and fewer (less than 5%) rock outcrops. Shallow drift also occurs on limestones along the the brows of the Gull River, Niagara, and Onondaga Escarpments. The dolostone of the Beekmantown Group in a belt between Arnprior and Brockville also has been swept nearly bare. Apart from these limestone plains the lime-

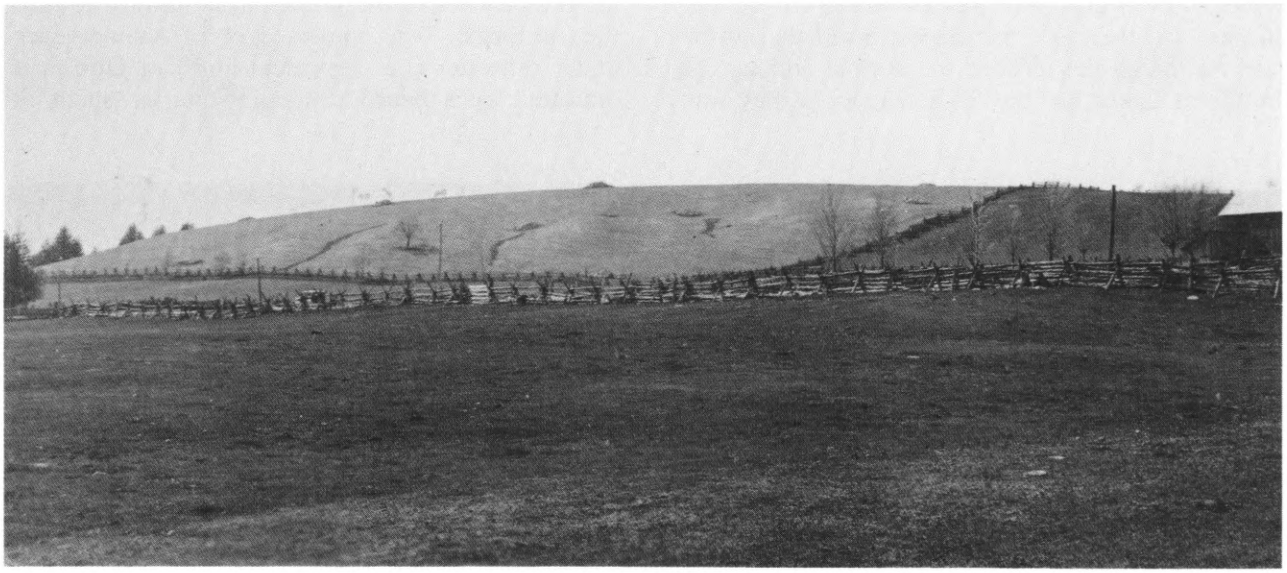
OGS 10 653

Photo 2. Planed surface with striae on limestone, near Lion's Head, on the Bruce Peninsula.

stones and shales in the south invariably are buried by a continuous layer of glacial deposits.

Where the upper deposit is a sheet of till the surface is often moulded, especially where the till is medium in texture. Smooth, oval (inverted spoon-shaped), hills appear, all aligned in the direction of movement of the last ice sheet, their tapered ends being their tails. They are called "drumlins" (Photo 3). Drumlins may vary from impressive hills with steep sides to hardly noticeable undulations. The biggest ones are 150 feet high and over a mile in length. Some long low specimens reach a length of two miles. At the other extreme is a smoothed plain scored with shallow grooves or "flutings" (Photo 4). Restricted drainage in the flutings has resulted in the accumulation of humus in the surface soil, and on air photos these appear as dark parallel streaks (Photo 5).

The recession of the glacier was halted periodically by stillstands or readvances. During these events the ice lobes frequently built end moraines along the ice margin. Moraines are made either of till which has been deposited by the glacier, or of coarsely stratified gravel and sand deposited at the ice front by water issuing from the melting ice. A common trait of all moraines is a knobby surface



OGS 10 654

Photo 3. Drumlin near Bradford.

OGS 10 655

Photo 4. Fluting on a drumlin east of Peterborough.

with undrained depressions (kettles) of irregular shape between the knobs, resulting from the melting of buried blocks of glacial ice. Associated with the moraines are the abandoned stream channels formed by glacial drainage. Nearly all of these channels are occupied by streams at present, but it is apparent that these streams are much too small (underfit streams) to have carved the main valley or deposited the great gravel terraces. Proof of this point is provided by the finding of channels here and there in which there are no streams.

The continental glacier completely disrupted the normal drainage of the Great Lakes region and the great mass of the overriding glacier resulted in a depression of the earth's crust. The amount of depression was generally greatest where the ice was thickest and therefore increased toward the northeast. As the glacier receded the normal drainage of the Great Lakes out the St. Lawrence Valley was plugged by the glacier. Initially, outlets were found toward the Mississippi River and later eastward from the Lake Ontario basin through the Mohawk Valley and Hudson Valley. In the Lake Huron-Georgian Bay basin with outlets to the south, crustal depression (isostatic depression) allowed the submergence of land which is now, after readjustment upward of the earth's crust, well above the level of the outlets at Chicago and Sarnia. Finally, immediately after the uncovering of the lower St. Lawrence Valley the St. Lawrence-Ottawa Lowland and adjacent parts of New York State and the Province of Quebec were below sea level.

After the recession of the glacier the earth's crust rebounded, uncovering these lowlands and tilting the beaches of the glacial lakes upward toward the northeast. The upper level of submergence under saltwater (i.e. seawater) north of Ottawa is indicated by a beach containing marine shells at

OGS 10 656

Photo 5. Aerial view of a fluted till plain southeast of Palmerston. The dark parallel streaks are caused by the wetter, darker soil in the shallow grooves or flutings. Photo courtesy of the Canadian Armed Forces.

Kingsmere, north of Ottawa, in the Province of Quebec at 690 feet a.s.l. In the Lake Huron region the tilting of the ancient, abandoned shorelines amounted to as much as 600 feet.

MORAINES

Figure 5 is a map designed to give a general picture of the arrangement of the moraines and to attach the names given them mostly by Taylor (1913) or the present authors. Map P.2715, back pocket, distinguishes between moraines consisting mainly of till and those built of glaciofluvial sands and gravels, like the one shown in Photo 6. Other interpretations of moraines of the Georgian Bay lobe have recently been put forward by Feenstra (1975), Sharpe (1978), Barnett (1979), and Gwyn and Cowan (1978). However, in this edition we adhere to the mapping and nomenclature used in previous editions.

In the southwestern part the moraines were built either by a broad tongue of ice advancing through the lowlands of Lakes Ontario and Erie, or by the ice sheet advancing from the north to meet this ice tongue and pushing forward as a lobe in the basin of Lake Huron. The Orangeville Moraine was formed between opposing ice lobes, a northern one advancing from Georgian Bay and two others from Lake Simcoe and Lake Ontario. The Elmira and Waterloo Moraines are also sandy and are consid-

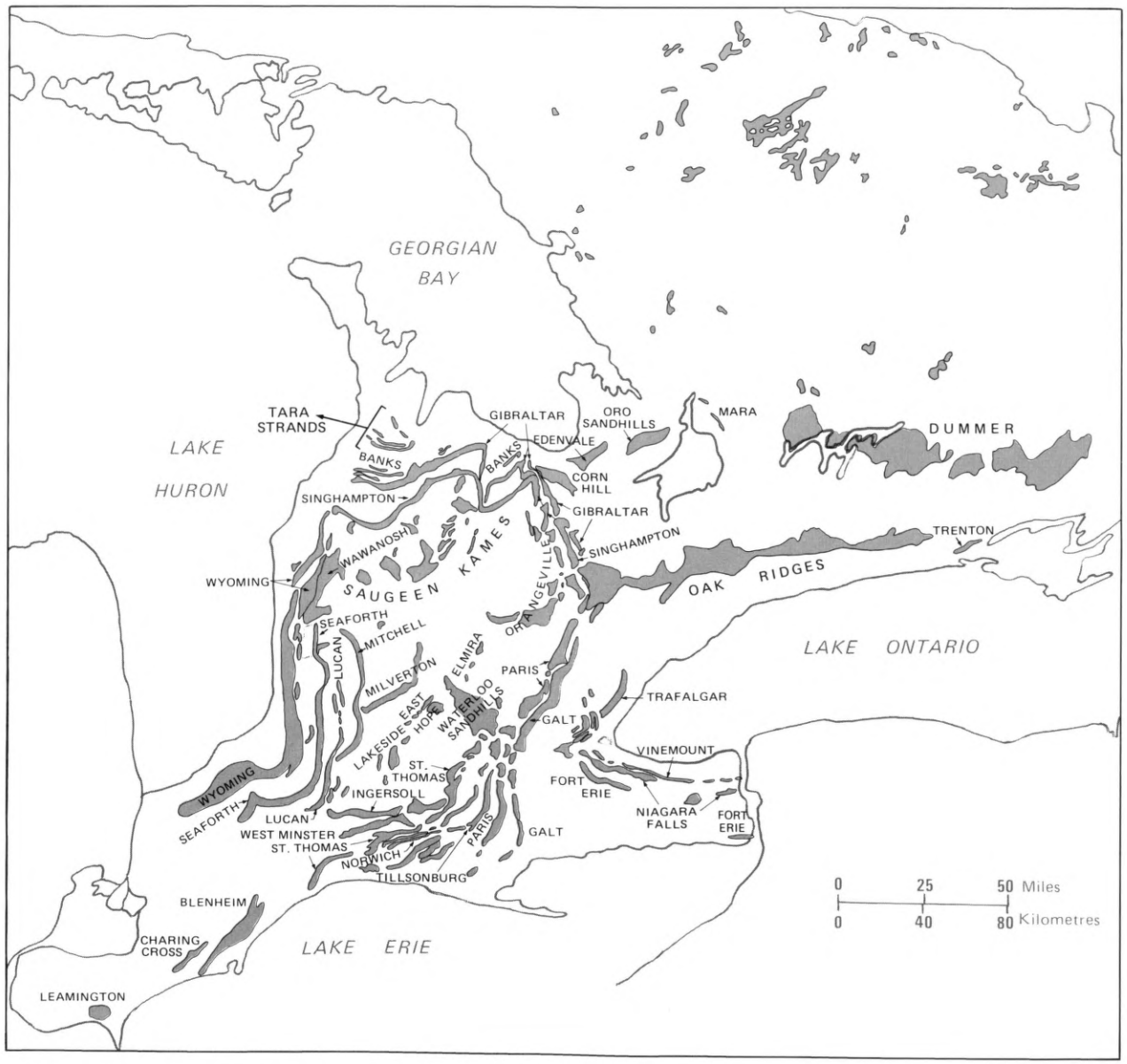
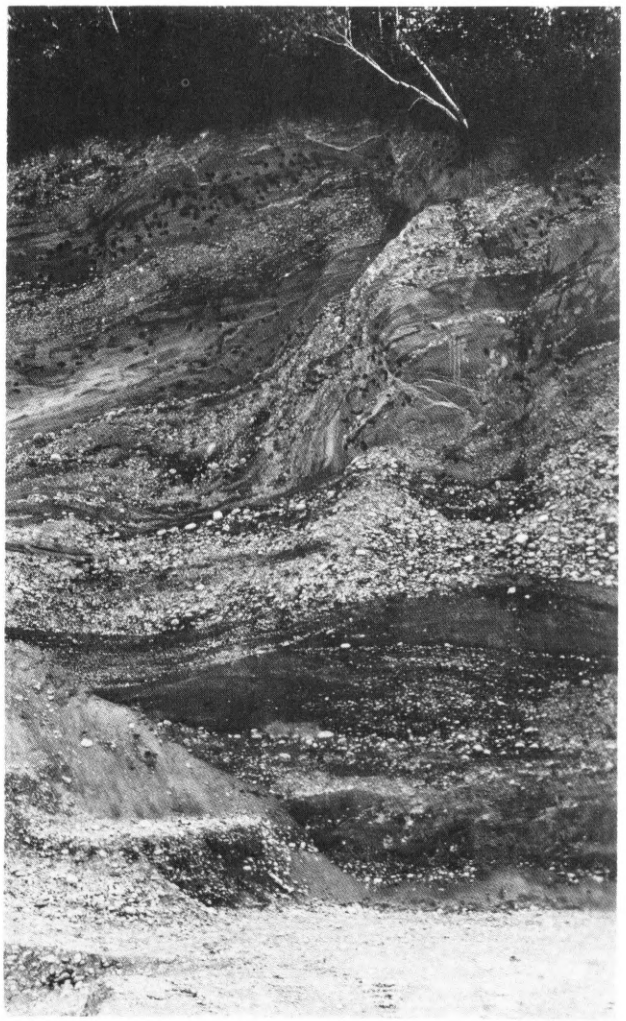


Figure 5. Moraines of Southern Ontario.

ered to be interlobate. The upland of peninsular Ontario has an elaborate array of moraines and spillways around it, the centrepiece in this series being the horseshoe-shaped Port Huron Moraine system. As noted on Figure 5, the Paris and Galt Moraines end at Caledon Village instead of Singhampton and Gibraltar as in Taylor's (1909) initial work. Thus the moraines of the Ontario-Erie lobe are separated from those of the Georgian Bay and Lake Simcoe ice sheet. While its nose was under water, the Ontario lobe built a series of concentric moraines around the western end of Lake Ontario above the Niagara Escarpment and later produced the Trafalgar Moraine. North of Lake Ontario the bulky Oak Ridges Moraine stands at the meeting point of the two opposing movements of ice.

The scattered morainic knobs along the northern border of the limestone bedrock in the Kawartha Lakes area have been considered collectively as the Dummer Moraines (Photo 7). East of Kingston there are no distinct continuous moraines to mark the position of the ice margin across this lowland at any stage. The stony till ridges and intervening plains in the eastern third of the United Counties of Stormont, Dundas, and Glengarry are mapped as till plains, but later work tends to show that the ridges themselves are moraines somewhat smoothed by wave action. The sands in the United Counties of Leeds and Grenville and a nearby part of Dundas County appear to be ice-marginal deposits partly reworked and spread out by the waves. Irregular, poorly sorted sand and gravel devoid of marine fossils appears in some of the low hills. Similar fragmentary, sandy morainic deposits with reworked strata on the surface containing marine fossils occur near Maxville, Kemptville, and just south of Ottawa (Gadd 1963).

Distinct, continuous, recessional moraines which would serve to mark the position of the ice front at one stage are notably absent between Georgian Bay and the Ottawa Valley. A few short discontinuous moraines of sandy till and glaciofluvial sand and gravel occur between Huntsville and North Bay and in Renfrew County. With one exception they trend westerly. The exception is the moraine extending along the brow of the St. Patrick scarp, as shown in Figure 5. Perhaps a lobe of ice separated in the Ottawa-Bonnechère Graben to produce this moraine. The moraines found between Huntsville and North Bay were nearly all submerged in Lake Algonquin and are unusually smooth due to reduction of the hills by wave action and deposition of sands or silt and clay in depressions. They consist mostly of sand but pockets of gravel and masses of



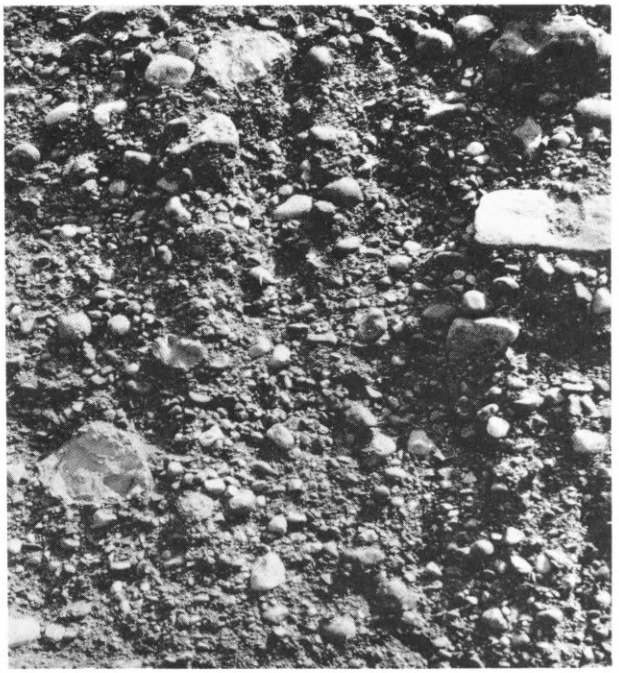
OGS 10 657

Photo 6. Typical materials in a kame at Glen Ross on the Trent River. The cross-bedding and irregular grading are characteristic.

OGS 10 658

Photo 7. Very rough, angular limestone cobbles and boulders are characteristic of the Dummer Moraines, as shown at this location near Erinsville, Lennox and Addington County.

sandy, stony till are also common. West of Mattawa extending from Grand Desert northward along the east side of Bonfield Township there is a sandy, gravelly moraine (the Rutherglen Moraine) which marks the limit of advance of a late, local ice lobe which pushed westward into the Mattawa Valley (Prest 1970, p.714-725; Harrison 1972). The largest areas of morainic deposits occur as groups of kames with associated outwash. One such area is in the middle of Algonquin Provincial Park mainly in the townships of Biggar, Osler, Devine, Bishop, McLaughlin, and Bower. It does not extend westward to join with moraines near Sundridge or South River, and it cannot be traced to the kames found west of Killaloe. Another smaller area of kames and outwash is found southeast of Mattawa. This does not connect with the moraine at Rutherglen but may be related to the same small ice lobe. Two small till moraines trending west occur in the Bonfield-Nipissing area south of North Bay.



OGS 10 659

Photo 8. Stream gravel near Arkona, Lambton County, showing the typical subangular pebbles and stones and lack of even grading.

SPILLWAYS

The glacial meltwater drainage channels (also called spillways) associated with the moraines are harder to recognize than the moraines themselves; the latter stand up above the surrounding terrain, whereas the spillways are entrenched. Moreover they are usually occupied by streams, which raises the question of whether they are normal stream valleys or glacial spillways. The typical spillway is a broad trough, floored wholly or in part by gravel beds (Photo 8) at one or more levels, often with a cedar swamp in the lowest part of the valley. It sometimes shows a peculiar disregard for existing grades, since it flowed along an ice front. The present stream has its own channel in the bottom of the larger valley. It is fairly common to find a spillway that now is unoccupied by any stream. On the upland west of the Niagara Escarpment the spillways mostly, but not always, run along the front of the moraines. In the Georgian Bay-Ottawa Valley region the drainage generally flowed away from the ice front. In that area the stream courses were governed by bedrock and there

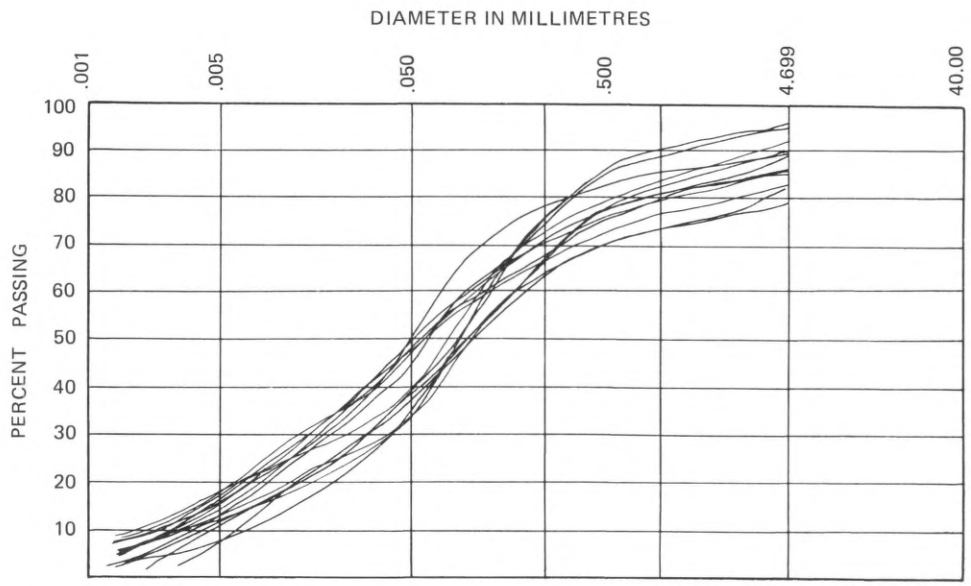


Figure 6. Texture curves of tills from 12 widely distributed drumlins (based on data from the Ontario Ministry of Transportation and Communications).

are no incised channels such as there are in the southern part.

DRUMLINS

Because drumlins are so prevalent in Ontario the term has become widely used. In early days these glacial hills were called sowbacks, whalebacks, or lenticular, mammillary, and elliptical hills by different writers. The name drumlin, Celtic for "little hill", was first used by H.M. Close (1867) when discussing a group of hills in northern Ireland, and later it was generally adopted by geologists.

The process of drumlin formation has been the subject of much speculation. The concentric bedding revealed in section through some drumlins suggested to early writers that they were built by a plastering-on process (Fairchild 1907a). On the other hand, the gouges between them reveal that the building may have also entailed some scooping-out. Furthermore, some drumlins have a sand and gravel core which may imply that subglacial meltwaters played a major role in their formation.

We have consistently noted, although this is not always supported in geological reports, that drumlins are formed only of medium-textured till (Figure 6). The tills are invariably gritty and stony. Neither very fine-grained tills nor very sandy tills are common in drumlins in Southern Ontario. Kames appear sometimes on the slopes of drumlins, especially on their tails, and sandy outwash or a veneer of windblown silt and fine sand are often found on the surface.

Drumlins are of interest because they point in the direction of movement of the glacier. The small map (Figure 7) gives the alignment of the drumlins and shows where they occur, but the oval dots are merely symbols and do not represent drumlins accurately placed or drawn to scale. The four miles to one inch maps show the drumlins drawn to scale, and whether they are the characteristic elongate, oval shape or are long and narrow.

The first drumlins to appear during the retreat of the glacier were those between Orangeville and Kitchener and those in the Woodstock area. The Woodstock drumlins are the only ones left by the Huron ice lobe. The large group north of the Guelph area, the scattered few northwest of Hamilton, and those near Caledonia show nicely the deployment of the ice lobe as it pushed westward from the Lake Ontario basin. South of Orangeville the drumlins have a bearing of 35° north of west (305° azimuth), near Moffat they point directly west (270°), while at Caledonia they bear 45° to the south of west (225°).

The first drumlins to be uncovered by the Georgian Bay lobe were the few west of Orangeville, which trend 60° east of south (120°). In the big field

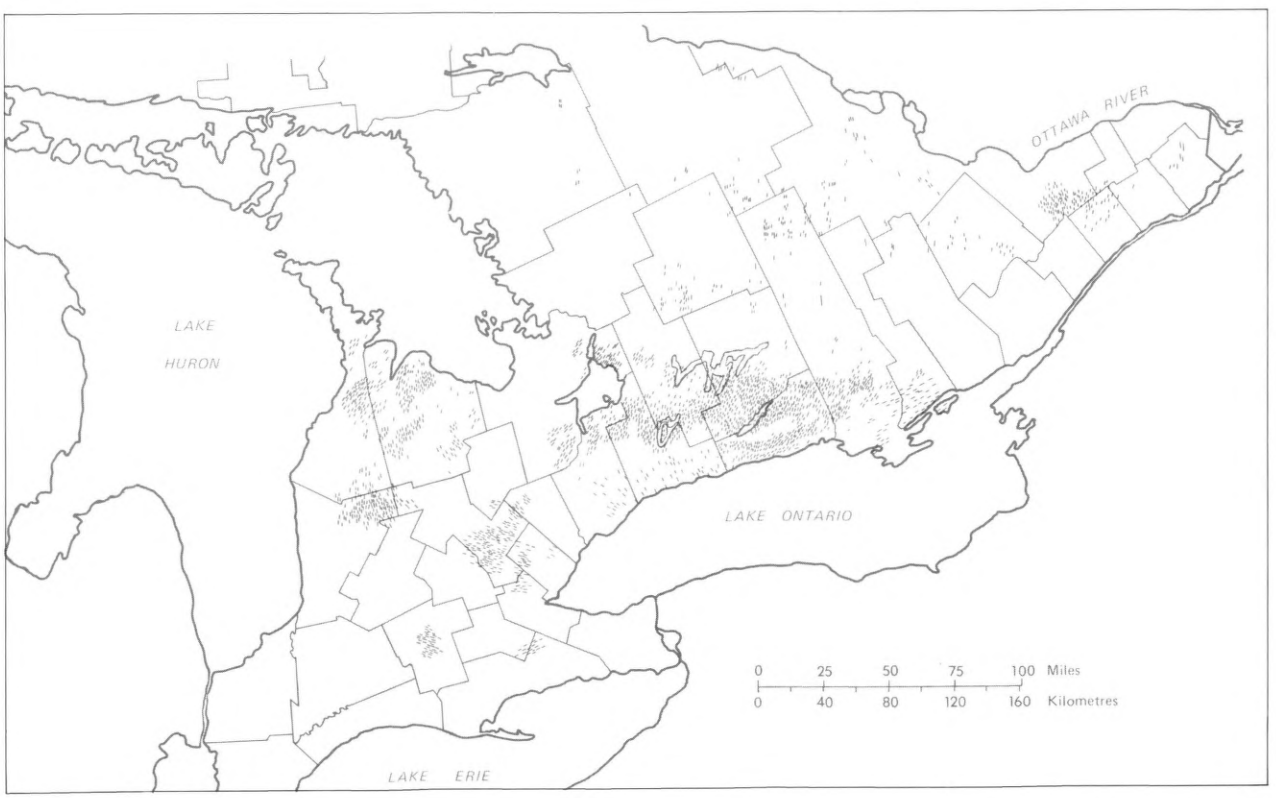


Figure 7. Drumlin fields of Southern Ontario.

between Listowel and Owen Sound the drumlins point almost directly south as do those in the Meaford area. The Arran group and those on the Bruce Peninsula bear to the west of south as much as 45° (225°). The latest thrust of the glacier over the Bruce Peninsula was obviously governed by the valleys of Colpoys Bay and Owen Sound. On Manitoulin Island most of the drumlins point 45° west of south (225°).

North of Lake Ontario 4,000 drumlins have been counted, the majority of them north of the Oak Ridges Moraine. This is a great field of drumlins, rivaling the one south of Lake Ontario in New York State which Fairchild (1929) regarded as the best display in the world. No doubt many more lie on the floor of Lake Ontario. Lake Scugog and Rice Lake are in the heart of this field and the several islands in Rice Lake are drumlins. Near Peterborough they are so closely clustered that it is difficult to separate them on a map (Photo 9). South of the Oak Ridges Moraine most of the drumlins west of Port Hope which were formed by the Ontario ice lobe are long, thin types pointing northward.

The relation of the drumlins to the Oak Ridges Moraine should be noted. In the Rice Lake area they have the same alignment north and south of the moraine, whereas beyond the eastern end of it the drumlin field is continuous nearly to the shore of Lake Ontario where the long, thin forms produced by a thrust directly into the Lake Ontario basin from the St. Lawrence Lowland are encountered.

The drumlins of eastern Ontario number about 500. They are most numerous south of Ottawa and more widely scattered in the northern part of the United Counties of Stormont, Dundas, and Glengarry. These point almost directly south. On the Canadian Shield, in spite of shallow drift, there are scattered drumlins as shown in Figure 7. Their alignment indicates a general southward movement of the ice sheet over the whole area.

ESKERS

Eskers are knobby, sinuous ridges (Photo 10) of sand and gravel which are roughly (but not necessarily) parallel to the direction of movement of the glacier. It is believed that they form from deposition of sediment by meltwater streams confined in tunnels or channels on the surface of, within, or beneath a glacier. They are surficial deposits, generally resting on the till, and they consist of gravel, cobbles, or sand in irregular strata (Photo 11). The sides are at the angle of repose (often about 30°) which increases with the coarseness of the materials; in Southern Ontario their height is usually between 25 and 75 feet. When associated with drumlins, eskers may lie along the hillsides but they are usually found in the areas of low ground. Some are only tens of feet long and are indistinguishable from kames, while the longest one in Southern Ontario (Codrington Esker north of Trenton) was traced for 55 miles.

Figure 8 is a map of eskers. Three sections of Southern Ontario were especially favourable for esker formation; the first is between Shelburne and Goderich, the second is on the drumlinized plain north of the Oak Ridges Moraine, and the third is in Algonquin Provincial Park. It is often possible to recognize eskers on contour maps and they can be traced with ease and accuracy on air photos (Photo 12). In eastern Ontario only a few have been recognized and these are partly levelled by wave action

OGS 10 660

Photo 9. A drumlin landscape, with stone boat trails showing in the distance.

OGS 10 661

Photo 10. Serpentine esker ridge situated four miles east of Chesley, Elderslie Township, with gravel pit in the distance. Photo courtesy of M.B. McLeod.

OGS 10 662

Photo 11. Pit face, in the same esker shown in Photo 10, exposes the typical irregular bedding of gravel and sand. Photo courtesy of M.B. McLeod.

and their crests remoulded in the shape of beaches or bars. The total length of all the eskers in the area under study is approximately 920 miles: 670 miles in the southern part and 250 miles in the area underlain by Precambrian bedrock. They give rise to poor soil but are valuable sources of gravel.

GLACIAL LAKES

During the recession of the last glacier some of the present-day drainage outlets were blocked, at times, by ice. Consequently, large areas, well above the levels of any modern lakes were submerged. The succession of glacial lakes which were dammed to high levels in the basins of Lake Erie, Huron, and Georgian Bay was summarized by Leverett and Taylor (1915, p.469). Again in 1958, Hough marshalled all available information. The sequence is shown in Figure 9 and the shorelines are mapped on Figure 10. In the Lake Ontario basin the shoreline of Lake Iroquois was mapped in good detail by Coleman (1937). We have mapped the other beaches in similar detail. Soil and physiographic surveys have added greatly to our knowledge of the sediments of the abandoned lake floors, and this also has been helpful in the interpretation of glacial history.

Beach ridges of gravel or sand and wave-cut bluffs with bouldery terraces at their bases are easy to identify (Photos 13, 14, and 15). The longer lived glacial lakes left distinct shore features and sandy deltas at the mouths of streams, but the shorter lived lakes left only faint, discontinuous beaches. The stratified silt and clay of the lake beds (Photo 16) provide important supporting evidence of prolonged inundation and sometimes the only conclusive evidence.

Map P.2715 (back pocket) shows not only the shore features, where present, of these ancient lakes (in red) but also shows the lacustrine clays and silts (in blue) and the deltas of sand (in yellow) left at the mouths of rivers which flowed into them. While geologists have concentrated on the beaches in order to interpret the glacial history, the clay and sand deposits make a far more important imprint on our geography. In the Thames Valley three sandy deltas are conspicuous. The highest one between Thamesville and London stands at its maximum at close to 910 feet a.s.l. The next one between 800 and 750 feet a.s.l. occupies most of Caradoc Township. The third one is between the 700- and 600-foot contours. Where the Grand River of that time emptied into standing water a huge delta was formed south and southwest of Brantford. The upper level of this delta is at about 850 feet a.s.l. and nearly all of it is west of the Galt Moraine. The fine sands east of the Galt Moraine extending to Copetown (near Ancaster) are nearly all under 775 feet a.s.l. No doubt these were mainly left by streams along the ice front which came over the Niagara Escarpment at Campbellville and

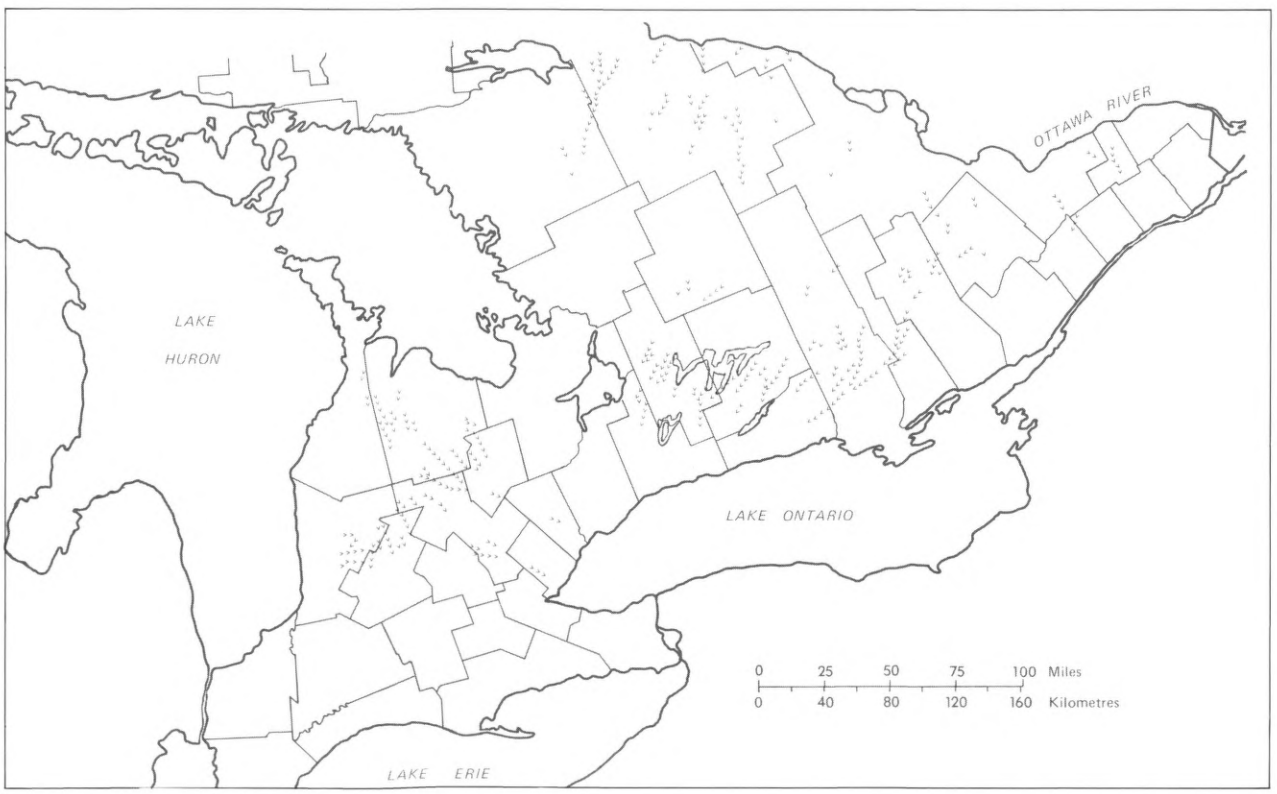
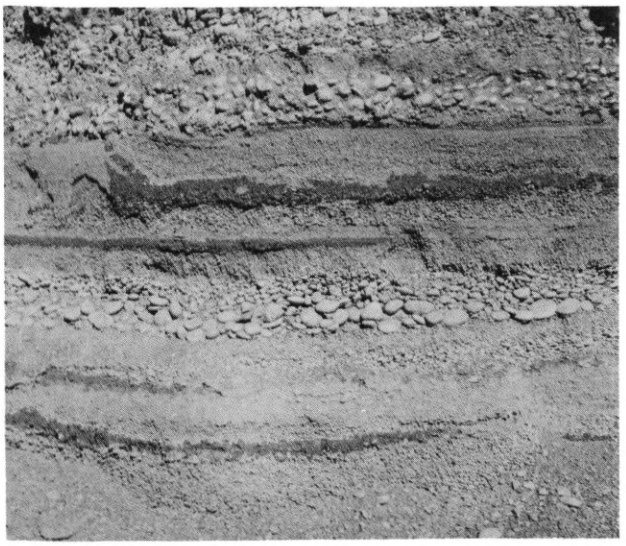


Figure 8. Eskers in Southern Ontario.

OGS 10 663

Photo 12. Air photo of an esker southwest of Atwood, Perth County. The white patches near the roads are gravel pits. Photo courtesy of the Canadian Armed Forces.

Dundas. Near the mouth of the Grand River there is another delta east of Dunnville mostly found at elevations below 600 feet a.s.l. Two yellow-coloured areas in the Saugeen Valley identify former deltas roughly below elevations of 900 and 700 feet a.s.l. The Bighead and Beaver Valleys contain small deltas below 775 feet. Most of the Nottawasaga flats in the Camp Borden (southwest of Barrie) to Alliston to Beeton to Cookstown area are floored with deltaic sand. Some of the sand plains seen along Highway 11 from Bracebridge to North Bay originated as deltas in a large glacial lake which inundated that area east of Georgian Bay. All along the north shore of Lake Ontario from Toronto to Belleville a series of little deltas coalesce to form a continuous strip of sand. Lastly, there are two big marine deltas in the Ottawa Valley. The upper one in the Petawawa area stands at altitudes of up to 590 feet a.s.l. Between Pembroke and Ottawa there are only scattered small patches of sand. Then, east of Ottawa, below 240



OGS 10 664

Photo 13. Rounded pebbles, evenly graded in the various strata, are typical of beach gravels.

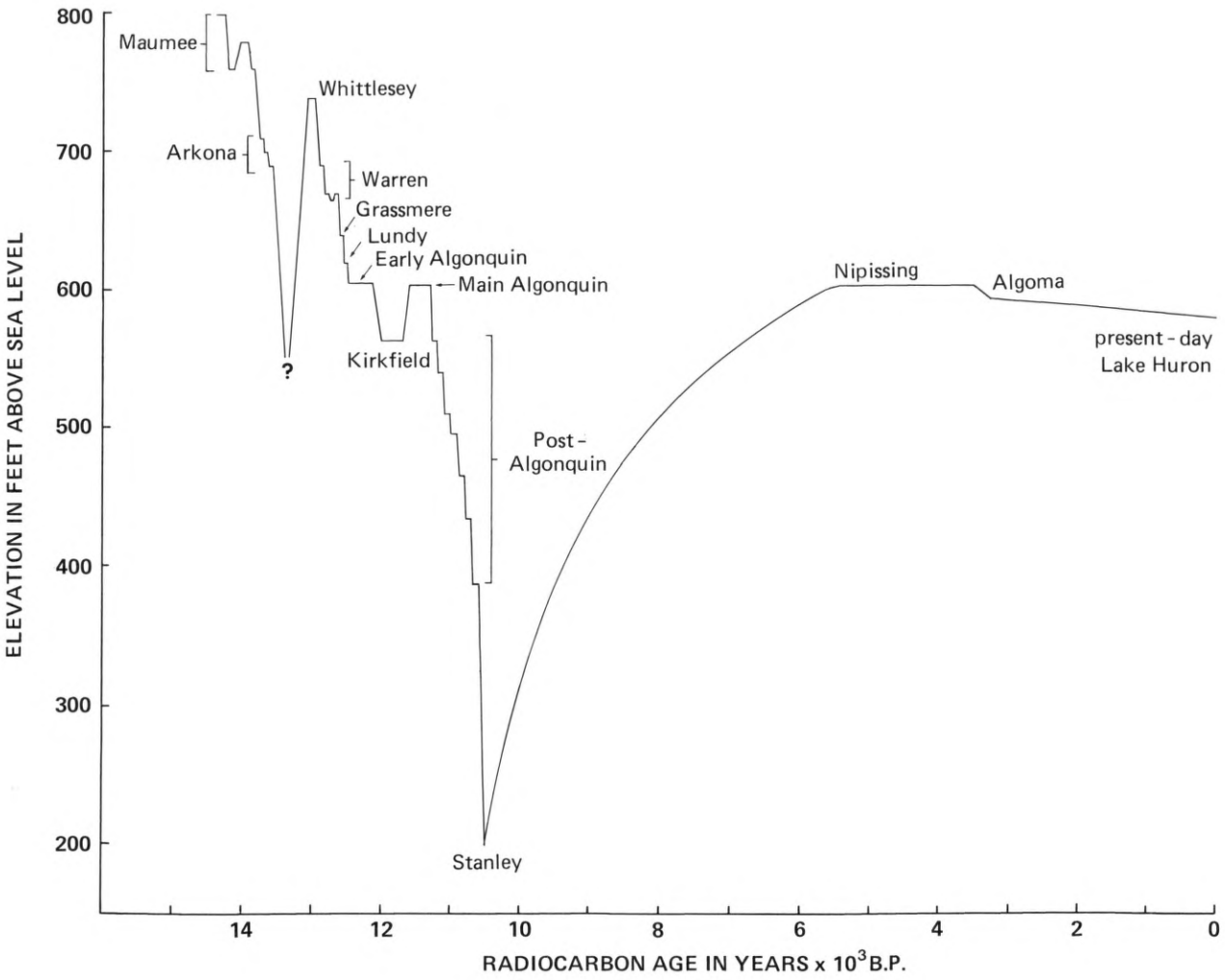
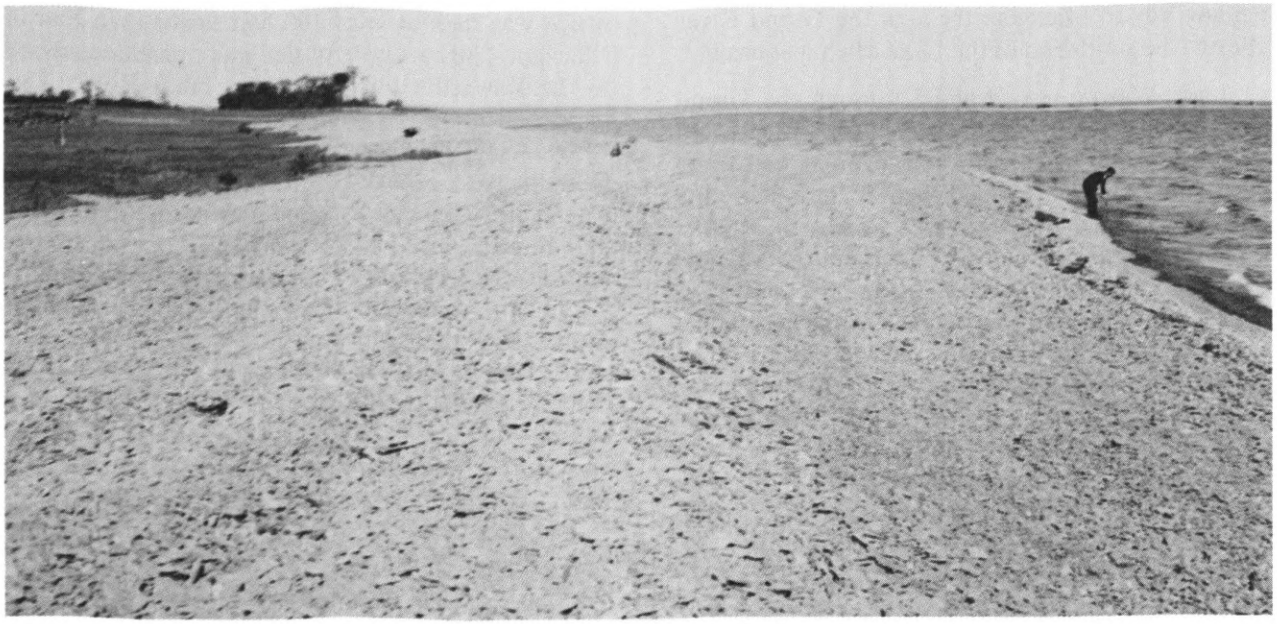


Figure 9. Sequence of former lakes of the Huron and Erie basins (after Fullerton 1980; Lewis 1969).

OGS 10 665

Photo 14. Abandoned marine beach strands near Carleton Place.

Figure 10. Former shorelines in Southern Ontario.



OGS 10 666

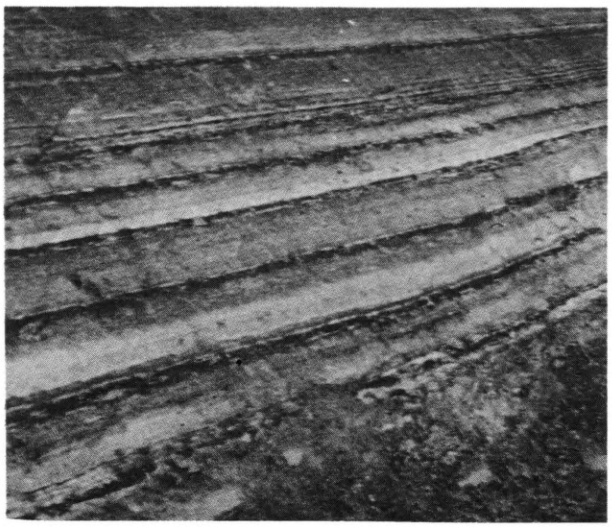
Photo 15. A present-day gravel beach at Chartwell Point (Prince Edward County) on Lake Ontario.

feet a.s.l., an extensive delta, cut through by stream channels, is found. Many of these deltas are surrounded by lacustrine clay and silt deposits and these areas, mapped in blue, make the yellow colour of the deltas stand out clearly.

The highest glacial lake of the Erie and Huron basins emptied westward from Fort Wayne, Ohio, down the Wabash River to the Mississippi. It is called Lake Maumee. During the early life of this lake the Huron and Erie ice lobes contacted each other just west of London, but they separated during its existence. The little lake plain between London and Thamesford, with its shoreline at 910 feet a.s.l., is considered to be a contemporary of Lake Maumee. A later, lower stage of this lake probably extended into the valley of Dingman Creek and the depression north of Coldstream.

Sixty feet below the upper Maumee watermark the beach of Lake Whittlesey may be expected. A poorly developed beach in Ontario, it serves as a boundary between till plain and lake plain from Exeter in the west to beyond Brantford on the east as shown in Figure 10. From an altitude of 800 feet a.s.l. at Arkona the shoreline rises to 875 feet a.s.l. northeast of Brantford at Westover. The outlet of Lake Whittlesey was at Ubly on the "thumb" of Michigan, whence it emptied into a smaller lake in the Saginaw Bay depression and then drained across Michigan and eventually toward the Mississippi River.

The Arkona beach, 30 to 40 feet below the Whittlesey, is also poorly defined in Ontario. According to Leverett and Taylor (1915), based on evidence seen in Michigan, Lake Arkona preceded Lake Whittlesey and the beach was therefore submerged and spread out by the waters of the later lake. The Arkona beach and the upper beach of Lake Warren are separated by an elevation of about 15 feet and are seldom far apart. Although Lake Arkona takes its name from an Ontario village, and occurs near there, the original beach at Arkona was found later to belong to Lake Whittlesey (Leverett and Taylor 1915). The outlet was westward from



OGS 10 667

Photo 16. Varved clay, Holland Landing. These are thick varves, with the lighter, thicker layers being silty and the darker, thinner layers being clayey.

Saginaw Bay in Michigan through the Grand River valley to the south end of the Lake Michigan basin.

Lake Warren also drained through the Grand River valley after it had eroded down 15 feet, and later 25 feet below the Arkona level. It had three stages but only two formed well-defined shoreline features in Ontario. The oldest one was 10 feet above the youngest one. The intervening level was the lowest, and was destroyed during the formation of the youngest beach. Thus twin beaches, finely formed and fairly continuous, are characteristic of this shoreline. On the Huron slope they run as far north as Paisley and, on the Ontario-Erie side, as far as Campbellville. In the south, Warren beaches appear at Ridgetown and in the Leamington area where some high ground stood as islands in this lake. The upper of these twin beaches is found at 685 feet at Leamington, 750 feet near Grand Bend, and 925 feet just north of Paisley.

Below the Warren water level and above those of Lakes Algonquin and Iroquois there are some fragmentary beaches at several levels. Leverett and Taylor (1915) recognized three lakes named Wayne, Grassmere, and Lundy (Elkton or Dana). Below these, an early stage of Lake St. Clair which left its mark on the topography and soil of Kent County should be mentioned at this time along with the delta and clay flats east of Dunnville. Both are confined roughly by the 600-foot contour. Below Warren levels in the area north of Lake Ontario shallow deposits of varved clay are found in the Regional Municipalities of Halton, Peel, and York. These Lake Peel clays are not found above the 700-foot contour. The shoreline is indefinite but small sandy deltas left by the Credit and Humber Rivers at 700 feet and 725 feet a.s.l., respectively, may mark the upper limits of this lake. Allowing 100 feet for crustal uplift places this near Lundy levels.

On the north slope of the Oak Ridges Moraine there are also deposits of varved clays. Although there are some in pockets at high levels, the main varved clay beds occur below 850 feet in the Schomberg area where thick beds cover all but the hilltops.

In the Lake Huron basin the next major beach below Warren is the Algonquin. Lake Algonquin came into being when the glacier had receded far enough north in the State of Michigan to open a passage between the Lake Huron and Lake Michigan basins. At first the outlet of Lake Algonquin was at Chicago at very close to the same altitude as the St. Clair River valley at Sarnia. Submergence of land above Lake Huron at that stage was due to isostatic depression which increased toward the north. Also, it was at a maximum when the land was first uncovered by the receding glacier. The Chicago outlet served until the glacier receded north of Kirkfield which was then at least 100 feet lower than that of Chicago. Thus a lower outlet was opened eastward to the Kawartha Lakes and the Trent River. This happened about 11,500 years ago (Karrow *et al.* 1975). As the glacier withdrew northward from Kirkfield, the land, relieved of the pressure of the glacier, rose again. Thus the Kirkfield outlet rose and, being in the north, raised lake levels to the south until they reached the level of the Chicago and Sarnia outlets. The Main Algonquin shoreline with its prominent shorecliffs and well-formed gravel beaches mark this three-outlet stage. The higher, pre-Kirkfield stage is not marked by a shoreline. However, in the area around Schomberg and the Holland Marsh extensive varved clay deposits occur immediately above the Main Algonquin levels. These clays occur consistently below 850 feet a.s.l. and may represent the Early Algonquin stage.

The Main Algonquin shorecliff is mostly undercut and obliterated between Sarnia and Point Clark. From there to Port Elgin it is present as a high bluff within a mile or two of the Huron shore. At Port Elgin a large sand and gravel bar is built across the Saugeen Valley. The shoreline runs inland east of Hepworth and consists of alternating stretches of bluffs and beaches. The Sauble River left deltaic sands around Hepworth, the deeper drier sands being subject to blowing. From Wiarton to Collingwood the Algonquin bluffs and beaches are nearly continuous and are close to Georgian Bay. In the Bighead and Beaver Valleys there are good deltas. The Nottawasaga flats are sandy except around Stayner where there is clay. Other clay plains occur around Elmvale and in Orillia and Mara Townships, and the Town of East Gwillimbury. Elsewhere the Algonquin lake bed in this area is sandy. The shoreline can be traced to Kirkfield, mostly in the form of beaches rather than bluffs.

The uplands between Lake Simcoe and Georgian Bay were islands in Lake Algonquin. The upper stage left bold bluffs and boulder terraces around these islands, while several distinct but minor beaches form steps down the hillsides. In fact a series of beaches between the Main Algonquin and the very prominent Nipissing shoreline is widespread in the Georgian Bay area (Goldthwait 1910; Johnston 1912; Deane 1946, 1950; Stanley 1936, 1937, 1938).

Between Kirkfield and North Bay there is good evidence of submergence in the form of varved clays and denuded rock ridges. Faint, sandy beaches occur at altitudes of 960 feet a.s.l. at Bracebridge, 1,117 feet at Dorset, 1,129 feet at Novar, 1,120 feet at South River, 1,195 feet north of Trout Creek, and 1,177 feet at Cooks Mills near the North Bay airport (Goldthwait 1910; Chapman 1954; Taylor 1894). However, in this rugged rocky terrain beaches are

very scarce and shorecliffs nonexistant. Running east from North Bay to Pembroke the Canadian National Railway follows a valley along a fault line. Lake Algonquin contacted this valley at a place called Fossmill. The floor of this valley, measured at a sill just east of Kilrush, is at 1,130 feet a.s.l. The Algonquin shoreline is not visible just south of Fossmill but extrapolation from the beach near Trout Creek at 1,195 feet a.s.l. brings the level of the shoreline to 160 feet above the Fossmill valley. Bare rock walls and spectacular boulder pavements here and there along the valley and the big delta around Petawawa in the Ottawa Valley provide ample evidence that this was once a river channel. Furthermore, the upper limits of Algonquin sediments drop 160 feet or more north of Fossmill. Varved clay which covers most of the lower ground east of Bonfield and in the Amable du Fond River valley are found up to but not above 1,000 feet a.s.l. If the water of Lake Algonquin dropped 160 feet with the opening of the Fossmill channel it would have uncovered the Nottawasaga flats and other lowlands bordering Lake Simcoe and Georgian Bay.

The commonly accepted interpretation of the recession of the glacier in the North Bay-Mattawa region (Lewis 1969; Harrison 1972) is that the ice front withdrew uncovering progressively lower outlets for Lake Algonquin across the slope south of Mattawa. However, it appears that the recession of the ice front in this area is not so simple. Noting that an esker, which extends up this slope to Papineau Lake, is not cut through by channels anywhere, the writer has proposed a different interpretation (Chapman 1975). Prest (1970, p.729) also noted the absence of stream channels across that slope and proposed another possible solution. In the Bonfield area southeast of North Bay the ice front had an easterly alignment as shown by two till moraines. Shortly thereafter the easterly alignment of the ice front changed as a small lobe of ice pushed westward from Mattawa to Rutherglen, creating an ice front aligned nearly north-south. This small lobe, the Mattawa lobe, kept the Mattawa Valley blocked and held Lake Algonquin up to the beach at 1,177 feet a.s.l. at Cooks Mills, 7 miles north of North Bay. Also lacustrine silts and clays are found northeast of Trout Lake well above the level of the Mattawa Valley. Eventually the Mattawa Valley was uncovered. At this time the amount of isostatic depression, estimated from the Algonquin beach at Cooks Mills which is found at 1,177 feet a.s.l. (Goldthwait 1910), is 572 feet, the altitude of this beach at Grand Bend being 605 feet a.s.l. The opening of an outlet eastward from North Bay allowed the lake level in the Huron and Michigan basins to drop approximately 400 feet, the controlling sill of the outlet being not east of North Bay but in the French River area. This low outlet stage in the Lake Huron and Georgian Bay basins is called Lake Stanley. The outlet channel in the Mattawa Valley is marked by trains of boulders, the boulders in places being well worn. Otherwise, the Stanley stage did not affect the physical features of the Mattawa Valley area. Isostatic uplift then proceeded to raise this area, producing rising water planes, until eventually the outlet reached the same altitude as the St. Clair River at Sarnia and the previously mentioned outlet at Chicago. A strongly developed shoreline formed at this time, the shoreline of the Nipissing Great Lakes.

The Nipissing beach ranks with the Main Algonquin beach in strength. Usually it is near the present shore and shows up mostly as a wave-cut bluff up to 90 feet high with boulder pavement on the terrace along the base. Gravel beaches were built in many sections; in fact sometimes a series of strand lines lies across the terrace between the Nipissing shorecliff and the present shore. South of Grand Bend, at Sauble Beach, and at Wasaga Beach, lines of sand dunes were built during and since Nipissing time. With this bouldery wave-swept border must be included the silty flats behind Lion's Head and the Minesing Swamp with its adjacent flats. In the latter case there was an isolated lake south of the ridge at Edenvale and a channel through this moraine was eventually cut down to Nipissing level. Around the present Lake Nipissing the bed of the ancient Nipissing lake stage is well represented by remarkably flat silt and clay plains commonly bordered by a small but distinct bluff. Highway 17 traverses this plain east of Sturgeon Falls and in the Verner area. The sandy plain around Nipissing village can also be mentioned. Along the eastern shore of Georgian Bay there are no large Nipissing lake plains, but there are many small ones among the rock ridges.

These are the youngest deposits in the region related to the effects of the Wisconsinan glacier. Continuing isostatic uplift raised the North Bay outlet above the St. Clair River and Chicago outlets. Being in till, the St. Clair River channel eroded more rapidly than the Chicago channel which is based on rock, so the St. Clair River eventually took over the whole discharge. With the outlet in the south, continuing uplift raised all land above 605 feet a.s.l. to above the water plane. Carbon-14 dating of wood found in the Nipissing beach gives an age of about 3,800 years ago (Lewis 1969). With continuing erosion of the Sarnia outlet, a low, short-lived stage, called the Algoma, existed in the Huron basin. Finally, further erosion of the outlet and isostatic uplift caused the lake levels to lower to that of present-day Lake Huron (Figure 9).

Prior to the Kirkfield stage of Algonquin, the Lake Ontario ice lobe had receded beyond the east-

ern end of that lake. While it still occupied the St. Lawrence Valley and blocked direct access to the sea, an outlet east of Rome, New York opened, thereby allowing drainage through the Mohawk Valley to the Hudson Valley and to the Atlantic. This outlet is at 557 feet a.s.l. and a beach at Quay, four miles northwest of Port Hope, Ontario, is at the same level. Joining these two points of equal elevation along the ancestral shoreline gives an isobase that indicates the trend of the warped water plane of this glacial lake. The ancient lake was named Lake Iroquois by J.W. Spencer in 1890. However, the raised shoreline was first noted by a Mr. Thomas Roy (1837), a civil engineer of Toronto, in a paper presented to the Geological Society of London. Only the summary of his paper is available on pages 537 and 538 of the Second Volume of the Proceedings of that Society, but it is noted here because it is the first printed record to appear on the abandoned high-level beaches in Ontario. It must be said that although Mr. Roy correctly recognized what he saw and described as shoreline deposits he could not explain the existence of such a high-level lake. That remained for G.K. Gilbert who traced the outlet down the Mowhawk Valley in New York State and advanced the idea, revolutionary at the time, that the glacier had formed a dam in the St. Lawrence Valley (Gilbert 1890).

Lake Iroquois left strongly developed shore features which, west of Quay (four miles north of Port Hope), can be attributed partly to rising lake levels. When the outlet at Rome, New York, first opened the lake level at the western end of the basin was nearly 200 feet below the present lake level. Crustal uplift produced rising lake levels which eventually reached the position of the Iroquois beach. A tentative date of 12,000 years B.P. (before present) is suggested by Karrow (1981) for the end of the Iroquois stage.

At the time when the glacier withdrew from the St. Lawrence Valley and allowed free access to the sea, the St. Lawrence Lowland, as far west as Brockville, was below sea level due to isostatic depression. The level of submergence increased northward, from 405 feet just north of Brockville to 590 feet a.s.l. near Petawawa. There is abundant evidence of the invasion of this area by saltwater in the form of marine shells embedded in the upper layers of stratified clay and, especially, the beaches. The bones of whales have been found also (Coleman 1901; Gadd 1963).

THE RECESSION OF THE WISCONSINAN GLACIER

At its maximum the Wisconsinan glacier covered all of Ontario and extended to southern Ohio. It was not until it had melted back about 150 miles, uncovering nearly all of Ohio, that the first land was uncovered in Southern Ontario. Beginning at that point the next section of this monograph, with the aid of 15 stage maps, will outline the retreat of the glacier from Southern Ontario. This next section deals with the position of the ice front, the drainage from the melting ice, and the glacial lakes at successive stages. The value of this fascinating story lies in the fact that it serves to explain the origin of the complex landscape of the region. Without this geological history it would be hardly possible to grasp and hold a mental picture of the various landforms and types of soil found throughout the Province.

For the sake of clarity an outline of the successive stages in the retreat of the Wisconsinan glacier as now interpreted will be given with a minimum of discussion. Some points, however, are still vague and controversial. Several minor events have been omitted when they have had little or no effect on the upper deposits.

It should be understood that the retreat or recession of a glacier does not mean that the ice moves backward. The ice front "recedes" when melting exceeds accumulation of snow. "Advance" occurs when accumulation exceeds melting. There is ample evidence that the glacier's retreat as it uncovered Ontario was spasmodic, the general retreat being interrupted by temporary readvances and still-stands. The cause of climatic variations which produced these fluctuations is a subject of considerable speculation.

The melting and retreat of the glacier was not simply an uncovering of the land from south to north. The wasting glacier consisted of several lobes and these first split apart near Orangeville or Waterloo as shown in Figure 11a. The surfaces of the lobes were highest in their centres and sloped down toward their edges, which means that the relief was often opposite to that of the present land surface. Drainage flowing into the crease between the lobes brought in sand and gravel and built the Orangeville Moraine. The sand contains a good deal of calcite while the gravel includes a sprinkling of siltstone, both from east of the Niagara Escarpment. Immediately west of this moraine the till contains a great deal of local dolostone, and siltstone is lacking. The Waterloo Moraine was built about the same time of similar materials, but the two are not connected as might be expected. Moreover, the southward extension of the Waterloo sandhills implies a southward advance of the Huron ice lobe, the limit of which is indefinite. The details of the glacier's movements in this area are still not clear.

Following the first split, the front of the southern ice lobe retreated and then readvanced over the

Guelph drumlin field and overrode most of the Waterloo Moraine. During its retreat glacial drainage passed laterally across the Guelph drumlin field, cutting channels across the slope and leaving extensive beds of gravel in the hollows. At about the same time the northern ice front receded, uncovering the Woodstock drumlin field. During retreat in Oxford County three deep spillways were cut across the slope of the till plain, the first between Woodstock and Ingersoll, the second past Embro, and the third east of St. Marys. The south branch of the Thames, Trout Creek, and the Middle Thames now occupy these valleys which all emptied into a small lake east of London (Figure 11b).

In its retreat from the north side of the Orangeville Moraine the Georgian Bay section of the glacier uncovered several drumlins and a short esker around Marsville and the smooth till plain to the north. Drainage from this ice front flowed down the path of the Grand River. It is apparent that this lobe of the glacier operated separately from the lobe in the basin of Lake Huron. First, the Georgian Bay lobe receded and the Huron lobe thrust forward to build the Milverton Moraine as shown on the second stage map (Figure 11b). It then retreated and the Georgian Bay lobe readvanced, overriding the Milverton Moraine north of Listowel (Figure 11c). This latter event left a sheet of gritty, stony till and smoothed the till surface while scoring it with shallow grooves or flutings (Photos 4 and 5). The Georgian Bay lobe then retreated and the Huron lobe advanced to the Mitchell Moraine (Figure 11d). A point that may not be evident from this fourth stage map is that the Milverton Moraine was overridden south of Fullarton village. It is evident from the course of the Mitchell Moraine that the frontal part of the Huron ice lobe expanded south of Goderich or was perhaps deflected by Georgian Bay lobe ice. The courses of the eskers also indicate a radial movement of ice out of the Lake Huron basin in this area.

During the building of the Mitchell Moraine, drainage collected in a shallow basin north of Brodhagen while the overflow went down the path of the North Thames River. Incidentally, two other shallow basins held water just prior to this period until their outlets gradually were deepened to drain them. One is marked by the marl beds and stratified sand and clay south of Atwood; the other is in the Ellice Marsh area in front of the Milverton Moraine.

Figures 11b and 11d show the Ingersoll and Westminster Moraines being built at almost the same time as the Milverton and Mitchell Moraines, respectively. It should be clearly stated, however, that these moraines of the Huron and Erie lobes cannot be correlated with certainty.

Because of their position and size in relation to their neighbours, the Seaforth and St. Thomas (Mount Elgin) Moraines are also considered to be contemporary by the writers (Figure 11e). Both are of similar brown, calcareous clay till and their southern extremities were built under water. After building the Seaforth Moraine the Huron lobe made only two minor halts in front of the Wyoming Moraine. The Erie lobe made two minor thrusts to push up the twin strands of the Norwich Moraine before retiring past Tillsonburg. Meanwhile, the Georgian Bay lobe had retired 40 miles north of Listowel uncovering the Dundalk fluted till plain and the Teeswater drumlin field, and perhaps together with the Huron lobe, leaving the Wawanosh Moraine and then the Saugeen kames before building the first till moraine, the Singhampton (Figure 11f).

Starting about six miles east of Flesherton it is evident that the Georgian Bay lobe, in its thrust forward to build the Singhampton Moraine, encroached on till left earlier by the Lake Simcoe lobe which had advanced southwestward to the Orangeville Moraine. The limit of this southwestern thrust is marked by a finely formed sandy moraine crossing the southwestern corner of Osprey Township and continuing in much stronger form southward through Melancthon to the kames at the head of the Pine River valley.

Withdrawing from the Seaforth and Clinton Moraines, the Huron ice lobe soon uncovered a valley west of Ubly, Michigan, which allowed the lake in front of it to fall 60 feet. Continued withdrawal uncovered an outlet down the Grand River valley, Michigan, 30 to 40 feet below the one at Ubly and the lake at this level is called Arkona. Although glacial Lake Arkona occurs near and takes its name from the Village of Arkona, Ontario (Spencer 1891, p.204), the originally designated beach at Arkona was found later to belong to Lake Whittlesey. According to Leverett and Taylor (1915) the Huron lobe probably receded a considerable distance before advancing again, closing the outlet of Lake Arkona, which forced the lake level up again to that of the Ubly outlet, establishing Lake Whittlesey. The Arkona beach was thus submerged and smoothed.

During the time of Lake Whittlesey (Figures 11f and 11g) the Lake Huron lobe, at its maximum, built the Wyoming Moraine which is, in places, a composite of two or three strands. Carbon-14 dating places the age of this moraine at about 13,000 years B.P. (Dreimanis 1966). A well-developed spillway in front of it is a companion feature from the Greenock Swamp to Hensall. The Georgian Bay ice lobe left two moraines, the Singhampton and Gibraltar. The Lake Simcoe lobe built the extensions of these two moraines from Singhampton and Gibraltar south-

ward to the Oak Ridges Moraine east of Caledon Village. The Lake Ontario lobe built the Paris, Galt, and little Moffat Moraines and the most northwesterly of the Waterdown Moraines which extends to the kames at the head of the Dundas Valley. South of there the moraines are too faint to be mapped and the ice front at the close of Whittlesey time is placed at the limit of Halton Till (Barnett 1978; Feenstra 1981), which on the shore of Lake Erie extends to morainic knobs at Mohawk Point (Figure 11g). They appear to be correlated with the Marilla Moraine in New York State although it is the Alden Moraine that contacts the Whittlesey beach at its most easterly point (Taylor 1913).

As shown in Figure 11f, the spillway in front of the Wyoming Moraine emptied into Lake Whittlesey near Hensall, but there is only a small delta in that area. In sharp contrast, the spillway in front of the Paris and Galt Moraines built an extensive delta south of Brantford. The preponderence of calcite over dolomite in these delta sands indicates that a good deal of the sand comes from east of the Niagara Escarpment, probably transported to the escarpment by the Lake Simcoe ice lobe. Drainage along the Georgian Bay lobe in front of the Singhampton Moraine left the big channel mostly floored with gravel extending past Durham, Hanover, and Walkerton to the Greenock Swamp. In front of the Gibraltar Moraine also there is a train of outwash gravel ending east of Chesley where the stream probably emptied into standing water. With the Lake Huron lobe against the Wyoming Moraine, and extending north from Glammis to beyond Paisley, the area between Walkerton and Chesley must have been submerged up to the level of the ponding in the Greenock Swamp area, although the writer has not found good evidence of it in the form of lake sediments. This sequence, however, is supported by the presence of clayey till of the Huron lobe overlying grittier till of the Georgian Bay lobe in a pit at Glammis (Cowan *et al.* 1978).

From Caledon Village north toward Singhampton the main spillway is in front of the Singhampton Moraine. This moraine was built by the Lake Simcoe ice lobe pressing against the Niagara Escarpment northeast of Caledon Village.

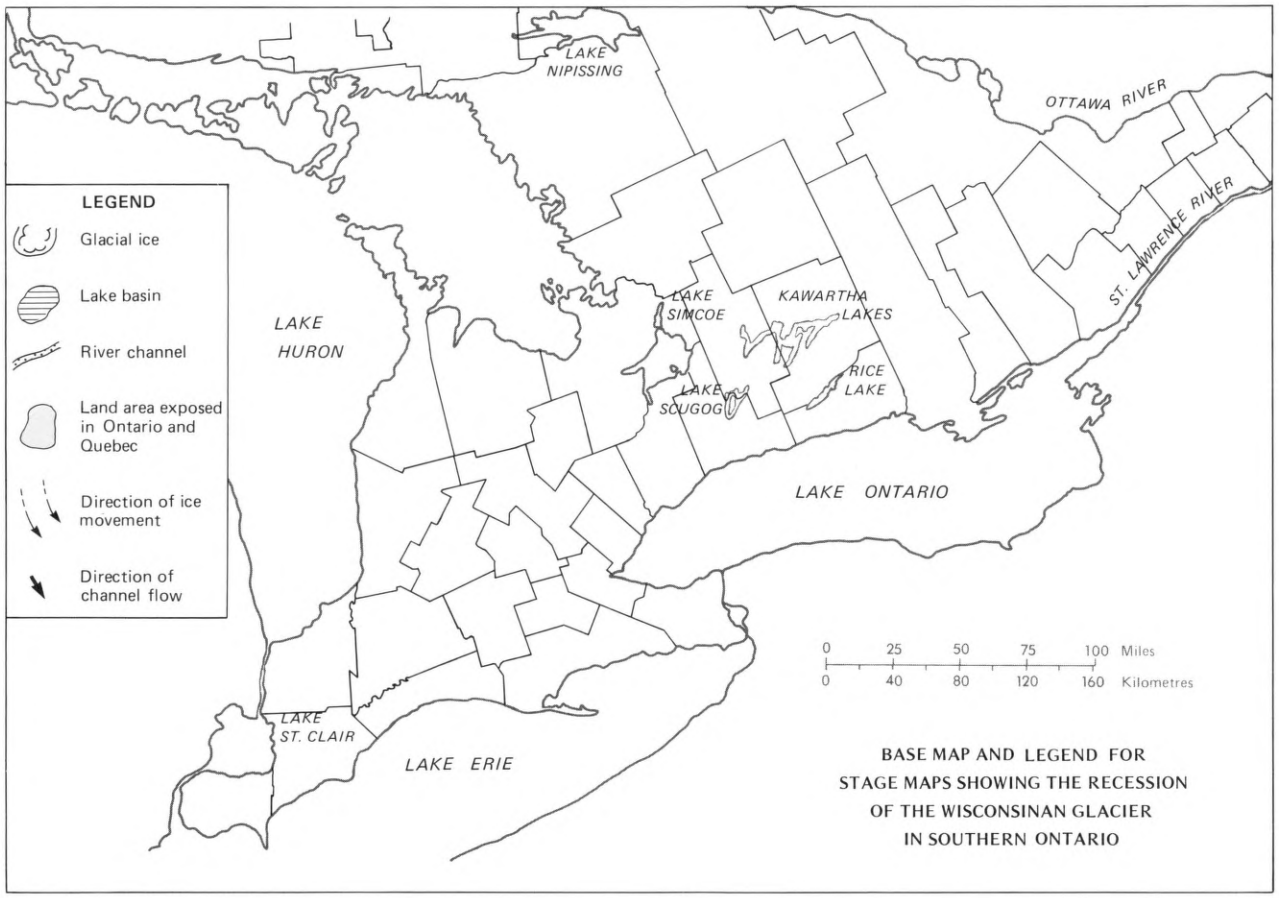
Until the time when the Galt Moraine was being built by the Ontario ice lobe the glacier over-topped the Niagara Escarpment in the Caledon area. Soon after, the Ontario lobe and the Lake Simcoe-Kawartha Lakes lobe separated over the high, hilly ridge over the Palgrave area damming a high-level lake between the ice lobes and the escarpment. This lake had its outlet at Belfountain from where the drainage ran down the spillway in front of the Paris Moraine (Chapman in press). The split between the Ontario and the northern lobes over the Oak Ridges Moraine gradually opened eastward, reaching beyond Uxbridge while the Ontario lobe was still overriding the escarpment south of Acton. At this stage, shown on Figure 11g, thick beds of lacustrine clay, silt, and fine sand were deposited up to 1,230 feet a.s.l. in the Uxbridge area. The well-developed stream channel running along the brow of the escarpment northwest of Cheltenham and through the Galt Moraine to Acton may well have served as the outlet for this high-level lake over the Oak Ridges Moraine. However, these beds of clay and silt are invariably covered by three feet or more of sand and are not conspicuous on the surface.

Lake Whittlesey gave way to Lake Warren (Figure 11h) when the ice front on the "thumb" of Michigan receded, opening a passage between southern Lake Huron and Saginaw Bay, allowing the lake levels to fall to the level of the Grand River in Michigan. Figure 11h shows the Huron lobe retired a little from the Wyoming Moraine, the Georgian Bay lobe at the Banks Moraine, and the Lake Ontario lobe at the Niagara Falls Moraine. The lattermost lobe dropped to the base of the escarpment from Campbellville to Cheltenham and then retreated toward Caledon East; drainage flowed south along this ice front and finally over the escarpment at Campbellville where it emptied into Lake Warren.

In the Lake Erie region Lake Warren sediments, especially silts, are widespread. A few of the Warren silt deposits are: the highly dissected deposits east and south of Brantford at the mouth of the Grand River; the silt around Fingal where Kettle Creek emptied; and other silt deposits near Ridgetown, east of Chatham and around Harrow. Stratified clay is widespread in the Warren lake plain. Often it is a shallow upper deposit. On the other hand, deep beds of varved clay occur in the Paisley-Chesley area.

The two Warren beaches, 10 feet apart in altitude and usually close together, are due to downcutting of the Grand River channel in Michigan. Figure 11h shows an early stage of Lake Warren with a long, narrow bay between the ice front and the Wyoming Moraine. Meltwater flowing into the northern end of this narrow estuary probably brought in and deposited the sand which occurs as an offshore strip in the Warren basin. Some of this material was swept up near the shore to form the Warren beaches which are surprisingly strong and continuous in that area of clay till.

Leverett and Taylor (1915) and others recognized two lakes following Lake Warren at 45- to 65-foot lower altitudes called Grassmere and Lundy. Unlike the Warren beaches in Ontario, Lakes Grassmere and Lundy did not leave continuous shorelines. The shallow gravel bar extending from near Leamington through the Town of Essex is at the



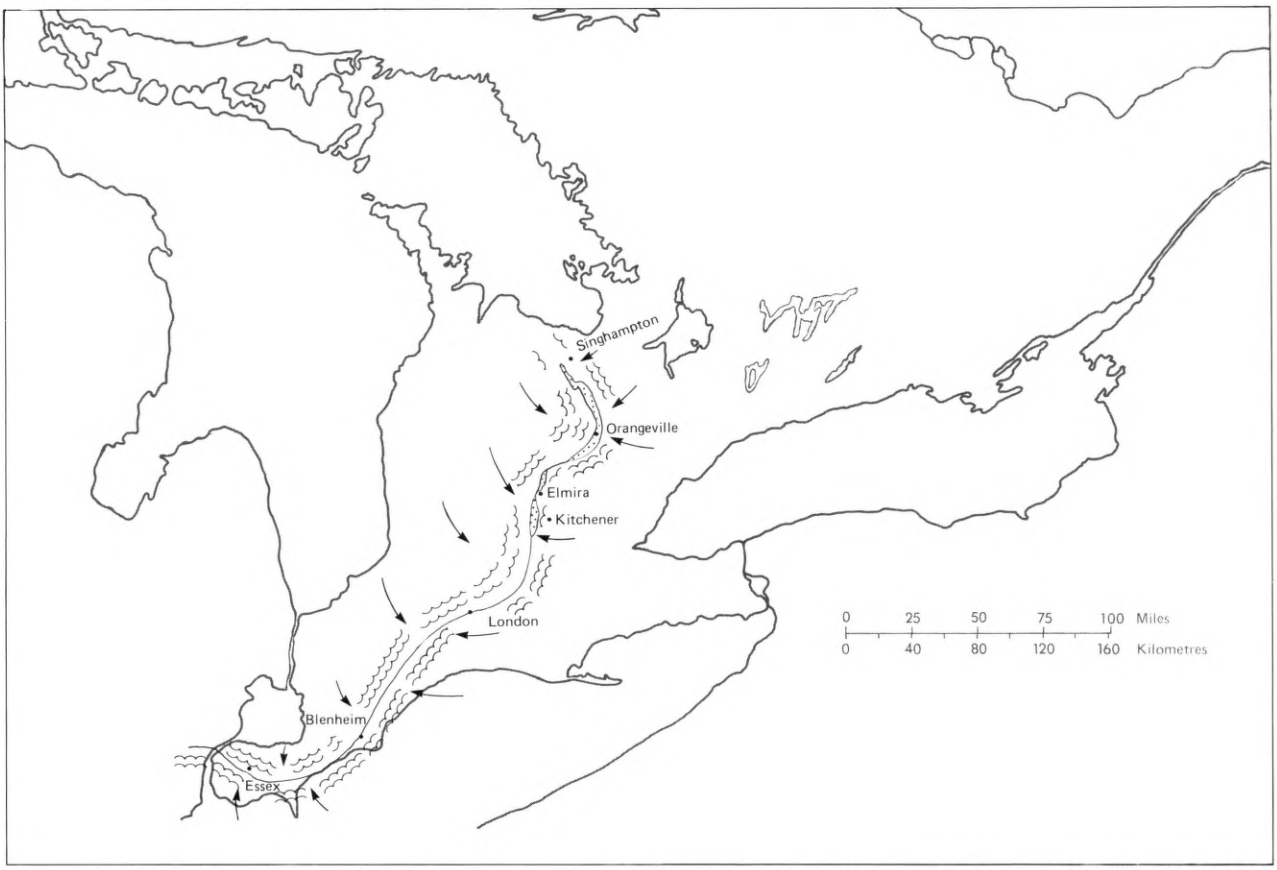


Figure 11a. The recession of the Wisconsinan glacier, showing the early ice positions at the Orangeville and Waterloo Moraines.

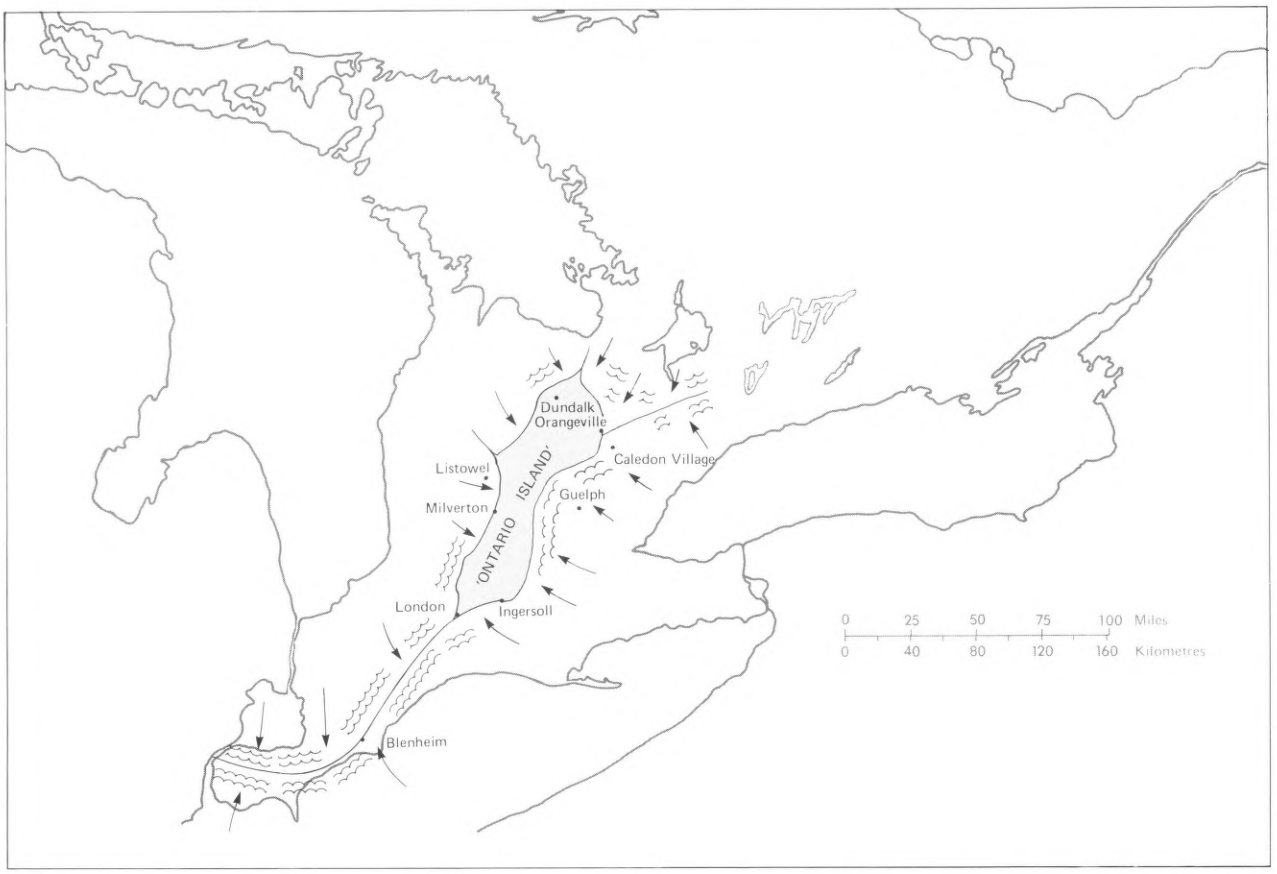


Figure 11b. The opening of the "Ontario Island" northeast of London and the Huron lobe at the Milverton Moraine.

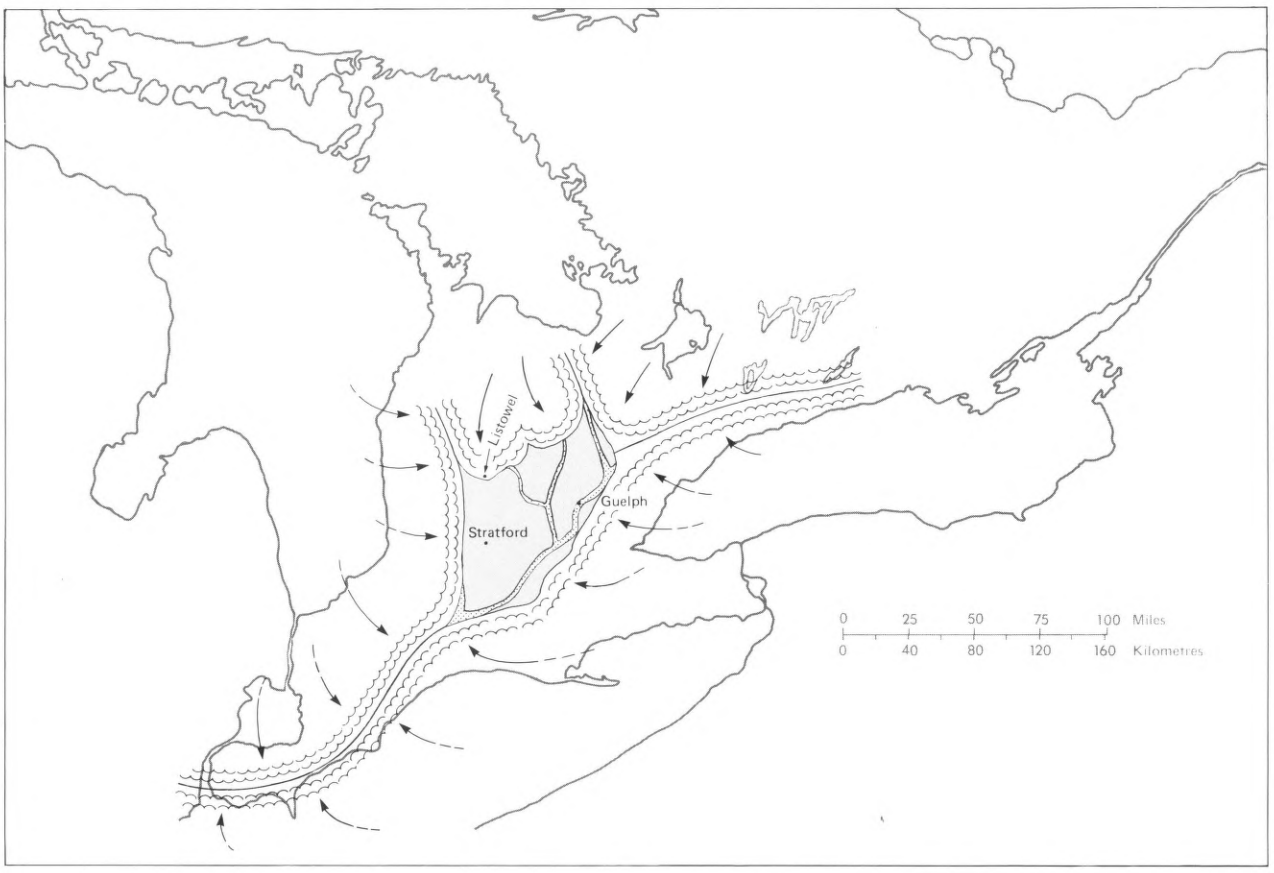


Figure 11c. Overriding of the Milverton Moraine by the Georgian Bay lobe.

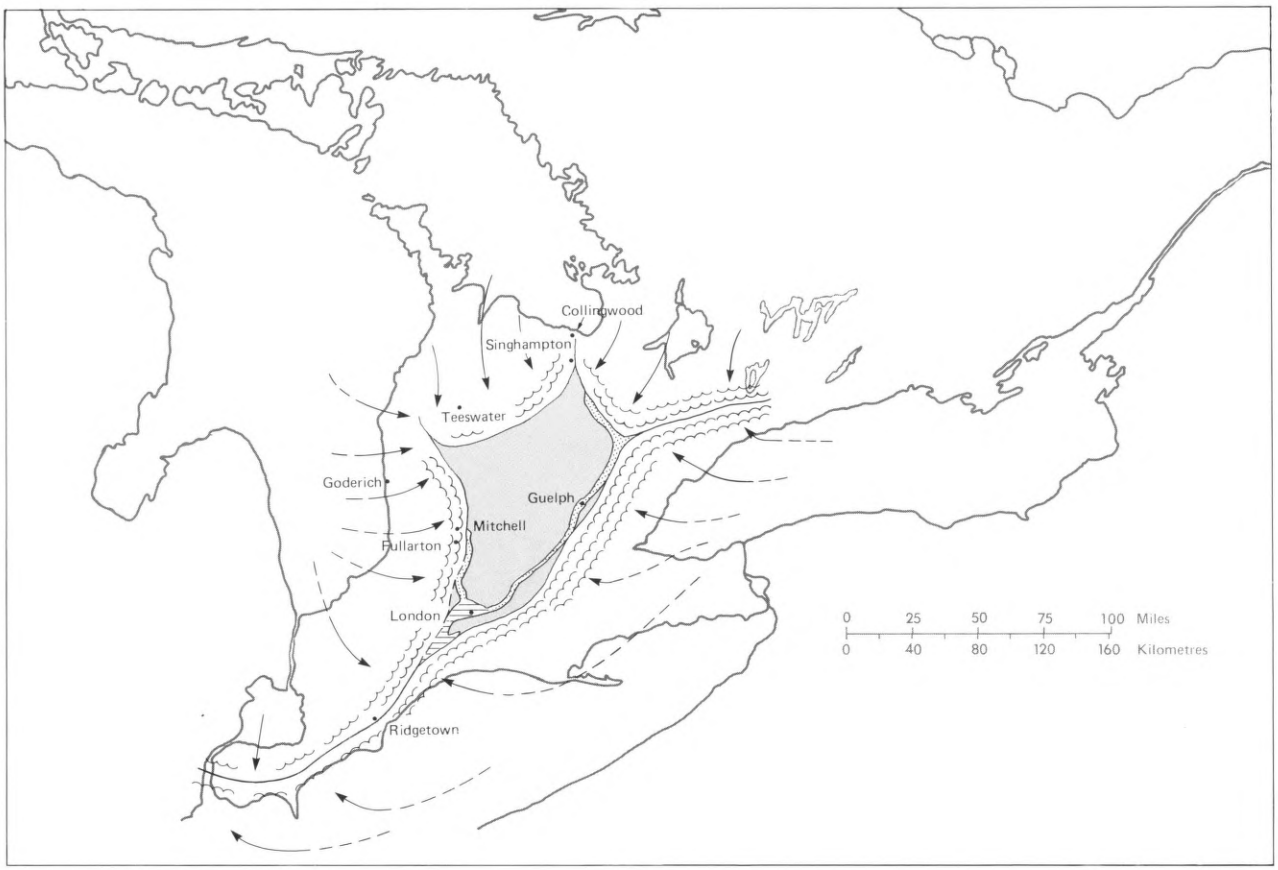


Figure 11d. Huron lobe at the Mitchell Moraine.

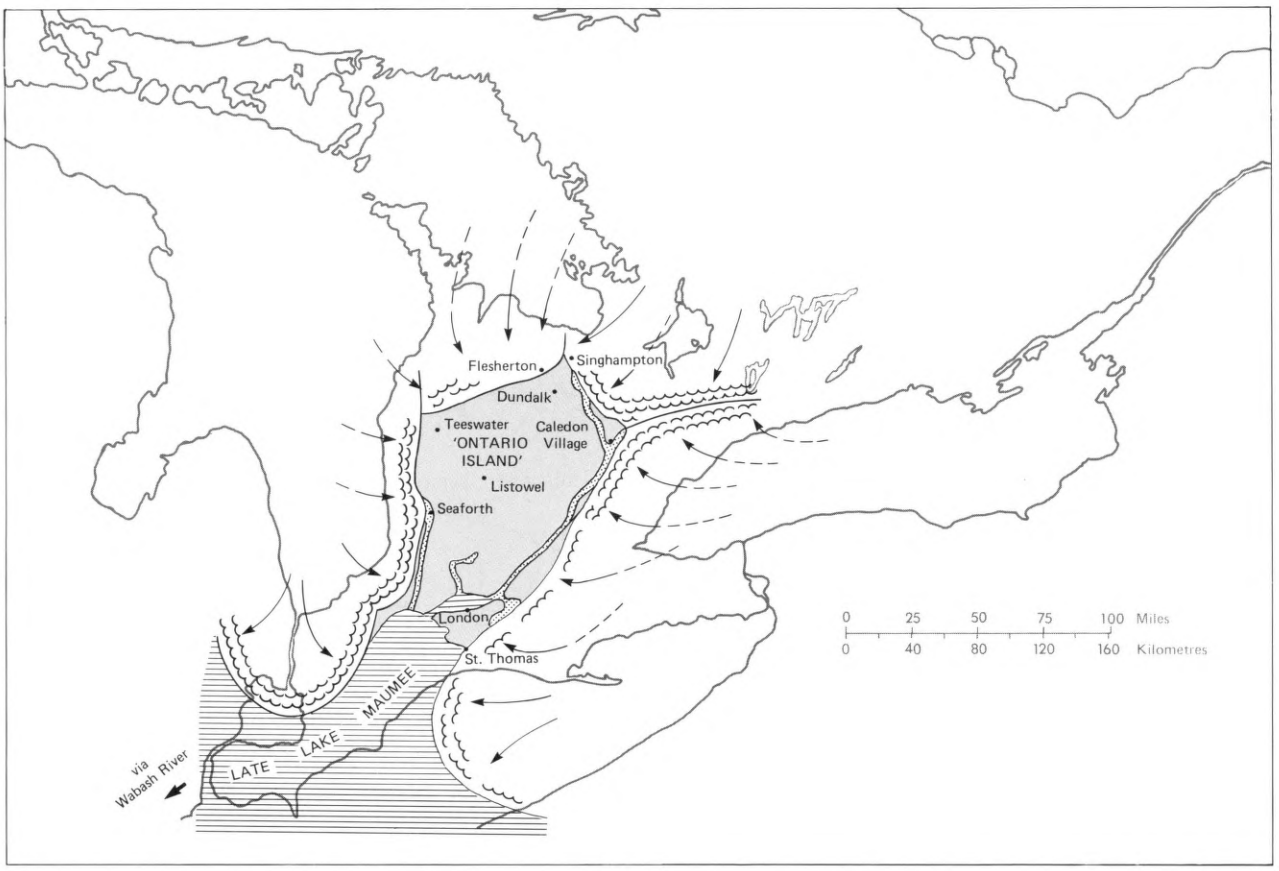


Figure 11e. Huron lobe at the Seaforth Moraine, and Ontario-Erie lobe at the St. Thomas Moraine.

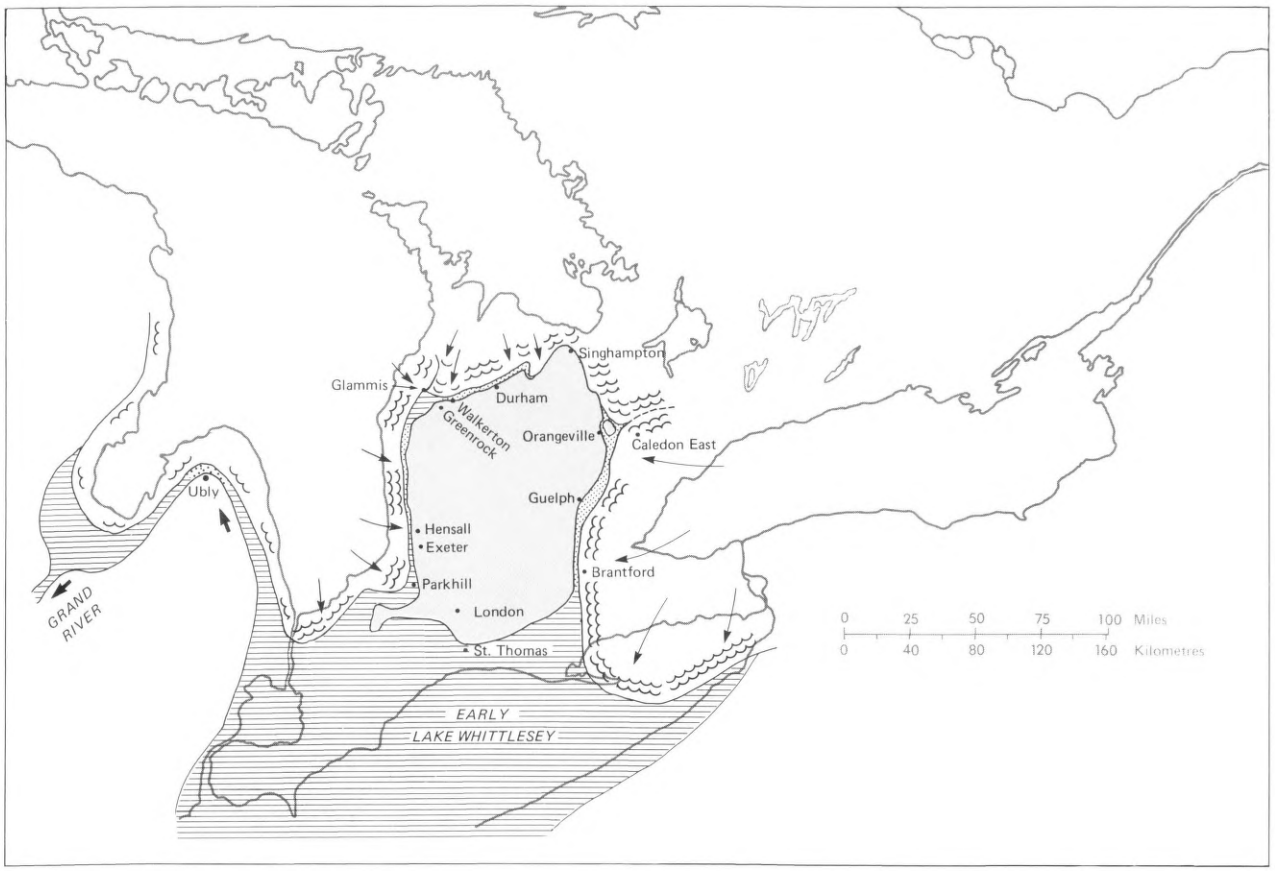


Figure 11f. Position of the ice fronts at the Port Huron Moraine system, during the early stage of Lake Whittlesey.

Figure 11g. Late stage of Lake Whittlesey, first separation of the Ontario-Erie lobe and Lake Simcoe-Kawartha Lakes lobe.

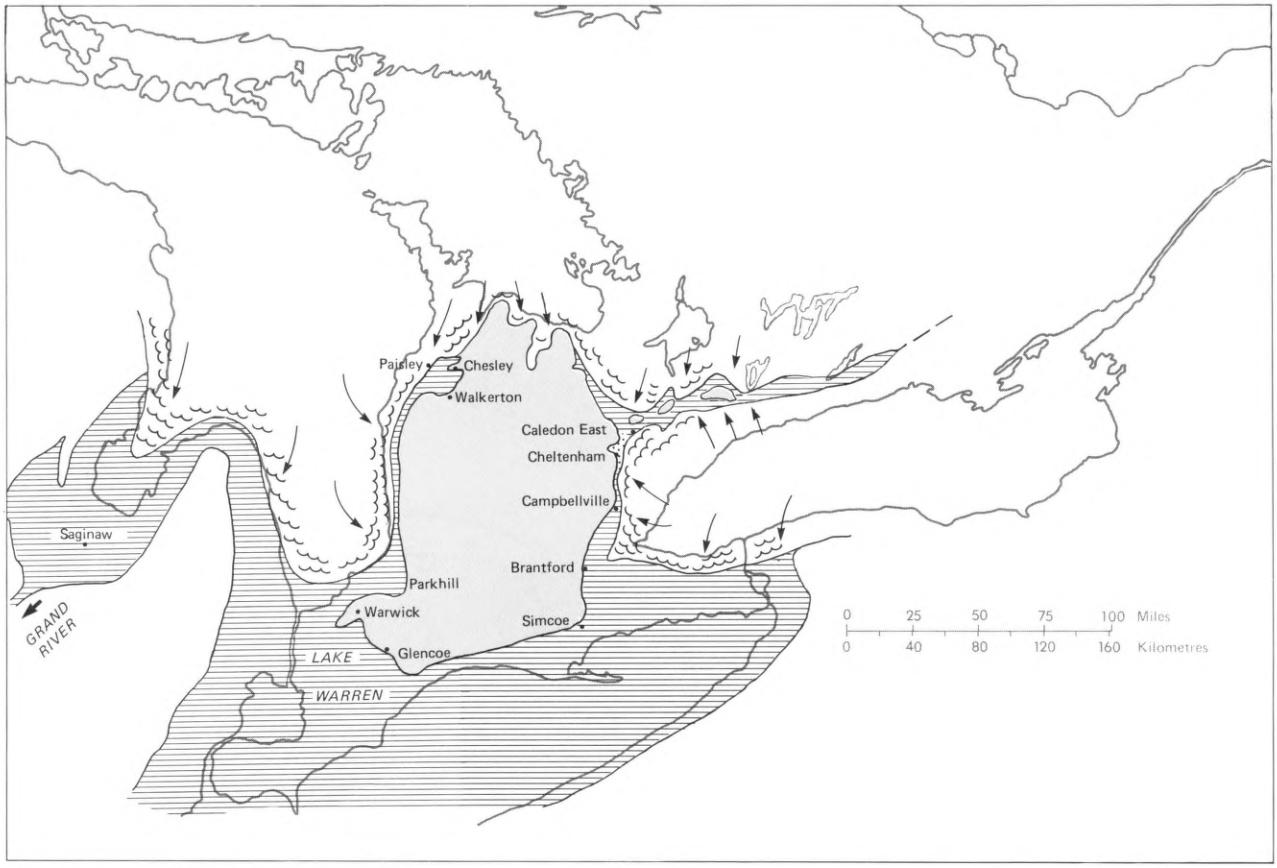


Figure 11h. Ice position at the Banks Moraine, during the time of Lake Warren.

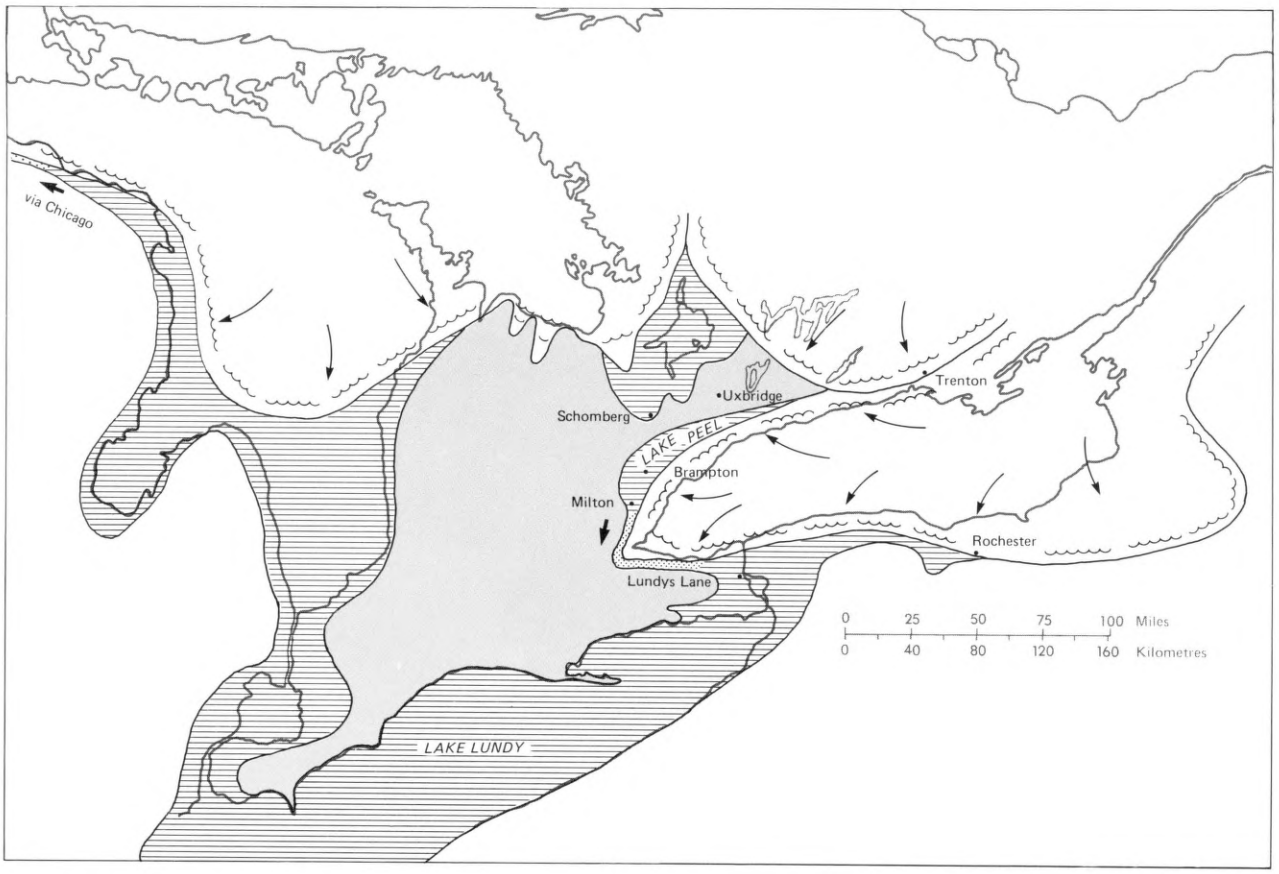


Figure 11i. Lake Lundy and Lake Peel.

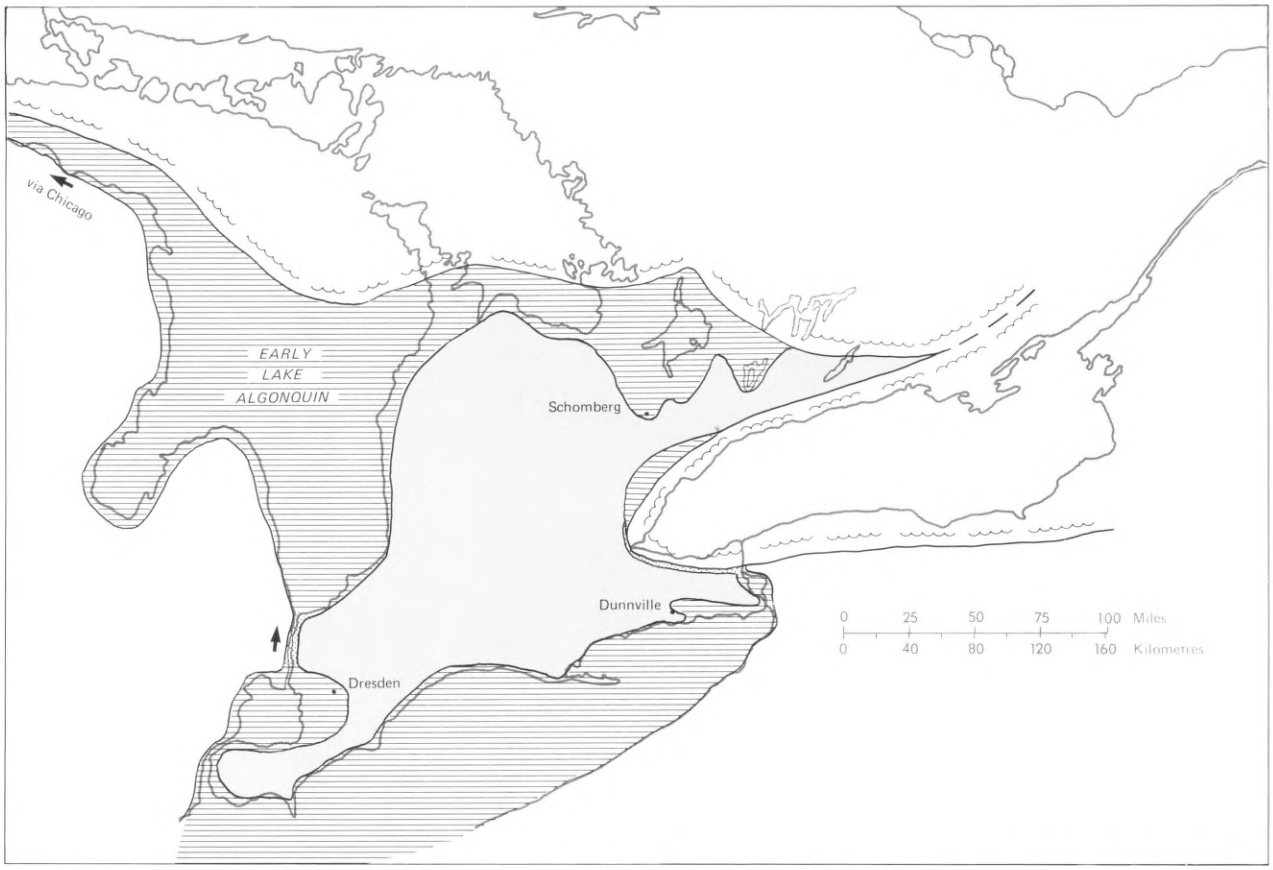


Figure 11j. Early Lake Algonquin and Lakes Dresden and Dunnville.

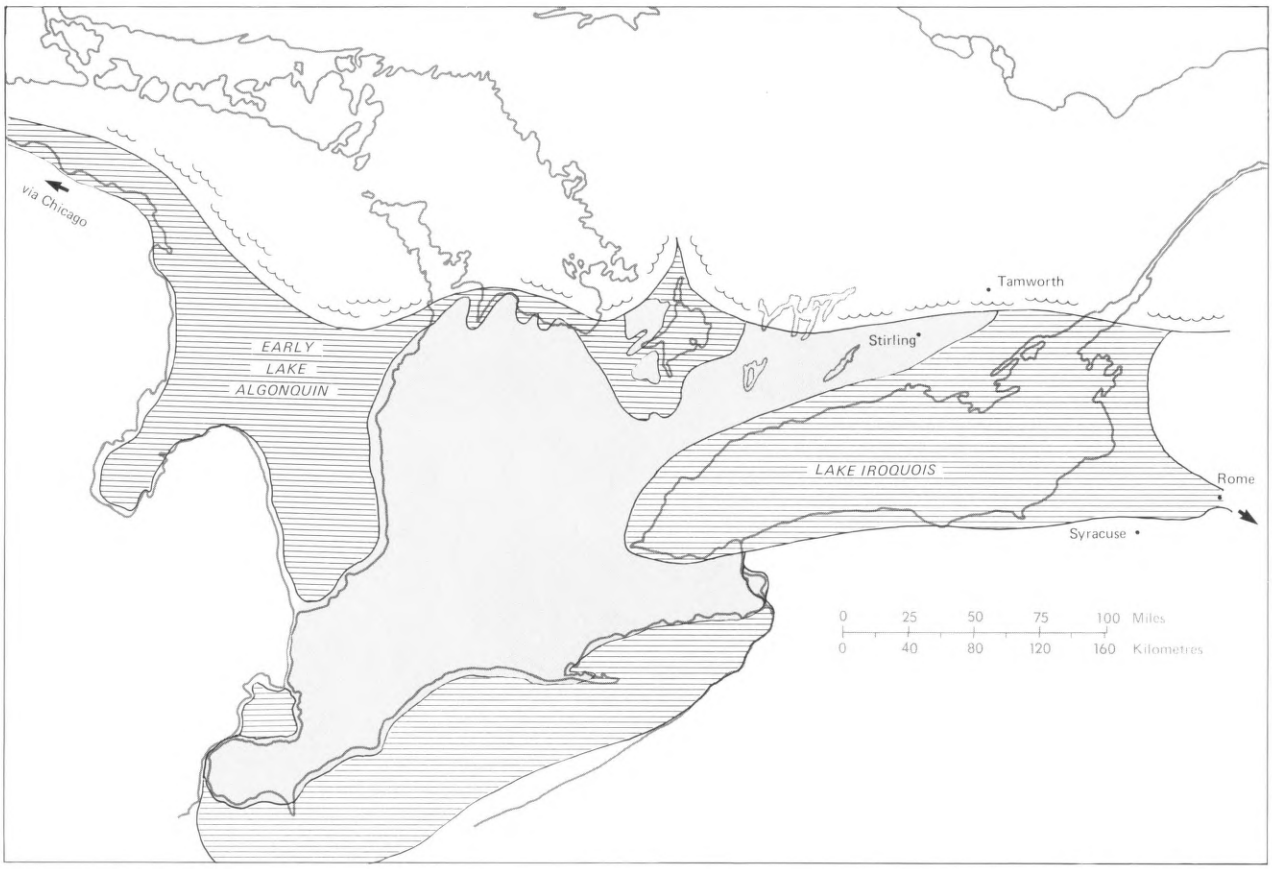


Figure 11k. Lake Iroquois.

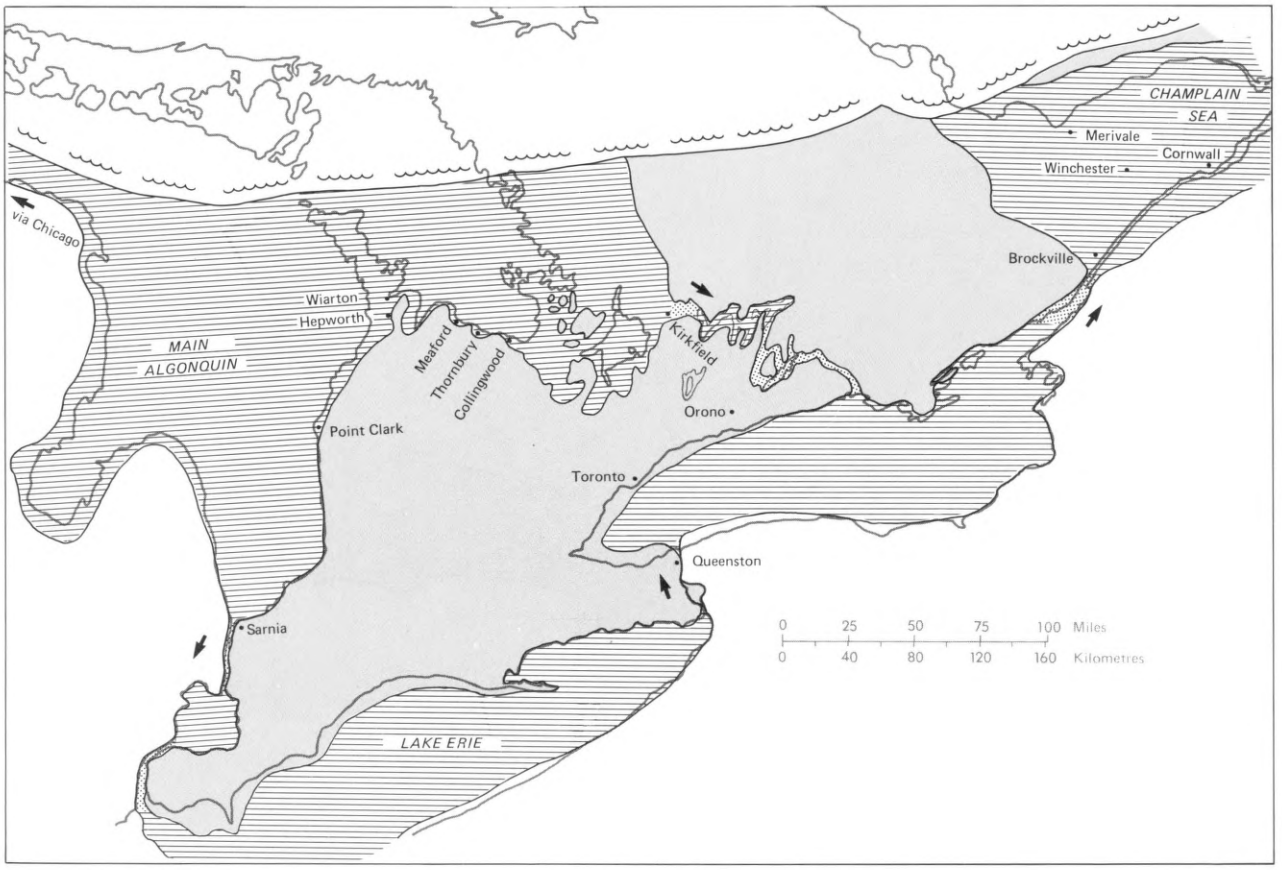


Figure 11l. Main Algonquin beach stage and the Champlain Sea.

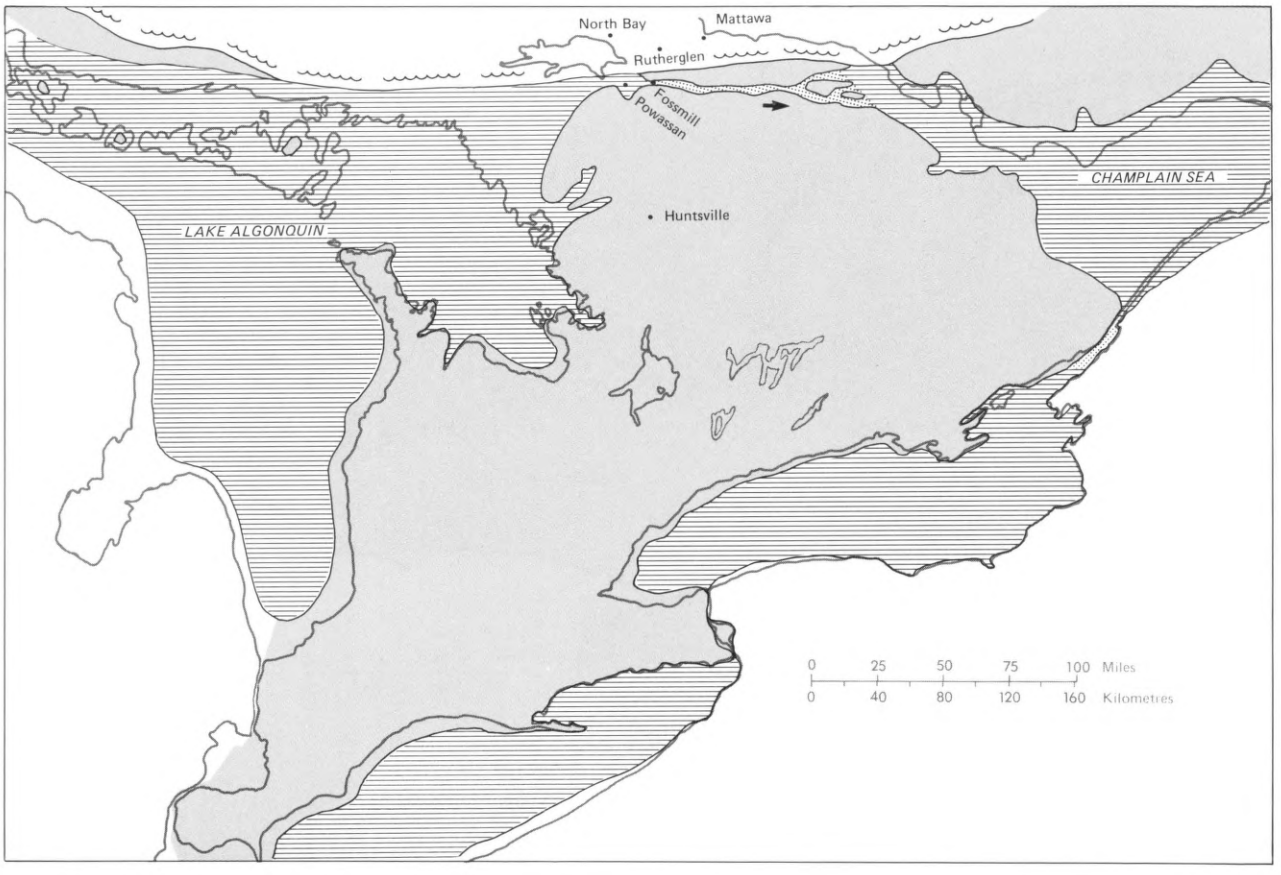


Figure 11m. Champlain Sea and the Fossmill stage of Lake Algonquin.

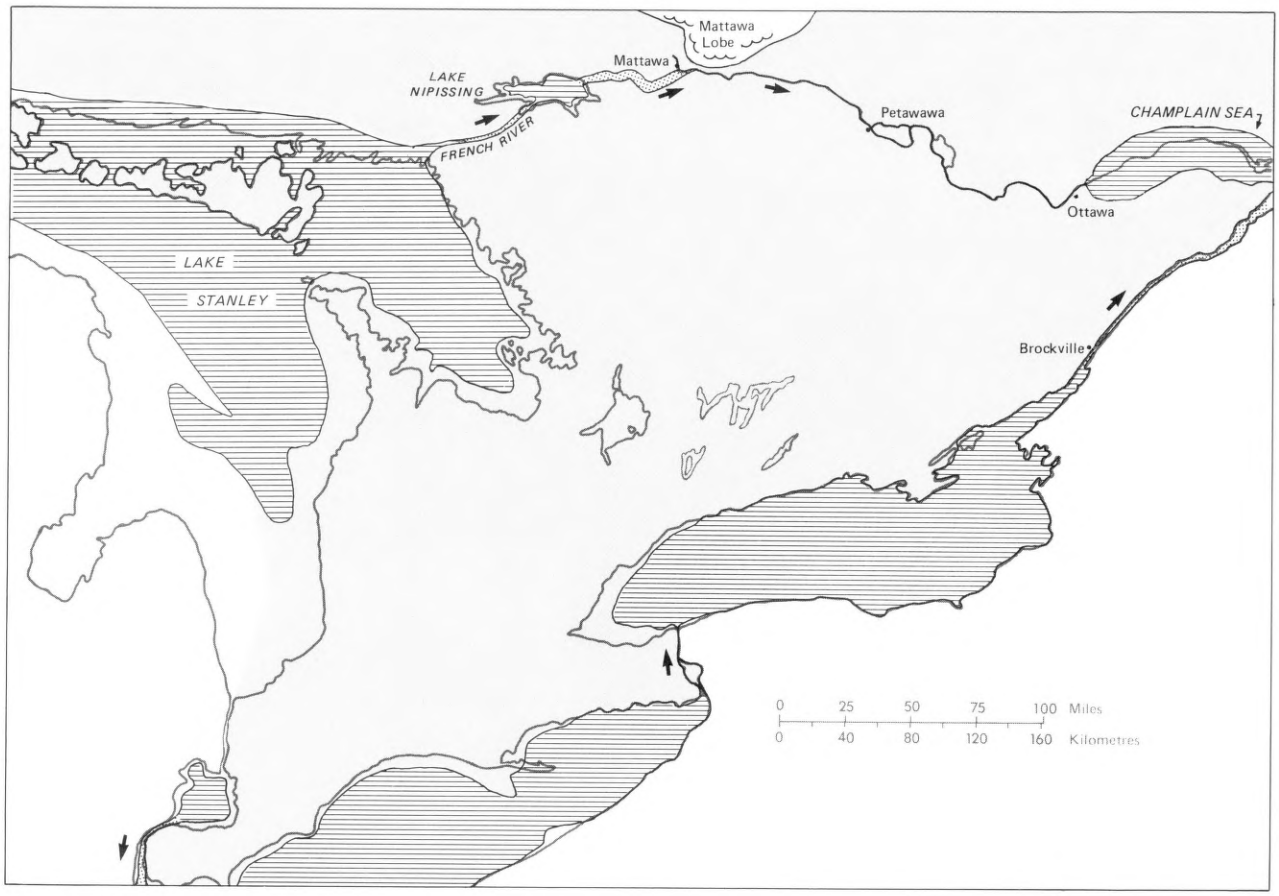


Figure 11n. Lake Stanley stage.

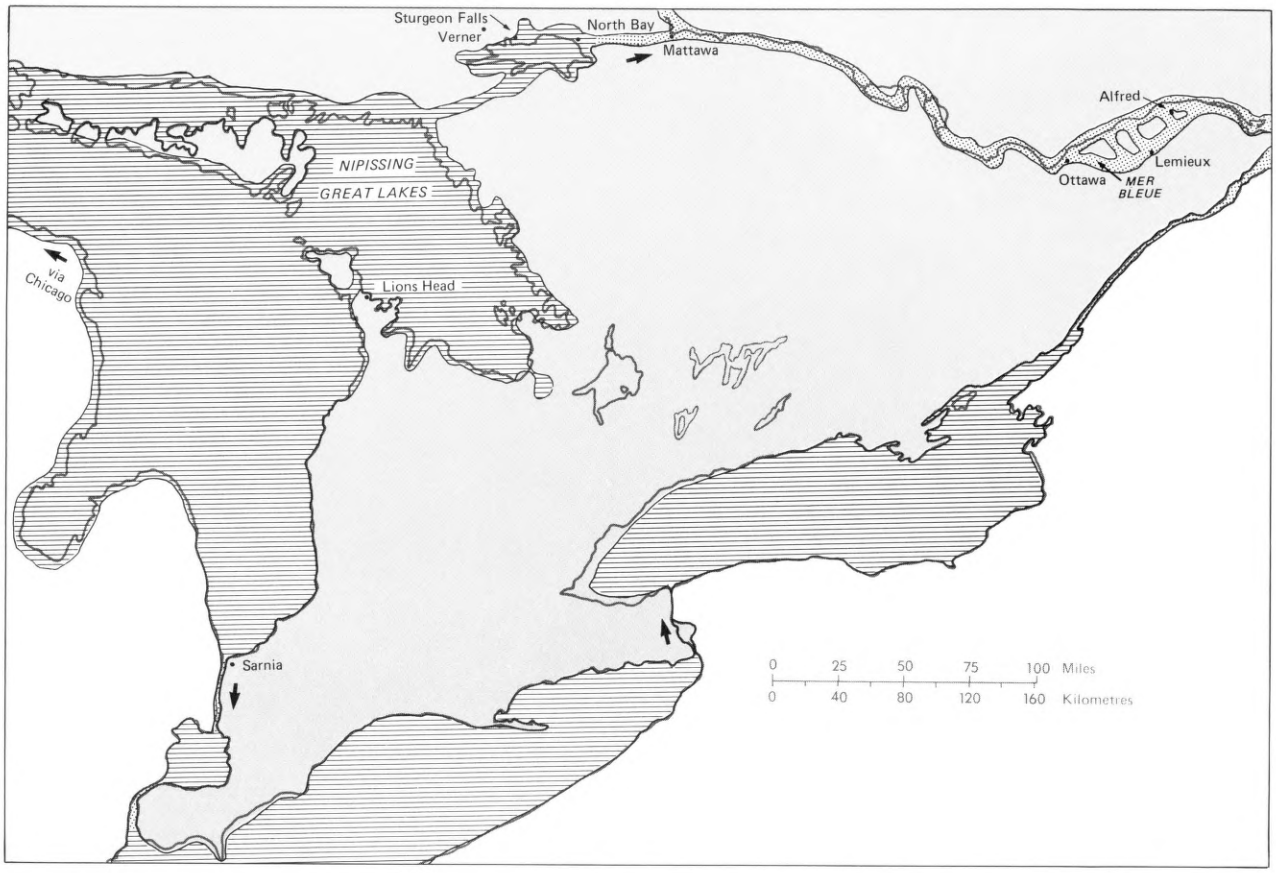


Figure 11o. Nipissing Great Lakes and drainage down the Ottawa Valley, St. Clair River, and via Chicago; also shows the cutting of channels through the delta east of Ottawa.

Grassmere level. The beach at Lundy's Lane, Niagara Falls, for which the lower lake was named, is also a shallow gravel bar capping a faint moraine. These beaches are faint and fragmentary in Ontario, indicating that these lakes were very short lived.

Figure 11i shows the Lake Ontario ice lobe blocking eastward drainage through New York State and Lake Lundy occupying the Lake Erie and southern Lake Huron basins. Drainage was westward into the Lake Michigan basin and eventually down the Mississippi River (Hough 1963). As is shown on Figure 11i, the Lake Ontario lobe stood at the Trafalgar Moraine extending from Streetsville, southwest to the Niagara Escarpment. It held a lake between the escarpment and the south slope of the Oak Ridges Moraine known as the Peel ponding or, better, Lake Peel. The varved clays deposited in this lake are shallow and weathering has destroyed the stratifications except in the deeper beds occasionally found in depressions. The clay veneer is thin on the higher ground, but even here it is usually enough to produce a Peel clay loam profile instead of the Chinguacousy profile which develops on the underlying shaley, clay till. The Credit and Humber Rivers built small deltas at 700 and 725 feet a.s.l. which mark the upper limits of this lake.

The Lake Simcoe ice lobe dammed water ahead of it against the northern flank of the Oak Ridges Moraine leaving beds of varved clay in the Schomberg area and in a series of little pondings eastwards. The varves are unusually thick, the couplets in places being four to six inches thick. The silty layers are light grey and calcareous. The position of the ice front at this stage is shown on Figure 11i overriding the Oak Ridges Moraine diagonally south of Rice Lake. The extent of the retreat before this readvance is not known and it is not certain when this overriding occurred. The drumlins on the southern slope south of Rice Lake, pointing southwestward, were built by the northern ice sheet. The limit of this advance is not clearly marked except near Trenton where a ridge of sand and gravel appears at the contact line between these drumlins and those of the Lake Ontario lobe.

Withdrawing northward from the slope south of the strait of Mackinaw in Michigan, the Huron ice lobe opened a passage between Lake Huron and Lake Michigan. At this time, as shown on Figure 11j, the Lake Ontario ice lobe still occupied much of the Lake Ontario basin, preventing eastward drainage. Drainage from the Lake Erie basin flowed northward through a channel into the Huron basin which in turn was draining via Chicago to the Mississippi River (Hough 1963). This Chicago outlet served a lake in the Michigan, southern Huron, and Georgian Bay basins called Early Lake Algonquin. It persisted while the ice front withdrew from the southern end of Georgian Bay and the lowlands to the southeast, until it cleared a channel eastward at Kirkfield to the Trent River valley. Although it seems certain that Early Lake Algonquin stood at a higher level than the Kirkfield outlet there is no traceable shoreline on the slopes south of Georgian Bay and in the lowlands of the Lake Simcoe region.

On the slopes west of Lake Simcoe and Cook Bay there are fragmentary beaches at about 825 feet a.s.l. The extensive varved clay deposits in the Schomberg area are mostly found under 850 feet a.s.l., and these provide the best evidence of submergence. Several geologists have suggested that Early Lake Algonquin dropped 40 to 100 feet when the Kirkfield outlet opened (Leverett and Taylor 1915; Johnston 1916; Crerar 1961). If the 850-foot limit of the Schomberg varved clays is taken to represent the level of Early Lake Algonquin, the drop in lake level due to the opening of the Kirkfield outlet would be well over 100 feet.

In the area east of Welland several short gravel beaches occur at altitudes of 600 to 625 feet a.s.l. They appear to mark, rather indefinitely, the limits of a lake plain into which the Grand River built a sandy delta at about 600 feet a.s.l. in the Dunnville area. This shoreline is no longer horizontal, but owing to warping of the earth's crust it rises gradually toward the north. This lake stage, as shown on Figure 11j, was related to a lake that covered the flat plain around Lake St. Clair. A low but distinct bluff or thin beach strand at 605 feet a.s.l. marks its shore from Dresden to Sombra; this is at the level of Lake Algonquin. Following Hough's (1963) interpretation, it is suggested that the drainage at this stage flowed northward through the St. Clair River channel into Early Lake Algonquin and this would explain how the St. Clair channel was cut down to the Algonquin level, a circumstance that is often overlooked or otherwise not explained.

The Lake Ontario ice lobe, in time, withdrew to the eastern end of the basin uncovering the Mohawk Valley at Rome, New York, which allowed the lake level to fall, thus initiating Lake Iroquois (Spencer 1889; Coleman 1937). The northern lobe receded nearly to the edge of the Canadian Shield in Iroquois time as shown in Figure 11k. The Dummer Moraines which represent the work of the northern lobe during this period are, however, no match for some of the earlier moraines. Moreover, they terminate abruptly just east of Tamworth and are not found in the Thousand Islands area. Judging by the strength of its shorecliffs and beaches, Lake Iroquois was much longer lived than any of the earlier glacial lakes. The Iroquois shoreline rises from 365 feet a.s.l. at Hamilton to 700 feet east of Stirling, which mostly is due to uplift since the draining of the lake. Lake Iroquois came to an end when the glacier with-

drew from the slope at Covey Hill, New York, uncovering lower outlets into the Hudson River valley. There are a few fragmentary beaches below the Iroquois beach, but nothing to equal the succession of Algonquin beaches found in the area bordering Georgian Bay.

East of Kingston the surface glacial deposits are the work of only one lobe advancing from the north with its front submerged. The ice movement is indicated by the trend of the drumlins (Figure 7) and related evidence in New York State (Clark and Karrow 1983). Lake Iroquois persisted until the glacier receded from Covey Hill in New York State, east of Cornwall, Ontario (MacClintock and Terasmae 1960). This first uncovered a col lower than the Iroquois water plane which then served as an outlet for a short-lived lake called Frontenac. It emptied into the Lake Champlain valley. Further retreat from Covey Hill allowed the water in the Lake Ontario basin to drop to the level of the outlet in the Lake Champlain valley, the lake at this level being called Lake Fort Ann. Neither of these lakes had any important effect on the surficial deposits in Ontario. Figure 11k shows the glacier occupying the St. Lawrence-Ottawa Lowland at the time of Lake Iroquois. However, we must mention that there is contrary evidence in the form of Carbon-14 dates on marine shells from the Ottawa area which indicate that the Champlain Sea had occupied that area as early as 12,800 years B.P. (Gadd 1980), which is at the time of Lake Iroquois. This would require an ice dam in the Thousand Islands area while land to the northeast in the Ottawa Valley was free of ice, an unlikely circumstance. In the upper St. Lawrence Valley marine fossils have not been found west of Brockville (Henderson 1967) but are present to the east and north. The Champlain Sea eventually covered nearly all of eastern Ontario as shown on Figures 11l and 11m. The shoreline in the west is rather indefinite as few beaches and no bluffs are found on that rocky slope.

The till ridges in the southern part of the United Counties of Stormont, Dundas, and Glengarry, and the eastern part of Leeds and Grenville lie roughly at right angles to the drumlins in the area to the north and are now interpreted as moraines built under water. The drumlins all have a south-trending alignment while in this same area a few fragmentary, sandy moraines trend roughly east. These deposits, spread out by wave action, account for the sand in southern Grenville and Dundas, near Winchester, Moose Creek, in the Merivale vicinity south of Ottawa, and many other places.

Lake Algonquin maintained contact with the ice front as it receded north of Kirkfield. It should be noted that when the Kirkfield outlet first opened, the lake level south of Kirkfield was below the Main Algonquin beach. It was not until crustal uplift had raised the Kirkfield outlet to the level of the outlets at Sarnia and Chicago that the main stage beaches and bluffs were formed (Figure 11l).

South of Point Clark the Algonquin beach is not always in evidence, having been undercut by the present lake except around the Thedford Marsh behind the sand dunes south of Grand Bend and near Sarnia where, if present, it cannot be separated from later beaches. The Main Algonquin shoreline may be traced from Point Clark to near Wiarton, around Georgian Bay to Collingwood, and then around the Nottawasaga flats and Lake Simcoe lowlands to Kirkfield. At Kirkfield the gravel beach leads to the outlet eastward toward Balsam Lake.

In the Georgian Bay area beaches are scarce. There are lacustrine clays, silts, and sands generally below beach levels of 910 feet a.s.l. at Uphill, 1,070 feet near Huntsville, 1,220 feet at South River, and 1,195 feet at Trout Creek (Goldthwait 1910; Leverett and Taylor 1915). The falling-off of beach levels at South River and Trout Creek is attributed to crustal uplift rather than the uncovering of lower outlets as there are no outlets at these levels leading eastward toward the Ottawa Valley (Chapman 1975). The first one to be found is east of Powassan, at Fossmill, leading down the valley followed by the Canadian National Railway and the Petawawa and Barron Rivers emptying into standing water west of Petawawa (Figure 11m).

The ice front of the glacier, as it receded from the Kawartha Lakes to North Bay, appears to have maintained a general east-trending alignment. However, in the Brudenel area one moraine runs along the brow of the St. Patrick scarp, indicating a tongue of ice with a southeasterly flow in the Ottawa Valley. Another exception to this is seen in the Mattawa area where a local lobe readvanced, pushing westward to the sandy moraine at Rutherglen and occupying the Ottawa Valley east of Mattawa for an undetermined distance.

The lack of any continuous moraine across the whole Algonquin region suggests an uneventful withdrawal, interrupted only by minor halts or readvances indicated by the several small, east-trending moraines found between Burk's Falls and North Bay, and Renfrew and Petawawa. The group of kames in the central part of Algonquin Provincial Park may suggest a halt in the recession at that point. According to the chronology proposed by Prest (1970) the rate of withdrawal of the ice front from Kirkfield to Fossmill is calculated to be 440 feet per year and it slowed to 112 feet per year between Fossmill and Mattawa.

Just south of Fossmill, a passage which Harrison (1972) described and named the Genesee outlet probably operated for a short period. A low saddle

in an esker in concession III, South Himsworth Township, would allow drainage eastward through low ground south of a small sandy moraine and then northward through a narrow col and eastward toward Kilrush Lake and the Petawawa River valley. A litter of boulders on the floor of this col is good evidence that it served as a drainage channel (Harrison 1972). Further recession of a mile uncovered the valley at Fossmill (as is shown on Figure 11m) which certainly served as an outlet eastward, the sill being just east of Kilrush Lake at 1,130 feet a.s.l. (Chapman 1954). North of Fossmill lacustrine deposits are not found above the level of a water plane at the Kilrush Lake altitude.

At the entrance to the outlet just west of Fossmill a gap of one-third of a mile wide is cut through the Boulter Esker. However, the sill was just east of Kilrush Lake at 1,130 feet to 1,140 feet a.s.l. (Chapman 1954; Harrison 1972). The path of the outlet is followed by the railway along a fault line through Cedar Lake, Radiant Lake, and Lake Traverse from where it split; the Petawawa River valley taking part of the flow, the remainder continuing straight on through Grand, Stratton, and St. Andrews Lakes, then down the Barron River. Both emptied into the Champlain Sea west of Petawawa and helped to build a large delta of sand having a maximum altitude of 590 feet a.s.l. The broader, quieter stretches of the spillway, as for example around the lakes, invariably contain trains of outwash, swamps, or bogs. Constrictions in the channel generally show the results of severe stream erosion in the form of bare rock walls and boulder-strewn floors. In the Grand Lake area a second channel through Greenleaf and Carcajou Lakes left a boulder pavement on the valley bottom. Between Grand and Stratton Lakes a neck of land is littered with big boulders and another boulder pavement occurs between Stratton and St. Andrews Lakes. Around High Falls at the outlet of St. Andrews Lake the bedrock is swept completely bare.

The little moraines in Chisholm Township show that the ice front there trended east and west. With the uncovering of the valley occupied in part by Sobie Lake and Guilmette Lake the sill east of the latter lake was about 15 feet below the Algonquin water plane controlled by the Kilrush sill, and drainage for a time could have passed through this valley to Kiosk and down the route of the Fossmill outlet (Prest 1970; Harrison 1972). Continuing withdrawal allowed Lake Algonquin to inundate the lower ground east of Bonfield and the Amable du Fond River valley leaving varved clay deposits up to 950 feet a.s.l.

We have assumed an east-west ice front to this point from which one would expect that continuing northward retreat would uncover a succession of progressively lower outlets across the slope south of Mattawa to the Ottawa Valley, eventually uncovering the Mattawa River Valley. However, topography or some other factors caused the ice front to become lobate, specifically with a lobe advancing westward from Mattawa, acting more or less independently from the main retreating ice mass. This relatively small lobe readvanced to the Rutherglen Moraine creating a nearly north-south ice front, and leaving a large embayment to the northwest into which lacustrine sediments around Feronia, Redbridge, and Balsam Creek were deposited. The beach at 1,177 feet a.s.l. at Cooks Mills near the North Bay airport marks the upper limit of the lake at this time.

Retreat from the Rutherglen Moraine led to drainage southward down the Amable du Fond valley and over a sill just east of Mink Lake at an elevation of 1,090 feet a.s.l. which would have allowed lake levels to drop 60 to 65 feet below the Fossmill level initiating Lake Sheguiandah of the Lower Algonquin series (Harrison 1972). Recession of the Mattawa lobe from the Rutherglen Moraine allowed the lower lands to be submerged in Calvin Township. In the Amable du Fond River area the varved clays, which provide the main evidence for submergence, are not found above the 950-foot level and the upper limits of these clays drop to 850 feet a.s.l. southeast of Mattawa. It is notable that the Papineau Esker has not been breached above 850 feet a.s.l. which led Prest (1970, p.729) to suggest that eastward drainage may have been accomplished north of the esker through subglacial drainage. In any event the Mattawa Valley eventually opened, resulting in a massive discharge of Lake Algonquin waters down the Ottawa Valley. This great river is now witnessed by scoured rocks and boulder pavements in various sections of the now-abandoned channel. The breakthrough came when the land at Mattawa was about 400 feet below the St. Clair River outlet which had held the Algonquin beach to a level of 605 feet at its southern border. This sudden drop in the level of Lake Algonquin resulted in the very low-level Lake Stanley in the Huron basin (Figure 11n) and ended the complex history of Lake Algonquin. During Lake Stanley much of the modern Huron lake bed was not submerged, but was covered with swamps. Organic material from the swamps has been radiocarbon dated at about 10,400 years B.P. (Lewis 1969). The Champlain Sea delta at Ottawa is similarly dated, so the deposition of these delta sands and the breakthrough in the Mattawa Valley are probably related. This delta originally covered 700 square miles. Since it lies below 240 feet a.s.l. there must have been very rapid isostatic uplift in Late Algonquin time.

With time, progressive isostatic rebound raised the level of the North Bay outlet and thus the Huron

basin waters, drowning the lowlands uncovered during the Lake Stanley stage. Eventually the North Bay outlet reached the same level as both the Chicago and Sarnia outlets at 605 feet a.s.l., ending the Lake Stanley stage and initiating what is known as the three-outlet phase of the Nipissing Great Lakes (Figure 11o) and it was during this stage that the strong Nipissing beaches and bluffs were formed.

The Champlain Sea had retreated eastward from Ottawa by the time of the Nipissing Great Lakes. The large sand delta east of Ottawa, however, was dissected by great flat-bottomed channels twenty to thirty feet deep and one to nine miles wide (Photo 17). There are two main channels and three cross channels cutting through sand beds into the clay below (Figure 12). They are the work of the Ottawa River when this land first rose above sea level and they resemble tidal estuaries. The river now occupies the north channel. The southern one is drained in part by Bear Creek and the South Nation River, while in two large undrained sections the Mer Bleue and Alfred peat bogs have developed. As shown on Figure 11o the cutting of these channels is attributed to the waters of the Nipissing Great Lakes. However, Carbon-14 dates (Gadd 1976) now indicate that these channels pre-date the main stage of the Nipissing Great Lakes.

The Nipissing shoreline is not well marked on the Canadian Shield but in the south the strong Nipissing bluffs and beaches were built which are generally close to the modern shore and up to 50 feet above present-day Lake Huron. The rising water levels not only facilitated the cutting of shorecliffs and the accumulation of gravel beaches, but resulted in the planing of the lake floor to a remarkably flat surface.

Around the present-day Lake Nipissing, the bed of the Nipissing Great Lakes is well represented by remarkably flat silt and clay plains commonly bordered by a small distinct bluff. Highway 17 traverses this plain east of Sturgeon Falls and in the Verner area. The sandy plain around Nipissing village can also be mentioned. Along the shore of Georgian Bay there are no large Nipissing lake plains but there are many small ones among the rock ridges.

Eventually the North Bay outlet rose above the Sarnia and Chicago outlets to create a two-outlet phase. The St. Clair River channel, being in till was eroded more rapidly than the Chicago outlet which has a rock sill, and so it eventually took over the whole discharge. With the outlet in the south, continuing uplift raised all of the land above 605 feet a.s.l. out of the water. This was the last land in Southern Ontario to be relieved of the effects of the Wisconsinan glacier. Gradually, erosion of the St. Clair River channel lowered the lake level to 595 feet a.s.l., at which point a recognizable shoreline formed. This stage, named Lake Algoma, was a final lake stage before the St. Clair channel was cut down to 580 feet a.s.l., the present-day level of Lake Huron.

It was during glacial recession, and before vegetation covered the ground, that the thin layer of silt was deposited on the surface of the till plains. It is regarded as wind-blown dust similar to the deeper loess deposits of the Mississippi Valley in the United States.

OGS 10 668

Photo 17. Stream-cut bluff near Vinette, United Counties of Prescott and Russell. The foreground is the bottom of a channel in the delta east of Ottawa.

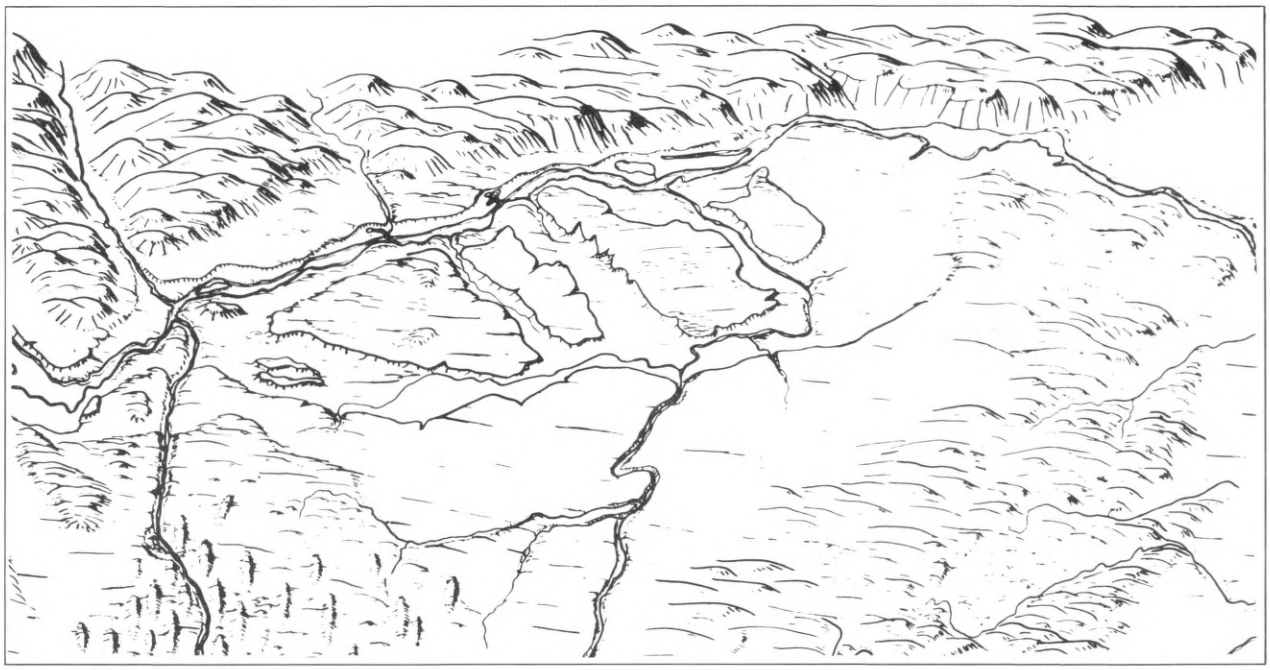


Figure 12. Physiographic drawing of the channels through the sandy delta, east of Ottawa.

POSTGLACIAL DEVELOPMENTS

Following the retreat of the glacier two processes have been operating to produce the landscapes as they appear today in Ontario. One is erosional and the other depositional. The first and the more important of the two is the cutting of river valleys, which includes the main valleys with their branches right out to the smallest gullies. These valleys and their relation to the Pleistocene deposits within the various watersheds will be dealt with in some detail later under the heading of "River Valleys".

Erosion by wind should be mentioned here also. Blowouts and sand dunes are common in deep, dry deposits of sand, but especially in lacustrine sand plains and some kame moraines. Some of the dunes are freshly made and are actively forming although this has been greatly controlled by reforestation. Most of them are old fixed dunes, long since covered by forests, with a soil profile developed at the surface.

In the wet, undrained depressions, bog plants have flourished and have accumulated, eventually to produce peat bogs. The shallower lakes are mostly filled with peat, but a central lake with peat encroaching upon it from the sides is also fairly common; the accumulation is continuing at the present time.

A peculiar and distinctive type of relief is found occasionally along the sides of the abandoned channels of the Ottawa River. It is due to mudflows (Crawford 1961). The marine clays of this area are sensitive, which means that they are very soft when wet and, under saturated conditions, landslides and mudflows sometimes occur. In the latter case the clay beds slump into a muddy "porridge" which flows to lower ground. The upper few feet of clay are more stable than lower beds, and blocks of this crust drop into the mud as it gives way beneath them and are floated away from the bank. The end result is a semicircular crater within which there are irregular concentric ribs formed by the blocks of crust tilted at various angles. In one case noted on the eastern outskirts of Ottawa and described by Crawford (1961) the mud came to rest on the floor of the old stream channel nearby. However, in most cases the material is not present on the channel floors so the flows no doubt occurred while the early Ottawa River still used the channels. The craters of these mudflows occupy several hundred acres in the United Counties of Prescott and Russell. The choppy relief is unique and cultivation of these lands is extremely difficult. Moreover, the instability of these clays close to any valley constitutes a latent serious hazard to buildings and even to life.

SURFACE FEATURES

In an earlier section a few points about the distribution and formation of moraines, drumlins, eskers, and shorelines were given to aid in the interpretation of glacial history. It is now in order to refer to Map P.2715 (back pocket) and to describe these surface features in some detail. Further details are available in the reports and maps published by the Ontario Geological Survey (Appendices A and B) and the Ontario Soil Survey (Appendix C).

MORAINES

In this section both the moraines and associated spillways are described. The features dealt with first are the Orangeville and Waterloo Moraines. They represent the first land to appear when the ice lobes separated. The Blenheim and Leamington Moraines are included here. Next, the group of clay till moraines north of London formed by the Huron lobe will be described. Then, the comparable groups south of London formed by the Erie ice lobe will be dealt with. This leaves only the Saugeen Kame Moraines and the sandy Wawanosh Moraine, the work of the Georgian Bay lobe, before describing the Port Huron Moraine system. It seems better to discuss moraines and spillways in these groups rather than in a strictly chronological order.

After dealing with the horseshoe-shaped set of Port Huron Moraines, the Banks Moraine, the Tara strands, and the Beaver Valley, Vinemount, Niagara Falls, and Fort Erie Moraines are described. The moraines of south-central Ontario, the Oak Ridges, Trafalgar, Trenton, Oro, Corn Hill, Edenvale, Mara, Dummer, and the fragmentary moraines of Eastern Ontario and the Georgian Bay-Ottawa Valley region are then discussed in that order.

In describing the moraines we built upon the well-known work of Taylor (1913), which has been a standard reference since 1913.

The boundaries of the moraines on the four miles to one inch maps usually outline the higher, more distinct crests. In some cases lower slopes and low outlying ridges which might have been included are left with the adjoining till plains.

Interlobate Moraines Built Between the Ontario-Erie and the Georgian Bay and Huron Ice Lobes

ORANGEVILLE MORAINE

This moraine was first mapped and named by Taylor (1913), but he did not regard it as an interlobate deposit formed in the first split of the ice lobes in Ontario. This conclusion was reached in 1949 (Chapman and Putnam 1949) and the interpretation was further changed by Chapman and Dell (1963) to include the extension northward to Horning's Mills and beyond. This latter section was formerly mapped as part of the Singhampton Moraine. It is clearly visible to the east of Highway 10 south of Primrose where it is over 100 feet high with an abrupt western face. It is flat topped except for occasional till ridges and consists mainly of gravel and sand. Two spurs projecting westward are made of similar glaciofluvial deposits and break the continuity of a train of shallow sandy outwash along the west flank of the moraine. The gravel in this section, as in the section south of Orangeville, includes a good deal of dull, rusty brown siltstone, while calcite is abundant in the sand fraction. In the Hillsburgh area the main component is fine sand. Thus while the Orangeville Moraine occupies an interlobate location, most of the sand and gravel was provided by the Ontario lobe. Other writers still retain Taylor's (1913) inter-

pretation that it does not represent the first split of the ice lobes, but rather a somewhat younger event (Gwyn and Cowan 1978).

At the head of the Hockley Valley there is a cluster of kames which extends into concession I of Amaranth Township. This is a usual development associated with valleys indenting the Niagara Escarpment. It is convenient to include it with this moraine, but the main extension of the moraine is two miles east of Orangeville and crosses Highway 10 one to two miles south. One very big gravel hill stands up conspicuously to the west of the highway a mile south of the town. The spillway on the eastern edge of town is a later development associated with the Singhampton Moraine.

South of Orangeville, Caledon Lake is held in position by a barrier of morainic hills to the south. This barrier appears to break the continuity of a broad channel with a gravelly and swampy floor extending through the moraine to Hillsburgh and Cedar Valley. This spillway cuts from the centre of the moraine at Caledon Lake to the southern border at Hillsburgh. The dry terraces have been cleared and cultivated, while white cedars and tamaracks remain in the swamps.

West of Belwood the moraine is reduced in size, fading to a clay till ridge near Alma particularly, but a mile or two south of that village a spillway reappears soon to be flanked by sandhills as in the Hillsburgh area. This group of kames is on the eastern side of the spillway which stops short of Floradale. The train of stream gravels continues from Floradale to Wallenstein, beyond which it disappears. A low till moraine lies east of it, meeting the Conestogo River at Hawkesville.

WATERLOO MORAINE

The Waterloo hills occupy an oblong tract west of Kitchener extending from St. Clements to Ayr. Some of the hills are kames but most are of sandy till. Sandy outwash prevails in the hollows. The topography is less rugged than on most kame moraines and the abundance of fine sand and sandy till is unusual. In these traits it resembles the Orangeville Moraine, but it lacks the accompanying spillway. It also contains more calcite than dolomite in the sand and more siltstone in the gravel.

The origin of these sandhills is puzzling. They lie near the interlobate line but extend southward between the Guelph and Woodstock drumlin fields. The modest topography and sandy till have resulted from a readvance of the Ontario-Erie lobe overriding the stratified sand and gravel.

Beyond the Nith River in North Easthope Township, the sandhills are cut through by a spillway from Lisbon through Amulree. In taking this course it cuts through high ground. The kames east of the channel stand up 100 feet or more above the adjacent plains. The higher knobs rise above 1,350 feet, and the floor of the channel is at approximately 1,175 feet a.s.l.

BLENHEIM MORAINE

This moraine was named by Taylor (1913, p.14) who wrote that "northeast of Blenheim it has a relief of 20 to 30 feet and is well defined." It is unusually wide, being nearly seven miles across at one point, and north of Duart splits into two strands. Very few kames are included but from a practical standpoint the dearth of gravel is offset by the beaches of glacial lakes. The twin Warren beaches encircle the highest section, then extend southwestward as a gravel bar on its crest through Cedar Springs to the bluff of Lake Erie where it disappears, having been undercut by the lake. It reappears a couple of miles west of Port Alma but fades out before reaching Wheatley. Without this gravel bar to set off the moraine, it would be hard to trace it south of Blenheim, which is surprising in view of its bulk east of Ridgetown. Regarding its extension westward to Leamington, Taylor (1913, p.13) wrote, "there is a low, flat, ridge hardly visible as a ridge." The interlobate nature of this moraine is highly conjectural.

LEAMINGTON MORAINE

In describing his Essex moraine, Taylor (1913, p.9) included the "high knoll west of Leamington." This stands about 100 feet above the surrounding lake plain and the highest part, north of Ruthven, is of heavy till. The shoulders and sides are mantled by gravelly beaches of Lakes Whittlesey and Warren. The interlobate aspects of this feature are not well known and it may well prove to be an Erie lobe feature.

The Essex Moraine was originally described as "a low, broad ridge of till, very smooth and with such gentle side slopes as to be quite inconspicuous to the eye as a ridge" by Taylor (1913, p.9). Although the gravel bar along its crest was not mentioned, it was later mapped as a Grassmere storm beach (Leverett and Taylor 1915). In fact it is the beach that provides most of the relief. Following the rule of mapping only moraines that can be distinguished in the field, we have omitted the Essex moraine, except the fragment at Leamington. The "occasional very low, stony knolls of till" (Taylor 1913, p.13) of the Kingsville boulder belt are also omitted because they are so scattered.

Moraines of the Huron Ice Lobe North of London

This section describes the principal pre-Port Huron

end moraines northwest of London, notably the Milverton, Mitchell, Lucan, and Seaforth Moraines. In addition to these there are lesser moraines known as the Dublin Moraine, a low ridge trending south just west of Dublin, and the Centralia Moraine which trends south through Centralia (Karrow 1977). Between Stratford and Tavistock three faint moraines of heavy till cross the smooth till plain. South of the Perth County border along Trout Creek and around Lakeside is another fragment like that in North Easthope Township, with kames and till intermingled. The Cobble hills on the Middlesex-Oxford line are an isolated group of kames now considered to be the work of the northern ice lobe.

MILVERTON MORAINE

Taylor's (1913, p.11) description of the Milverton Moraine, "a slender, lightly built moraine, rather narrow but quite well defined, its relief being generally 20 to 30 feet, sometimes 50 feet" needs no amplification. The material in it is a pale brown calcareous clay till with only a light sprinkling of pebbles and boulders included. Moreover it contains very little sand. No doubt the colour is given by the brown limestone which underlies this area. Despite considerable variation in texture and stoniness, the foregoing describes all the silty clay till which is common to a broad belt east of Lake Huron.

From Fullarton village, where it contacts the Mitchell Moraine, the Milverton Moraine crosses a till plain of little relief ending east of Listowel. North of that point there is a smooth till plain scored by flutings trending southward, the work of the Georgian Bay ice lobe. This type of plain extends south of Atwood while south of Monkton the faint knoll-and-sag type of relief appears instead. The fluted till is more stony and gritty than the silty clay till of the Huron lobe.

Drainage from the northern section of the Milverton Moraine went down the Nith Valley, while the remaining part flowed toward the Thames Valley but left no definite channel. The moraine serves as a dam to prevent westward drainage of the Ellice swamp. Stratified silt, sand, and clay appear on the margin of this bog.

MITCHELL MORAINE

The Mitchell Moraine is a single strand of heavy till like the Milverton Moraine. It is well defined from Walton to Brodhagen, Mitchell, Bannock, and Prospect Hill and is crossed by Highway 7 just east of Elginfield. A couple of miles beyond, it comes to an abrupt end where it is overridden by the Lucan Moraine. At the northern extremity it comes to a rather indefinite ending two or three miles north of Walton. Actually it appears to curve westward to Blyth, losing its identity in the moraine west of that village. The kames west of Brussels are not part of it as they are set on the drumlinized till of the Georgian Bay lobe.

From Mitchell southward a spillway, now followed by the Thames, runs along the front of the moraine ending near Thorndale. North of Brodhagen the flat and occasionally swampy nature of the terrain and the presence of stratified sediments indicate temporary ponding of water on the lower land east of the moraine.

LUCAN MORAINE

The third in the series north of London, this moraine can be traced from the townline of Caradoc through Lobo, Ilderton, Lucan, and Woodham, north of which it is fragmentary. The ridge passing two miles east of Staffa, curving northwestward to Kinburn (Constance), may be its extension or the product of a slightly earlier thrust. Another possible correlative is the ridge north of Farquhar which fades out west of Cromarty.

When the ice front was at the Lucan Moraine, drainage flowed past Elginfield and down the Medway River. Beginning near Cromarty two or three shallow troughs extend to Kirkton, the more westerly one being without streams in two separate sections. The most pronounced channel occurs between Granton and Elginfield where a broad valley over half a mile wide is covered with stratified sand and silt. It is rather odd that the present drainage does not continue down the spillway as an extended Medway River. The break through the Mitchell Moraine near Prospect Hill and the capture of the upper reaches of the Medway Valley by Fish Creek appear to be later developments.

SEAFORTH MORAINE

As Taylor (1913, p.11) expressed it, the Seaforth Moraine "is somewhat stronger and more bulky than the three preceding it." South of Blyth it consists of brown clay till like the others. All these moraines have a general height of approximately 50 feet and the knoll-and-kettle topography is not too rough to prevent the clearing and cultivation of the land. The southern reaches of the Seaforth Moraine, beyond Watford where the ice front was under water, are too faint to be mapped. From Watford a broad ridge extends toward Arkona. Just south of that village it doubles sharply to skirt the south side of the Ausable River valley, sweeping gradually around to the north until it is crossed by Highway 4 east of Clandeboye. For a few miles south of Seaforth it is weak but elsewhere it is stronger. South of Blyth it ends amid a cluster of kames in the southern extension of the Wawanosh Moraine.

Glacial drainage failed to produce a definite

channel in front of the Seaforth Moraine north of Hurondale. South of that hamlet a continuous shallow trough, now followed by tributaries of the Ausable, lies on its eastern flank. It is present in best form between Denfield and Lucan Crossing. There is some doubt about where this spillway met glacial Lake Maumee. The delta at Coldstream and Poplar Hill appears to be the highest point where there is definite evidence of standing water. However, we examined the bedding and pebbles in a gravel pit near Denfield (lot 31, concession XV, London Township), and found well-rounded, evenly sorted pebbles, like beach gravel. On similar evidence Taylor (1913) suggested that the lake extended as far north as Exeter.

Moraines of the Erie Ice Lobe South of London

Between London and Tillsonburg there are several moraines similar in form and composition to those north of London. Although they are distinct ridges (Photo 18) they never attain the height or ruggedness of the more sandy and bouldery moraines between Paris and Caledon Village. They all fade out toward the southwest where the Erie lobe was under the water of glacial lakes. The greyish brown, silty clay in these ridges is similar to that found in the moraines north of London. The predominant pebbles are of pale brown or brownish grey cherty limestone from the underlying formation while Precambrian "greenstones" and conglomerates are common.

In addition to the major moraines described below there is a lesser feature trending southwesterly through Courtland, the Courtland Moraine, and a second one, largely buried beneath the Norfolk sand plain, trending southwesterly at Mabee (Mabee's Corners), the Mabee Moraine (Barnett 1982).

INGERSOLL MORAINE

This moraine, the first south of the Thames River, does not touch the Town of Ingersoll but swings away from the river along the southern boundary of Zorra Township. It skirts a group of drumlins, then turns northward to the river again east of Woodstock crossing Highway 2 three or four miles east of the city. West of Woodstock it is of silty clay till with a few kames while its extension, found in the disconnected morainic hills between Woodstock and the Nith River, consists of loose, loamy, or sandy till.

The great Thames spillway carried the drainage when the glacier stood at the Ingersoll Moraine and while at least two later moraines were being constructed. It is a broad channel cut to bedrock, having a depth of 75 to 100 feet. Gravel terraces between Thamesford and London were left by the same stream and are present in the bottom of the channel farther north. A few miles north of Woodstock the deep channel ends, but a wide train of sand and gravel can be followed over the low divide into the Grand River basin. A deep channel appears again at Plattsville continuing toward Ayr along the course of the Nith River. From Ayr northward to Blair and Preston (part of the City of Cambridge), it is a swampy trough drained only by small brooks and at Blair it contacts the great gravel terraces in front of the Paris Moraine.

OGS 10 669

Photo 18. Clay till moraine south of Woodstock. The crest of this smooth moraine is on the skyline.

WESTMINSTER MORAINE

The Westminster Moraine is separated from the Ingersoll by Dingman Creek. Similar in form and composition, it is a clay ridge approximately 50 feet high and a mile and a half wide. In diminished form it can be identified where it crosses the Talbot Road midway between Lambeth and Talbotville Royal. From there eastward it grows larger to a point near Crampton where it meets the spillway that heads toward the Thames at Putnam, and beyond that it cannot be identified.

Dingman Creek from Derwent to Lambeth drains a broad valley floored with clay, silt, and sand or gravel. These sediments relate to a late stage of Lake Maumee.

ST. THOMAS MORAINE

The St. Thomas Moraine is the strongest moraine of the series between London and Tillsonburg and extends for 60 miles from Wallacetown to Eastwood. South of St. Thomas it was built by a submerged ice front, but nevertheless, it is prominent and includes more gravel than usual as far as Wallacetown, where it dwindles rapidly and disappears under stratified clay and silt. At St. Thomas a gap occurs in the ridge so that in a sense the selection of that name for the moraine is questionable. A happier choice would have been Mount Elgin, after the little village that perches on the moraine where it is best developed. At Burgessville the moraine touches the Ingersoll Moraine, parting from it again at Oxford Centre and running as a separate strand toward Drumbo where it becomes buried under outwash sands. Beyond the Grand River it shares the fate of the other members of this series in being merged with or overridden by the Paris Moraine.

The upper reaches of Kettle Creek and Reynolds Creek follow glacial drainage channels in front of the St. Thomas Moraine. These channels are marked by deposition rather than erosion, the broad valley being lined with silt or, less extensively, with sand and gravel.

NORWICH MORAINE

Between the St. Thomas and Tillsonburg Moraines is another which may be named after the village of Norwich. In the southwest it splits into two narrow strands separated by a branch of Catfish Creek. At Lyons they lie within a mile and a quarter of each other. At Norwich and New Durham it is a distinct continuous ridge, while between Cathcart and Cambridge (Galt) there are only disconnected segments separated by sand and gravel beds.

TILLSONBURG MORAINE

The fifth moraine southeast of London passes through Tillsonburg and that name was applied to it by Taylor (1913). When building this moraine the glacier was washed by the water of Lake Whittlesey south of Tillsonburg. The sands and gravels at Otterville were deposited by ice-border drainage. Southward, delta sands bury the moraine completely in several stretches between Tillsonburg and Sparta. For about five miles west of Sparta there appears, oddly enough, an isolated ridge over 100 feet high while its only traces west of Kettle Creek are in the form of a few knobs of clay till between Union and Fingal.

From Tillsonburg the moraine can be traced northward to the outskirts of Ayr, beyond which its identity is lost in the gravelly hills west of Cambridge (Galt). This moraine is well marked by contours on the National Topographic System map sheets of Tillsonburg (NTS 40 I/15), Brantford (NTS 40 P/1), and Cambridge (NTS 40 P/8). The Nith River has cut a wide gap through it west of Paris.

Sandy Moraines of the Georgian Bay Ice Lobe

SAUGEEN KAME MORAINES

Within the Saugeen drainage basin between Wingham and Flesherton the Georgian Bay lobe left scattered groups of kames within a drumlin field. Quite often these sandhills are found along the shoulders of the river valleys. Associated with them are great quantities of coarse pitted outwash. The Holstein vicinity is almost covered by gravel terraces at several levels, which altogether occupy an extensive area. The Saugeen Kames exhibit some of our roughest morainic topography and consist of unusually coarse material. Some authors have suggested that these kames may correlate with the Singhampton Moraine (Sharpe 1978; Feenstra 1975).

WAWANOSH MORAINE

From Clinton northward through East and West Wawanosh Townships and past Langside there is a morainic belt about five miles wide. It is a complex of low glacial till ridges and hills of sand and gravel in which the gravelly knobs invariably stand up as the highest peaks at 1,050 to 1,100 feet, while the less rugged parts of the moraine are generally of silty till. The kames are concentrated in the north and the south. In West Wawanosh Township there is mostly clay till, as in the Wyoming Moraine adjacent on the west. Along its eastern border this moraine merges almost imperceptibly with the drumlinized till plain.

The gravel trains and sandy outwash common to the depressions of that plain continue right to the moraine.

The stratigraphy of the Wawanosh Moraine and the lobate configuration of the Mitchell Moraine have suggested to modern workers (Cooper *et al.* 1977; Cowan *et al.* in preparation) that the Wawanosh Moraine was formed in an interlobate position between the Georgian Bay and Huron lobes and was subsequently overridden by the Huron lobe.

Port Huron Moraine System

The result of a strong readvance following a poorly defined retreat, the Port Huron Moraines are strongly developed in Ontario and Michigan. Thus, they serve as a marker at one important stage in the recession of the last glacier. In Ontario they consist of the Wyoming, Singhampton, Gibraltar, Paris, Galt, Waterdown, and Crystal Beach Moraines. The correlation of penecontemporaneous glacial events over such a long distance is not without controversy. Interested readers should consult Barnett (1979b), Cowan *et al.* (1978), Feenstra (1975), Sharpe (1977, 1978), Sharpe and Edwards (1979), and Gwyn and Cowan (1978) for additional discussion.

WYOMING MORAINE

The Wyoming Moraine on the eastern side of Lake Huron is the correlative of the Port Huron Moraine in Michigan. Consisting of clay till like the several moraines before it, it was originally described by Taylor (1913, p.12) as "one of the strongest moraines of the series."

From Ailsa Craig southward, the Wyoming Moraine was built into the waters of Lake Whittlesey and forms a single broad ridge which fades out four miles west of Wyoming. From Ailsa Craig northward to the Bayfield River there are two strands lying close together with a big spillway to the east and a smaller one between them (Photo 19). The main spillway splits north of Zurich and passes on both sides of the modest ridge on which Hills Green is situated. This ridge and Taylor's (1913) Clinton Moraine, which lies on the east side of the spillway from Brucefield to the Maitland River, might well be regarded as part of the Wyoming Moraine, although doubtless they are the result of earlier thrusts of the glacier. From Goderich to Lucknow one main strand can be identified and it is broken by a gap at the Lucknow River. In addition the spillway south of Lucknow is divided by short morainic ridges in several places. On the western slope of the moraine, glacial drainage left small channels and intermittent gravel trains which provided some of the gravel for the beaches of Lake Warren.

North of Lucknow the moraine is broad with two crests usually in evidence. It lies west of the Greenock Swamp and contacts the Singhampton Moraine north of Glammis in a cluster of kames. The moraine is not in evidence north of Glammis but the brown clayey till associated with the Huron lobe continues to beyond Paisley (Sharpe and Edwards 1979) where it contacts the Gibraltar Moraine.

As indicated on our maps the southern part of Taylor's (1913) Goderich moraine is regarded as the continuation of the Wyoming Moraine, therefore, the former name is dropped. The section on the brow of the Blue Mountain and its extensions is given the name of Banks. Thus the Banks Moraine becomes the third of a group including the Singhampton and Gibraltar Moraines. We do not consider Taylor's (1913) Kincardine moraines definite enough to be mapped. Finally, there is no moraine between Port Elgin and Hepworth. In his cursory survey of this area Taylor (1913) apparently failed to recognize the drumlins. The two bits of moraines shown on his map east of Owen Sound are also drumlins.

SINGHAMPTON MORAINE

The northern limb of the Port Huron Moraine system in Ontario runs through rough stony land and is composed of loose stony loam in which dolostone predominates. It is a single-crested till ridge running across the drumlinized plain. Kames appear at frequent intervals. Between Kinghurst and Berkeley the adjacent terrain is very rough, making it difficult to segregate the moraine. The kames west of Flesherton (Photo 20) are not included in this moraine.

From Singhampton to Caledon Village this moraine lies on the brow of the Niagara cuesta, although broken by the larger re-entrants in the escarpment. It is fragmentary from Singhampton to Maple Valley, then gains prominence past Honeywood. South of Hornings Mills this moraine shifts to

OGS 10 670

Photo 19. Wyoming Moraine near Hensall, Huron County, showing the poorer bean crop on the eroded clay knolls.

the east and combines with the Gibraltar Moraine to form the massive ridge east of the Violet Hill spillway (Photo 21). Between Orangeville and Caledon Village several drumlins of the Guelph group lie to the west of it; apparently that area had been moulded by the Ontario-Erie lobe before the moraine was built. The thrust which built the moraine advanced onto the sides of these drumlins.

Glacial drainage in front of the Singhampton Moraine flowed both west and south from Singhampton, gaining volume as it progressed. Along the eastern arm a great gravel train appears south of the Pine River valley. North and south of the Hockley road it consists of outwash sand and gravel beds and these continue to Orangeville where they provide level ground for the racetrack and fair grounds. There also, the Orangeville Reservoir is dammed on the bottom of the old spillway. It is a swampy flat-bottomed depression across the eastern approaches to the town. From there it extends down the path of the Credit River to Cataract. West of Singhampton the meltwaters eroded a small channel near Flesherton and, south of that town, entered shallow catch basins from which they escaped down the Saugeen Valley. The big gravel pit at Durham is in this spillway, and gravel trains lead into it from the north. From Allan Park to Hanover the terrace is unusually broad and continuous. Being more confined in the Walkerton area the drainage carved distinct valleys which now contain cedar swamps. Two main and two minor routes were used to reach the Greenock Swamp, judging by the evidences of stream action. The Greenock Swamp and the surrounding land is floored with silt and fine sand. No doubt it held standing water when this spillway was active.

GIBRALTAR MORAINE

This moraine lies behind the Singhampton and is similar but slightly weaker. West of Chesley it was built by a submerged ice front and as a result is reduced in height and is relatively smooth. Its crest stands at about 900 feet a.s.l. East of Chesley the moraine becomes rough and bouldery like the Singhampton Moraine. As far east as Williamsford an abundance of coarse outwash appears along its southern flank and several shallow lakes or ponds appear amid this sand and gravel. In Holland and Euphrasia Townships, where the overburden is thin, the drift is rocky and the surface is not smoothed. Here, the separation of the moraines from the till plains is no easy matter. East of the Beaver Valley, the intervening till plain is also rocky and uneven, while the moraine itself stands out between Lady Bank and Gibraltar. Precambrian boulders are numerous on the brow of the escarpment in this area. At Gibraltar the moraine lies on ground above 1,700 feet, while at Paisley the altitude is only 900 feet a.s.l.

The eastern arm of the Gibraltar Moraine is intimately associated with the main terraces of sand and gravel on the face of the escarpment. These may

OGS 10 671

Photo 20. Rugged kame moraine at the head of the Beaver Valley, near Flesherton. Photo courtesy of M.B. McLeod.

be seen in splendid form on the Dufferin County line at Lavender, between Whitfield and Perm, or on any side road in Mono Township. They are particularly well displayed at Violet Hill where Photo 21 was taken. The moraine itself includes a good deal of sand. The till is coarse in texture and is strongly influenced by red shale and sandstone derived from nearby sources. Just north of Mono Mills the gravel terrace is above the escarpment but it falls below again from that hamlet to Sleswick.

PARIS MORAINE

Taylor's (1913) original Paris Moraine included an extension from Caledon Village to Gibraltar. In this account the name will be applied only to the section south of Caledon Village which was built by the Ontario-Erie ice lobe.

From Acton to Cambridge (Galt) it is a high bouldery ridge. At or near Paris this moraine was waterlaid and it becomes steadily fainter toward Lake Erie. As noted by Taylor (1913, p.14) "it is still a sharply defined ridge at Scotland, but is weaker at Vanessa and is quite faint east of Delhi. Farther south it is scarcely perceptible as a ridge, but exerts some control over minor drainage." Taylor's (1913) mapping projected this moraine east of Big Creek toward Port Burwell. However, west of that course the sandy till that comes to the surface between Langton and Carholme may be a segment of the moraine which barely escaped burial by sand.

The Paris Moraine differs in composition from those just described. South of Paris it is sandy and to the north it consists of loose bouldery loam including considerable coarse outwash, the material being mostly dolostone from the Niagara cuesta. Towards Caledon Village an admixture of red shale is visible. The prominence of the moraine is reduced south of Paris because it is partly buried by stratified sand. North of Delhi the waves of Lake Whittlesey built gravel bars on selected sites.

The work of the running water that drained along the ice front during this stage is no less impressive than the work of the glacier itself. The spillway from Caledon Village to Brantford is unsurpassed in southwestern Ontario. Broad gravel terraces, often at two or more levels with swampy stretches in the lowest one, can be traced all the way. From Erin to the brow of the escarpment the Credit River now occupies the old valley. Near Brisbane for a short distance there is no stream in it, then the Eramosa River takes possession until it meets the Speed River at Guelph, which in turn gives way to the Grand River at Cambridge (Preston). From Highway 7 the spillway can be seen where it passes through the farm of the Ontario Correctional Centre at Guelph. Nearby on the Cutten Fields golf course the gravel terraces are well displayed and a stream-cut bluff diagonally truncates the end of "College Hill".

GALT MORAINE

The Galt Moraine lies just behind the Paris Moraine and never far from it except in the extreme south. At the southern boundary of Brant County they are less than two miles apart while the distance between them from Simcoe to Delhi is ten miles. South and east of Guelph, in several places, the two come together producing a broad composite moraine. The Galt Moraine passes south of Acton, crosses Highway 7 two miles east of that town, and extends in diminishing strength toward the escarpment, fading out north of Limehouse.

The Galt Moraine is similar in form and composition to the Paris Moraine. It is a rugged stony ridge of loose loamy till north of Brantford and a

OGS 10 672

Photo 21. Spillway at Violet Hill, Dufferin County. The treed areas in the broad channel are cedar swamps.

smoother sandier ridge from Brantford to Simcoe. South of Acton several drumlins appear in intimate association with the moraine. Kames occur quite frequently.

The glacial drainage broke through the Paris Moraine at Eden Mills and followed the earlier spillway to Paris leaving only local drainage to pass along the Galt Moraine. These spillways are marked by gravel terraces rather than by deep channels.

East of the Galt Moraine another smaller moraine extends through Moffat, and was named after that village by Karrow (1963). The first strands of the Waterdown Moraines probably belong to the Port Huron Moraine system. They lie about two miles away from the edge of the Niagara Escarpment and extend from the Kilbride vicinity to the kames at the tip of the Dundas Valley. To the south and then east there is no moraine to mark the continuation of the ice front at this stage until Mohawk Bay, where there are morainic ridges which may be related.

Moraines Behind the Gibraltar and Galt Moraines

BANKS MORAINE

The Banks Moraine is not quite as well developed as the Singhampton and Gibraltar Moraines; otherwise it is similar. At the crossroads village of Banks it lies on the very crest of the Blue Mountain, making a sharp bend at that point. Three or four of the knobs rise over 1,700 feet a.s.l. or 1,120 feet above Georgian Bay. To the west this moraine holds a position on the edge of the escarpment to Walters Falls or Massie with a gap at the Beaver Valley. The moraine is distinct from Banks to Duncan even though the adjoining plain is rocky and uneven. North of Kolapore and near Duncan the moraine splits, part of it dropping below the edge of the escarpment to form little valley moraines across re-entrants. West of the Beaver Valley the whole promontory east of Walters Falls is best classed as a morainic complex; in fact the Banks and Gibraltar Moraines coalesce through Holland and most of Sullivan Townships. However, the little valley moraines east of Massie are looked upon as part of the Banks Moraine. In Elderslie Township the two are distinct, with the Snake River draining the depression between them. The Banks Moraine serves as a natural southern border for the Arran drumlin field. In that section it is a smooth, single-crested strand. Sharpe and Edwards (1979) refer to this section of the Banks Moraine as the Williscroft Moraine and refer to the Gibraltar Moraine (near Paisley) as the Banks Moraine.

From the angle at Banks the eastern arm of this moraine soon falls below the top of the escarpment. In the Pretty River valley it forms a striking semicircular barrier with a gap cut through it by the stream. With several breaks it appears to pass west of Duntroon to Glen Huron and Dunedin. Clay from the reddish shale of the escarpment makes up the bulk of the material in this section. The moraine is missing on the face of the scarp near Creemore, but it reappears on the lower slope south of the Pine River and from there to the Hockley Valley lies close behind the Gibraltar Moraine. That stretch is predominantly sandy and it is intimately associated with outwash. The Banks Moraine loses its identity south of Hockley where it merges with the sandy complex which is part of the Oak Ridges Moraine of central Ontario.

TARA STRANDS

Across the Arran drumlin field, at right angles to the long axes of the drumlins, are several small moraines. The first appears near Tara and the last southeast of Wiarton. Usually less than 500 feet across, they are nevertheless distinct moraines of loamy till with an occasional kame.

BEAVER VALLEY MORAINES

In the lower Beaver Valley there are two, small, distinctive moraines. The one north of Heathcote may be a contemporary of the Corn Hill Moraine. Its distinctive trait consists of transverse ribs with sloughs between them which may be seen from the county road near the Beaver River. The pattern shown on the air photos is striking, and in form they are similar to Deane's (1950) ice-block ridges.

On either side of Thornbury the Nipissing shorecliff is cut into a thin bouldery moraine which affects the stoniness and drainage of the land on several farms.

VINEMOUNT, NIAGARA FALLS, AND FORT ERIE MORAINES

Around the western end of Lake Ontario there are three moraines above the "Hamilton Mountain" named by Taylor (1913): Vinemount, Niagara Falls, and Fort Erie, from north to south. North of Dundas they extend past Waterdown as distinct ridges of silty stony till partly covered with lacustrine sands. South of the Dundas Valley the Vinemount Moraine, a definite ridge of clayey till, lies near the brow of the escarpment, while the Niagara Falls Moraine lies farther south; it fades out east of Smithville and reappears near Niagara Falls.

The Vinemount Moraine is fairly continuous and extends into New York State. It was probably built at the same time as the Trafalgar Moraine. The second moraine, although discontinuous, may reasonably be related to the faint moraine west of Niag-

ara Falls, which seems to be the extension of the Tonawanda Moraine in New York State. The Niagara Falls Moraine is a mere swell in the clay plain east of the Welland Canal, except in the Lundy's Lane section where it is topped by a gravel bar. The big kame at Fonthill is in line with this moraine and may be included with it although it is a valley-head feature of different composition. The kames and outwash around Ancaster and Copetown are similar. The third moraine south of Hamilton is a low ridge of similar clayey till south of Twenty Mile Creek. Mount Hope and Binbrook are both set on its crest. Five miles east of Binbrook it becomes indistinct but provides enough relief to serve as a drainage divide between Twenty Mile Creek and the Welland River for the next 15 miles. It bears the name Fort Erie because Taylor (1913) considered the faint ridge running west from Fort Erie for five miles to be correlated, although this is questionable.

Moraines of South-Central Ontario

OAK RIDGES MORAINE

The build of south-central Ontario is dominated by a massive ridge of drift extending from the Niagara Escarpment to the Trent River. The crest has a general altitude of 1,000 feet a.s.l. and is 750 feet above Lake Ontario. A few areas stand above 1,100 feet and the highest ridges reach 1,300 feet. The underlying limestone and shale stand generally at 400 to 500 feet a.s.l. (White and Karrow 1971), which means that the ridge consists of about 500 feet of overburden; one boring near Richmond Hill went 203 m to bedrock (Sado *et al.* 1983; Johnson *et al.* 1983). However, our main concern is the upper deposits on the crest. It is mapped as a kame moraine but has special characteristics which must be mentioned. Except for a piece in King Township, where there is clay till and a few high ridges of till, it is sandy. The surface consists of sand or gravel hills with fairly level tracts of sand between them. A layer of windblown sand up to three feet or more in thickness is invariably found on the surface and in some parts there are active blow-outs and sand dunes. What are seldom seen on the surface are widespread deposits of lacustrine clay, silt, and fine sand. Passing mention of these fine sediments has been made in the previous editions and it was suggested that they must be due to submergence, probably in local pondings. More recent tests have confirmed the widespread occurrence in the Uxbridge area of thick deposits of lacustrine clay and silt; some on the very crest of the moraine. Clearly, this part of the ridge was under water at one stage, dammed between the north and south ice lobes, and this lake likely extended west to the Niagara Escarpment as shown on Figure 11g.

The Oak Ridges Moraine consists of several distinct sections (Figure 13). The first is just east of the Niagara Escarpment in the Albion Hills area of the Town of Caledon, formerly Albion Township (Photo 22) where the hills consist of deep beds of evenly graded fine sand. These are clearly deep water deposits but they are quite abnormal in having very rough, hummocky relief (White 1975). The strata are often badly contorted which lends support

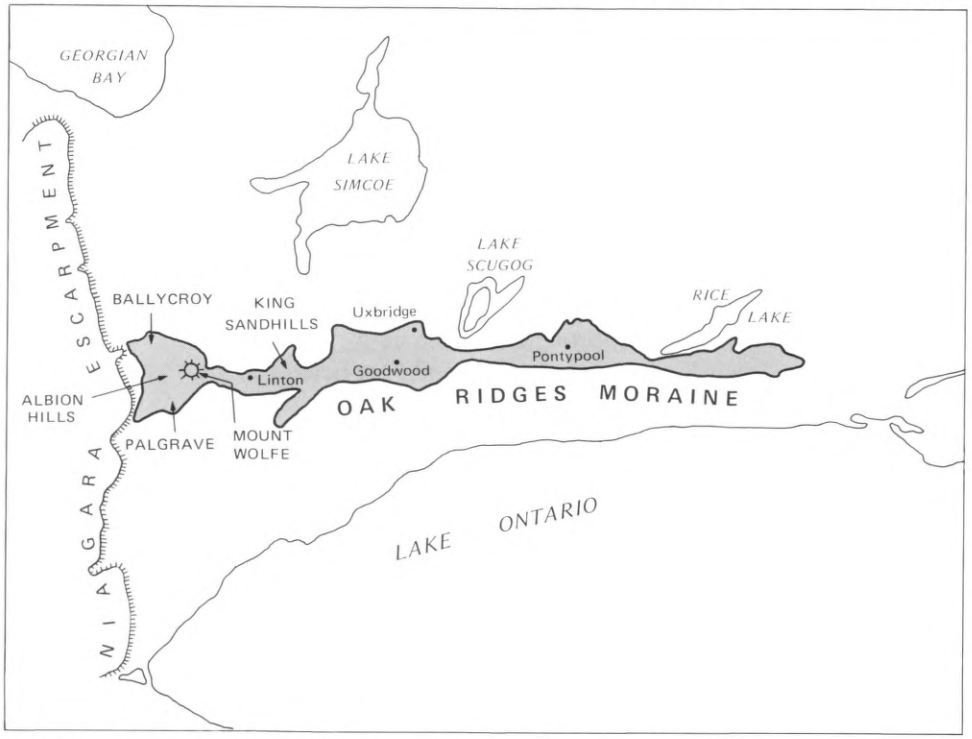


Figure 13. Sketch map showing the parts of the Oak Ridges Moraine.

to the idea that the choppy relief is due to slumping when buried ice melted and the walls of ice receded. This is bounded on the north by a belt of kame moraine (Ballycroy section) extending from the escarpment to Mount Wolfe, and on the south by the Palgrave section. East of Mount Wolfe to Highway 27 the moraine consists of clay till and this till dominates the southern half through King Township. This is the part which Taylor (1913) called the "Linton moraine". East of Highway 27 the northern half of the moraine consists of rugged sandhills through King Township and from there eastward the moraine is sandy except for a few knobs of till. Blowsand is common in the Vivian area while the relief is generally smoother in Uxbridge Township. This is the area, called the Goodwood Formation by Duckworth (1975, 1979), which has extensive lacustrine clays and silts under the surface sand. The moraine has a scalloped northern boundary and becomes very narrow south of Lake Scugog and at the western end of Rice Lake. Between these points is the wider Pontypool section which shows the first signs of overriding from the northeast. The effects of overriding are more definite south and east of Rice Lake where sandy till is fairly general on or very near the surface and occasional drumlins occur oriented southwestward. East of the Trent River the ridge at Oak Lake is in line with the Oak Ridges Moraine and perhaps should be considered as part of it.

The Oak Ridges Moraine contains a great deal of limestone derived from the Simcoe Group. As soil-building material the sand is fairly high in phosphorus and low in its potash content. The till is also high in lime.

TRAFALGAR MORAINE

Taylor's (1913) Scarborough moraine took its name from Scarborough Bluffs. It extended from the escarpment east of Waterdown to Scarborough, and then swung northeastward toward Claremont. In his description Taylor remarked on the weak expression between Streetsville and Toronto and admitted not having found it above the Davenport Road hill within the city itself. In an article written in 1943 the present writers objected to the extension from Scarborough Bluffs toward Claremont, because all of that area is drumlinized (Chapman and Putnam 1943b). Further study has shown that the surface at Scarborough Bluffs is distinctly drumlinized as well as the area to the northeast. In view of this we have discarded the name Scarborough and substituted Trafalgar, after the township where it is best represented. The Trafalgar Moraine appears as subdued morainic relief west of the Humber River in the area

OGS 10 673

Photo 22. The Oak Ridges Moraine in Albion Township. Photo courtesy of the Metropolitan Toronto and Region Conservation Authority.

north of Highway 5 and continues past Burnamthorpe Road to Streetsville (in Mississauga). West of Streetsville the moraine is quite definite, standing in contrast to the smoothed till plain just above the Iroquois shorecliff and the clay plain to the north. The Trafalgar Moraine is built of reddish clayey till containing a great deal of shale from the Queenston Formation.

TRENTON MORAINE

The ridge of sand and gravel extending from Trenton to Smithfield and westward to the sand terrace north of Brighton is considered to be a moraine. Because it was submerged in Lake Iroquois it was smoothed by wave action, but the glaciofluvial nature of the deposit is shown by the irregular bedding in the gravel pit near the railway north of Trenton. The sands in the terrace north of Brighton may have come from complete mutilation of its westward extension by wave action.

In the Bay of Quinte area there are two drumlin fields in which the alignment is different. Those formed by a Lake Ontario ice lobe lie parallel to the lakeshore, at approximately 70° west of south (250° azimuth). The other group was then formed by the northern ice sheet and trends 30° west of south (210°). The Trenton Moraine is at the southern limit of these drumlins, where they contact the Lake Ontario group. It marks the limit of the advance of the northern ice lobe which overrode the Oak Ridges Moraine east of Lake Scugog.

ORO MORAINE

Northwest of Lake Simcoe a broad belt of sandhills extends from near Midhurst through the northern part of Oro Township to Bass Lake. It forms the highest land in the vicinity, rising to 1,300 feet a.s.l. The sands are largely derived from Precambrian rocks, with a little local limestone intermixed.

The explanation of a moraine in this position presents the same sort of problem as does the Waterloo Moraine. The last thrust of the Wisconsinan glacier in this area was from the northeast, as is duly shown by the moulding of the adjacent till plains. The Oro Moraine does not lie at right angles to this thrust. It may be the result of a split between two lobes and as such would be an interlobate formation. The other possibility is that it is actually an earlier sandy moraine built by a Georgian Bay lobe and overridden from the northeast by the last advance of the glacier.

CORN HILL MORAINE

Around the southern end of Georgian Bay there are four short moraines. The foremost is a broad ridge running diagonally across Nottawasaga Township. It lies against an outlying remnant of the Niagara cuesta. Approximately three miles west of New Lowell it disappears under deltaic sands and is not found again to the east. The till is a mixture in which local rocks such as red and grey shale or sandstone, limestone, and siliceous rocks from farther north are well represented. Corn Hill is the name applied to this ridge by Hunter (1903). There is no village of that name, and corn is not grown extensively.

Although they are not connected with the Corn Hill Moraine, the two short ridges running along concessions V and VI of Sunnidale Township are the work of the same ice lobe. The red shale is missing but otherwise their composition is similar.

EDENVALE MORAINE

Between the Minesing flats and Jack Lake there is a ridge of boulder clay with sand spread on the surface. Through it the Nottawasaga River has cut a gorge 90 feet deep. The ridge appears to extend only from the hamlet of Jack Lake to Phelpston. However, a drainage divide extending from Crossland to Wyevale may be a continuation. The surface of this ridge is smooth and it lies more in line with the broad curving uplands of north Simcoe County than with the probable position of the receding front of the last ice sheet.

MARA MORAINE

Northeast of Lake Simcoe, extending across the limestone plain at the north side of the drumlin field in Mara and into Rama and Eldon Townships there are two, thin, discontinuous moraines. They mark a northwest-southeast trend of the ice front. Some sections are surprisingly rough for moraines built in water but other sections were levelled by the waves of Lake Algonquin.

DUMMER MORAINES

During the life of glacial Lake Iroquois the ice barrier crossed the St. Lawrence Valley in the Thousand Islands vicinity. On the basis of scattered morainic knobs near the border of the Gull River Formation, Coleman (1937) extended this ice barrier to the Kawartha Lakes. The limestone in this belt is thinly covered with till consisting mostly of coarse angular limestone fragments. The surface is littered with blocks of limestone and large Precambrian boulders. The finer matrix generally has a faint reddish colour from red shale and siltstone which occur just under and appear along the northern border of the Gull River Formation. This extensive and loosely knit feature disappears east of Tamworth. The very small moraines which produce a washboard

effect in the Napanee and other valleys (Loken and Leahey 1964) can hardly be considered as part of this moraine.

Eastern Ontario Moraines

In the St. Lawrence-Ottawa Lowland east of Kingston the moraines are fragmentary and smoothed by wave action. The hills of sand and gravel near Seeleys Bay still have the form of kames. However, there are quite extensive areas of glaciofluvial sands that have been largely reworked and contain marine shells. They are concentrated in a broad arc through Augusta, Edwardsburg, and Matilda Townships to Maxville, but are also found just south of Ottawa and scattered throughout Renfrew County. A moraine crosses the Ottawa River at Petawawa. The stony ridges in the southern part of the United Counties of Stormont, Dundas, and Glengarry are mapped as till plains rather than moraines because of the smoothing of their surfaces.

Georgian Bay-Ottawa Valley Moraines

Distinct, continuous, recessional moraines which would serve to mark the position of the ice front at one stage are notably absent between Georgian Bay and the Ottawa Valley. A few short discontinuous moraines of sandy till and glaciofluvial sand and gravel occur between Huntsville and North Bay and in Renfrew County. With one exception they trend westerly. The exception is the moraine extending along the brow of the St. Patrick scarp, as shown in Figure 5. Perhaps a lobe of ice separated in the Ottawa-Bonnechère Graben to produce this moraine. The moraines found between Huntsville and North Bay were nearly all submerged in Lake Algonquin and are unusually smooth due to reduction of the hills by wave action and deposition of sands or some silt and clay in depressions. They consist mostly of sand but pockets of gravel and masses of sandy, stony till are also common. As it receded from Fossmill through Chisholm Township to Lake Nosbonsing, the glacier made minor readvances to build several small, fragmentary, east-trending moraines which were partly buried by clay in Lake Algonquin.

DRUMLINS

Between 6,000 and 7,000 drumlins have been mapped in Southern Ontario in widely scattered groups. Their distribution is shown on Figure 7, a map which also shows the relative numbers of drumlins and the trends of their long axes. They are drawn to scale on the four miles to one inch maps so that their position, shape, and size are shown. Their height, form, and the steepness of their slopes are dealt with in the following descriptions, together with a few points on the composition of their tills.

Drumlins consist, almost invariably, of medium-textured stony till. While there is considerable variation in the proportion of sand and clay in these tills, heavy clay or light sand is seldom found. To illustrate this point the particle-size curves for several typical tills from drumlins are shown in Figure 6. The grouping of the curves is quite apparent. However, lenses or larger bodies of sand and gravel or even stratified clay are sometimes found in drumlins.

Drumlins afford some very good soils, their chief limitations being steep slopes and stoniness. Wet spots due to seepage along their sides are quite common, but otherwise the soils of drumlins are well drained. The hollows between these hills are usually wet and often swampy. The soils on drumlins, being medium in texture, are easy to till, adaptable, and fairly durable. The sides of drumlins are regular slopes which may be worked on the contour and strip cropped; in fact, this is the major application of contour cultivation in the Province. It is already practiced to a considerable extent where the lot lines happen to be in line with drumlins. Where the roads and fences run diagonally across the drumlins, as in Peterborough and Northumberland Counties, they present a severe handicap to contour farming.

The drumlin fields present a pleasing landscape. They are not usually so highly cleared as the clay plains; woodlots of hardwoods, with perhaps a few evergreens intermingled, and cedar swamps are left to grace the countryside. Even the stone piles along the fences and in the fields add variety to the landscape though they are otherwise objectionable to the farmer. Most of the farmsteads have attractive well-drained settings.

DRUMLINS OF THE LAKE ONTARIO ICE LOBE

The Lake Ontario lobe left three or four groups of drumlins west of the Niagara Escarpment and others north of Lake Ontario. Those in the Guelph area number about 300, most of them lying west of the Paris Moraine in association with beds of stream gravel. A few more lie south of the Paris and Galt Moraines near Moffat, Puslinch, and Freelton. The field around Woodstock, formerly included, is now attributed to the Huron ice lobe. The small group near Caledonia lies partly buried in varved clay. East of the escarpment there are drumlins south of Georgetown and on the south-facing slopes north of Lake Ontario, many of them running almost directly

up the slope. The long thin drumlins around the Bay of Quinte and eastward are roughly in line with the shore of Lake Ontario.

The Guelph drumlins rest on dolostones of the Amabel and Guelph Formations. The till is only moderately stony and consists mainly of dolostone, with the fine sand fraction being nearly half dolostone. Fragments of shale from the Queenston Formation impart a reddish cast which is strong near the Niagara Escarpment, diminishing westward. The drumlins are mild in form with moderate slopes, seldom more than 8%. Although they vary in size there is a preponderance of drumlins that are one-half to three-quarters of a mile long and 1,300 to 2,000 feet wide, with a height of 60 to 70 feet.

Near Acton the Paris and Galt Moraines lie close together while the drumlins lie immediately behind and in front of them and even between them. In several instances, south of Acton, drumlins half buried by the moraine were noted.

To the south of Freelton there are several peculiar drumlinized ridges. They run roughly east and west but are not regular in outline. Their crests approach a height of 100 feet above both the rocky table land to the south and the Beverly Swamp to the north and west. On some of them there are gravel bars at Lake Whittlesey levels (Karrow 1959).

The small group in the Caledonia vicinity lies below the Onondaga Escarpment. They are underlain by the shale, sandstone, and dolostone of the Salina Formation while other dolostones lie to the east. Probably the local bedrock was drift covered during the later glaciations. However, there is a good deal of grey and red shale mixed with dolostone and limestone in the local till. As usual there is a sprinkling of pebbles and rounded boulders imported from the Canadian Shield.

Immediately east of the Niagara Escarpment in the Regional Municipality of Halton, the till plain is fluted and several recognizable drumlins occur north of Milton. The till here is reddish due to the shale of the Queenston Formation and consequently is less calcareous than most of the tills in the south part of Southern Ontario. Even the sand fraction contains an abundance of shale fragments.

Between the Trafalgar Moraine and the Iroquois shoreline the till is shallow but it is fluted. The flutings score the plain from a few degrees south of east, and in places they are worn in the soft bedrock itself.

In the City of Scarborough the till is a light clay loam or silty loam in texture. It is derived mainly from the underlying grey and black shale and the limestone of the Lindsay Formation which borders it on the east. It is not particularly stony, but there are occasional large boulders to contend with in digging excavations. The drumlins are low in form and inclined to be quite long. On air photos the depressions between them are very conspicuous near the Wexford and Malvern areas in Scarborough. A few drumlins are found scattered in the area northwest of Agincourt.

South of the Oak Ridges Moraine west of Orono, the drumlins are related to the Lake Ontario ice lobe. They are quite widely scattered, about half of them being in the Iroquois lake plain where they rise above the clay beds. Near the ancient shore they were obliterated by wave action and only the boulders remain. West of Oshawa shale is plentiful, but to the east it disappears and the till is dominated by limestone.

Near the Lake Ontario shore between Cobourg and Brighton there are several drumlins which point east and west; it is not until Belleville is reached that any number with this alignment appear. However, while driving along Highway 2, the drumlins of the main, central Ontario field, pointing southwest, can be seen on the slope to the north.

Prince Edward County has between 50 and 60 drumlins, most of them centrally located. They are of the long narrow type characteristic of those left by the Lake Ontario ice lobe. The southern end of Lennox and Addington County has about 175 drumlins, which is none too many because between them the limestone is barely covered except where there is lacustrine clay. This area was completely submerged at the time of Lake Iroquois and the crests of the drumlins are strewn with boulders as the result of wave action.

DRUMLINS OF THE HURON ICE LOBE

The Woodstock drumlins are underlain by limestone of the Bois Blanc Formation, and the high content of this limestone in the till imparts a very pale brown colour. Boulders are not numerous. North of the Thames River the drumlins are indistinct and fade out entirely north of Mud Creek, to be replaced by a fluted till plain.

DRUMLINS OF THE GEORGIAN BAY ICE SHEET

The drumlins around Marsville, the flutings and incipient drumlins of the Dundalk-Arthur plain, together with the extensive field to the northwest, are the work of ice advancing from Georgian Bay. Well over 1,500 distinct drumlins have been mapped; our original estimate of 2,000 of these hills is a little too high (Putnam and Chapman 1943). It is well to remember that in a drumlin field a varying proportion of the till is planed and moulded although not made into distinct drumlins: for instance the rolling till plain between Mount Forest and Walkerton has very few drumlins.

In form and composition the Marsville drumlins are similar to the Guelph drumlins. Those in the townships south of Teeswater are also similar except that instead of dolostone they contain a preponderance of pale brown or grey limestone. The outwash sands and gravels between them are reminiscent of Erin and Eramosa Townships. North of Durham in Grey County there are some big drumlins with steep sides, composed of very bouldery till. As they are north of the limestones of the Bois Blanc Formation, dolostone predominates. The Arran group is of similar till, but with a higher proportion of igneous rocks and a minor amount of red shale. A count of small pebbles from an exposure west of Owen Sound gave 25% dolostone and most of the remainder are hard rocks of Precambrian age. Clay flats are associated with the drumlins in parts of this area while in the heart of the field the hills are packed close together so that it is not easy to map them separately. Many of the larger ones have flutings along their sides. In general they are long and have steep slopes, the largest being two miles long with a breadth of three-eighths of a mile.

Manitoulin Island has about 175 drumlins, mostly of the slender type. They were all submerged in Lake Algonquin and bear the mark of this experience in the form of boulder pavement on their crowns and sides. It is unfortunate that an area including so much shallow soil should find some of its deep soil rendered unfit for cultivation by excessive stoniness.

The composition of the till in the Manitoulin drumlins varies considerably. In the Tehkummah vicinity the pebbles in one typical drumlin consisted of 35% dolostone, 10% sandstone, and 55% Precambrian rock in which quartzite, diabase, volcanics, and other dark basic rocks were well represented. Dolostone in the drumlins increases westward, with red shale appearing in those around Ice Lake.

The rolling topography, smooth slopes, and generally prosperous farms of a drumlin field make a very pleasing landscape, and nowhere is this better illustrated than in the Bighead Valley back of Meaford. The drumlins here stand up plainly, being higher than usual and nearly oval in outline. A normal member of this group would measure 1,000 feet by 2,500 feet, with a height of 75 to 100 feet. Near Woodford several high ones appear. No drumlins remain in the Algonquin lake bed near Meaford; undoubtedly there were some, but they were unable to stand up to the waves. The local till is a pale greyish brown clay loam with a reddish cast. The red colour is imparted by shale of the Queenston Formation and the illuviated layer of the soil has the buff colour which is a mark of shaly soil. However, limestone and siliceous rock are also well represented in the till. For some reason no comparable group of drumlins was formed in the Beaver Valley a few miles to the east.

DRUMLINS OF THE SIMCOE AND KAWARTHA LAKES ICE SHEET

An area of about 2,000 square miles in central Ontario contains roughly 4,000 drumlins. Most of them are north of the Oak Ridges Moraine but the group south of the ridge in Northumberland County is important. The field extends beyond the east end of the moraine across Hastings County into Lennox and Addington County.

Most of these drumlins are well formed, 1,000 to 1,300 feet wide and one-half to three-quarters of a mile long, with a height of about 75 feet (Photo 23). Some very low ones occur north of Lake Scugog. Others in Emily and Smith Townships are short and nearly round. Those in Northumberland County are notable for their large size. East of Orillia and in parts of Douro and Dummer Townships, both in areas of fairly shallow till, they tend to be elongate.

In the belt just south of the limestone border it might be supposed that the bulk of the material in the till would be from the Canadian Shield, but this is not so. In fact the amount of Precambrian material increases with the distance south of the Precambrian-Paleozoic rock boundary (Gravenor 1957). In much of this drumlin field local limestones make up 45 to 65% of the till but the proportion decreases in the finer material of the matrix. Stoniness tends to decrease from the border of the Canadian Shield toward the Oak Ridges Moraine while sand content increases.

EASTERN ONTARIO FIELD

Between the St. Lawrence and Ottawa Rivers, drumlins are scattered across the central part. Usually they are widely distributed with clay beds occupying the intervening low ground. They are most closely spaced in the Manotick-North Gower area. Invariably, they point to the south.

The till in Glengarry and Stormont is much like that in Peterborough and south Hastings Counties except for a sprinkling of sandstone. In Dundas, grey or black shale is mixed with the limestone and siliceous rock, while in Carleton there is a little shale with a preponderance of sandy dolostone. All of it is stony and since wave action has concentrated the boulders on the surface in many places the soils cannot be other than stony. However, the sides of the drumlins in eastern Ontario are seldom as steep as they are in Northumberland, Peterborough, or Grey Counties.

On the Canadian Shield the till, being shallow, usually follows the rough contours of the bedrock. Where it is deeper the surface is drumlinized and is

OGS 10 674

Photo 23. An island in Rice Lake with the typical drumlin form.

much smoother. Well-formed drumlins are nowhere numerous but there are widespread tracts with scattered drumlins set in smoothed or moulded till plains. Although groups of drumlins invariably occur in areas of deeper till, the peculiar occurrence of isolated drumlins in areas of almost bare rock must be noted as, for example, "The Ridge" south of Coe Hill.

The moulded till plains have smoothly rolling relief, the swells being elongated north and south in line with the direction of ice movement. There may be distinct flutings on the surface and crag-and-tail features are common, the tails of till built southward from the rock knobs. These smooth till plains are not mapped as a separate type but are associated with the drumlins mapped in Figure 7. They are most extensive in western Renfrew and northern Hastings Counties with smaller tracts occurring all over the southern part of the Precambrian bedrock region.

ESKERS

Eskers (Figure 8) have been noted frequently in geological writings but it was not until 1943 that a map of them for the south part of Southern Ontario was published (Putnam and Chapman 1943), and that was only on a small scale. The inclusion of these features on Map P.2715 and the four miles to one inch maps improves this situation significantly. No doubt more detailed surveys will discover other small eskers but our mapping of them is fairly complete.

Eskers are of interest to agriculture because they afford poor soil. Mostly they are cleared and kept in pasture although the dry sand and gravel ridges produce scanty herbage. However, they are valuable sources of gravel, especially for road building. On the till plains of the south part of Southern Ontario they are usually crossed by a road every mile and a quarter and thus are convenient sources of road metal. Small pits have been opened on almost every road and in places whole sections have been worked out. The gravel is often coarse and crushing may be required. The deposits are also quite uneven and may include fine sands. Because eskers usually rest on the till there is often no overburden and standing water is not a problem in these ridges.

The first eskers to be formed were those around Guelph, chief among which is the one that begins south of the Ontario Agricultural College (OAC) farm at the University of Guelph and ends at West Montrose. On the OAC farm it is barely recognizable just behind the Ontario Veterinary College where some gravel has been removed. There is another small gravel pit where the esker crosses College Avenue. The spillway swept away a section of it at the Speed River, but it reappears west of the city and proceeds as a modest single ridge with a few breaks to West Montrose. There, a mile-long section is missing, having been swept away by a meltwater river during the recession of the Lake Ontario ice lobe. Beyond the gap the extension is a very small, smooth ridge which ends east of Elmira. Other than the West Montrose Esker there are only a few short bits of eskers among the Guelph drumlins.

In 1910, F.B. Taylor reported having traced an esker ten miles southeast from Mount Forest, saying that he did not reach either end (Taylor 1910). It extends five or six miles farther in either direction and is one of the five lengthy eskers that cross the Dundalk till plain. The Egerton Esker rises in Glenelg Township and ends in the centre of the Luther Marsh. Four or five miles to the west lies the Brice Hill Esker, while another shorter one crosses the corner of Melancthon Township southeast from Riverview. Photo 24 is an aerial view along the latter not far from Jessopville. A much bulkier ridge follows a swampy path through the centre of the township

splitting into single eskers north of the Osprey Township line. Southwest of Mount Forest conditions were equally favourable for eskers, but they are all less than ten miles in length. One of these is outlined by the contour in Figure 14.

In McKillop Township two good eskers are encountered running at right angles to those just described. They are related to the ice lobe which built the Mitchell Moraine, but from a more practical point of view they provide the only gravel in the township excepting the kame four miles north of Seaforth.

Just above the Niagara Escarpment there are only a few short eskers, the longest extending from near Kilbride westward for about two miles. East of the escarpment the Lake Ontario ice lobe left only one esker, the one northeast of Brampton which is partly buried under till. Actually, it would be better to say "used to be" buried because the esker has been almost all excavated for gravel.

Although partly south of the Oak Ridges Moraine, the Codrington Esker is the longest built by the Kawartha Lakes ice sheet. It was traced from a point near Codrington west of the Trent River to a point on the edge of the Canadian Shield beyond Beaver Lake, a distance of over 40 miles. Oddly, its course is out of line with the drumlins. Mirynech's (1963) survey of the Trenton map area traced this esker to Biddy Lake near Colborne. It crosses Hastings County from Frankford to Marlbank with short gaps in the Moira River flats near Foxboro. It almost divides Beaver Lake in two. The road from Erinsville to Lime Lake follows it, running along its crest for several miles. A tributary some 18 miles in length extends to Tweed past Phillipston and Thomasburg, and a shorter branch is mapped south of Tamworth.

The stream that laid down this gravel flowed to the west crossing the limestone border at Beaver Lake. On examining the gravel in the esker on either side of this little lake we were surprised to learn that, although not one limestone pebble could be found north of it, the gravel a scant mile or two south of the boundary was approximately 75% limestone.

A very big esker lies between Norwood and Westwood north of Rice Lake. Just southwest of Norwood it is more than 100 feet high, and there it exhibits a fairly common trait in having an extra ridge flanking the main one. The Omemee Esker which crosses Highway 7 just west of that village is also a big one, especially in the Pigeon River flats and it contains very coarse, cobbly materials. The Kawartha Lakes region has a series of these remarkable gravel ridges composed mostly of limestone gravel. Cameron Lake is bordered by one on the east and south, while toward Cannington quite a group of them appears.

There are no typical eskers in Ontario east of Kingston owing to the fact that the receding ice front

OGS 10 675

Photo 24. Oblique aerial view of an esker near Jessopville, Dufferin County. The serpentine humpy form is well shown.

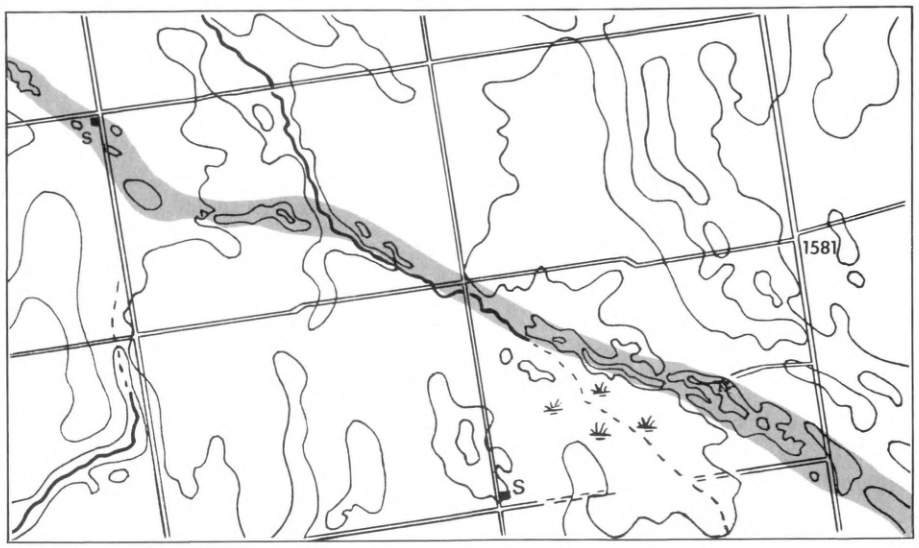


Figure 14. A section of the Palmerston map sheet (NTS 40 P/15), on which the contours intermittently outline an esker (shaded).

was always under water. However, four eskers, now extensively reworked by wave action, have been recognized. All of them have lost their knobbiness and are reduced in height, with the extra sand spread alongside. One runs north from Kars to the border of the City of Nepean. Gravel pits in this ridge expose esker structure at its base and regularly stratified beach gravel, containing marine shells, above. Most common among the shells are those of *Portlandia arctica* and *Hiatella arctica*. The second esker can be traced from a point one mile east of Kemptville to Reids Mills and discontinuously to West Osgoode and Greely. Some sections have been entirely reworked, for example at Reids Mills, where the gravel was apparently thrown into beach ridges. The third esker runs south of Finch for three or four miles. The fourth is north of Bearbrook. All four eskers trend roughly south in line with the orientation of the drumlins.

Eskers are fairly numerous in the northern and eastern parts of the Georgian Bay-Ottawa Valley region. They are scarce in the south and west, with only two appearing between Georgian Bay and Highway 11. Logging roads follow eskers wherever possible because they are dry ridges of high ground and contain sand and gravel. The deep sandy soils usually produce good stands of white and red pine and white spruce. All the known eskers are traced in some detail on Map P.2715, whereas the general pattern of distribution may be seen at a glance on Figure 8.

The longest esker in this region extends from the Mattawa Valley northeast of Bonfield to Washago, over 100 miles. It has two branches north of Fossmill; the larger one has a prominent form where it extends through Boulter Township southwest of Grand Desert and so the name Boulter is given to this esker. North of Grand Desert what is now recognized as a moraine (the Rutherglen Moraine) may well be an extension of the esker overridden from the east by the Mattawa lobe, a tongue which pushed forward from the main mass of ice into the Ottawa and Mattawa Valleys. In Boulter Township this esker stands over 100 feet high in places and may consist of two or three strands. It includes a series of deep depressions which are skirted by the forest access road built along the crest. The other branch extends from just north of Fossmill to Bonfield and beyond to the Mattawa River. It consists of a single ridge and is in most places less than 50 feet high. Gravel is being taken from pits in it near Bonfield village. At Fossmill there is a gap, whereas south of there the Boulter Esker consists mostly of a single ridge which continues in good form to a point east of the South River airport where there is a gap. Then it reappears and can be traced southward with some breaks to Pevensey. South of there this esker is not mapped as such because it has been levelled and spread out by wave action. The belt of sand followed closely by Highway 11 is the reworked esker with irregular bedding, typical of ice-contact deposits appearing in some exposed sections. These deposits should not be confused with the delta sands in this same belt left by streams such as the north branch of the Muskoka, and the East and South Rivers where they emptied into glacial Lake Algonquin.

West of the Boulter Esker there are two small eskers: one is west of Bernard Lake in a clay plain and the other goes south from Burk's Falls for less than a mile. Both are partially overlain by clay. The lack of eskers in the wide belt east of Georgian Bay is in keeping with the scarcity of drift of any kind.

Five miles east of Mattawa in the area adjacent to the Ottawa River, there is an esker which can be traced from this point southwestward nearly to Papineau Lake. The largest esker and, in fact the largest in the Shield region, is the one which extends from Deux-Rivières south for 10 miles to Wendigo Lake and is closely followed by the Brent access road. Near Deux-Rivières it is more than half a mile wide and 75 feet high with a fairly level top. It consists almost entirely of fine sand with very little gravel. East of Deux-Rivières five other short eskers occur just south of the Ottawa River

The area in Algonquin Provincial Park between the Canadian National Railway and Highway 60 has about 15 eskers. Some are in remote areas, for example, the large one west of Plumb, Robinson, and Whiskyjack Lakes. A good example is located south from Odenback on Radiant Lake. One of the longest and largest is crossed by Highway 60 at Amable Creek midway between Whitney and Madawaska. From that point it extends with several gaps for over 25 miles northward and 10 miles continuously southward to Wallace. It should not be surprising that there are many eskers in Algonquin Provincial Park because the till there is deeper than on most of the Shield area.

In the southeastern part of the Canadian Shield one esker extends intermittently from near Springtown and southward through Darling Township; there are four other shorter, small ones in Lanark County. The south-sloping part of this region has only a few eskers. There are two good-sized eskers trending south in Madoc Township. Farther west, almost at right angles to these two, the Norwood Esker extends past Havelock to Crow Lake and then northeastward, in places standing more than 100 feet high. In Peterborough County north of the Kawartha Lakes the drift is thin and there are no eskers. In Haliburton County there is the small intermittent esker in the Irondale River valley extending for about ten miles upstream and downstream from Gooderham, and two others south of Haliburton, one about five miles long ending in a cluster of kames southeast of Canning Lake and the other a short, complex one south of Canning Lake.

In summary, the region underlain by Precambrian bedrock has over 30 major eskers of various lengths and sizes.

ABANDONED SHORELINES AND LACUSTRINE SEDIMENTS

Approximately one-third of Southern Ontario was submerged for a time during or immediately after the retreat of the last glacier. In the Georgian Bay-Ottawa Valley region this amounted to nearly one-quarter, while it was more than half in the south part. Waterlaid sediments are practically free of stones, this feature and the level topogaphy of the beds being the surface earmarks of a lake plain. The sediments themselves are stratified. Some glacial forms often remain to break the near-levelness of the lacustrine and marine plains but never without being modified to some extent. Wave action worked to produce a boulder pavement or beach gravels on their surfaces.

An outline of the several glacial lakes which successively inundated lands at various levels was given in a previous section (Figures 11a to 11o). Taylor (1910, p.165) concluded that the plain between Stratford and Milverton was a till plain even if it were "as flat as the ocean in time of calm." From this it is evident that he had looked for stratified clay. However, he did not mention any of the tracts where stratified sediments do appear. One is found in the Conestogo Valley. Near the marlbeds south of Atwood in concession VIII of Elma Township, a freshly dug ditch in 1941 showed stratified clay and sand several feet deep over the till. The marl required shallow water for its accumulation, therefore, there is no doubt that shallow water stood in the basin until a tributary of the Maitland emptied it. Two other tracts of lacustrine clay, without the marl, occur north of Brodhagen in front of the Mitchell Moraine and southeast of Tavistock. Both lie on divides between two watersheds and drain in two directions leaving central areas where no drainage courses are established.

In the upper Great Lakes basin, a succession of lakes occurred at various levels during the Wisconsinan glaciation. From oldest to youngest they are Maumee, Arkona, Whittlesey, Warren, Grassmere, Lundy, Algonquin, and Nipissing.

It is important to understand that the beach deposits of these glacial lakes are no longer horizontal. At the time when the beaches were formed, the mass of the glacier had depressed the earth's crust, the amount of depression increasing toward the north where the ice mass was the thickest. After the glacier retired, the land gradually rose again, almost to its former level, raising the elevation of the beaches toward the north. The amount of depression at the time of the several lakes' existence can be estimated by the rising altitudes of those beaches. This is shown graphically in Figure 15. The altitudes are those measured along the lines of maximum uplift, which are at right angles to the lines of equal uplift. These latter lines are curved (Farrand and Gajda 1962). The lines of maximum uplift were taken to be 23° in the Whittlesey, Warren, Algonquin, and Nipissing basins, 20° in the Lake Iroquois basin, and 10° in the Champlain Sea area of eastern Ontario.

THE LONDON CORRELATIVE OF LAKE MAUMEE

The ponding east of London has already been discussed as a correlative of glacial Lake Maumee; while it is not bounded by a distinct shoreline the limits of the stratified beds are reached just under the 900-foot contour. The finer sediments give way to stream gravels along either branch of the Thames River. The central area is level and it is no accident that a block of it near Crumlin was selected for an airport. The beds of uniform silt exposed on the campus of the University of Western Ontario, north of the stadium, are Maumee sediments. Similar beds also underlie the gravels along the North Thames River below Thorndale.

Two beaches above the level of Lake Whittlesey appear near Lambeth. The upper one is followed by the road northwest of the village for a mile. It is a broad gravel beach just above the 850-foot contour. The other is 20 feet lower and extends from Scottsville toward the first bend in Highway 2 west of Lambeth where it gives way to a low bluff. At these levels lacustrine deposits, when present, consist of shallow pockets of silt. Lake Maumee silts and clays are present in association with Erie lobe moraines south of London and near Tillsonburg.

LAKE WHITTLESEY

In Ontario, Lake Whittlesey is noted for its deltas while its shoreline is but faintly developed. The best stretch of beach is that between Arkona and Watford; it consists of shaly gravel. The continuation of the shoreline around the end of the Seaforth Moraine is a distinct bluff, except for a bit of a beach near Sutorville. Continuing toward Kerwood the shorecliff diminishes in form, fading out before reaching the vicinity of the village. Two short gravel beaches appear on either side of the railroad west of Kerwood. Neither beaches nor bluffs appear within five miles of Strathroy to set a sharp boundary between the sands of Caradoc and the Seaforth

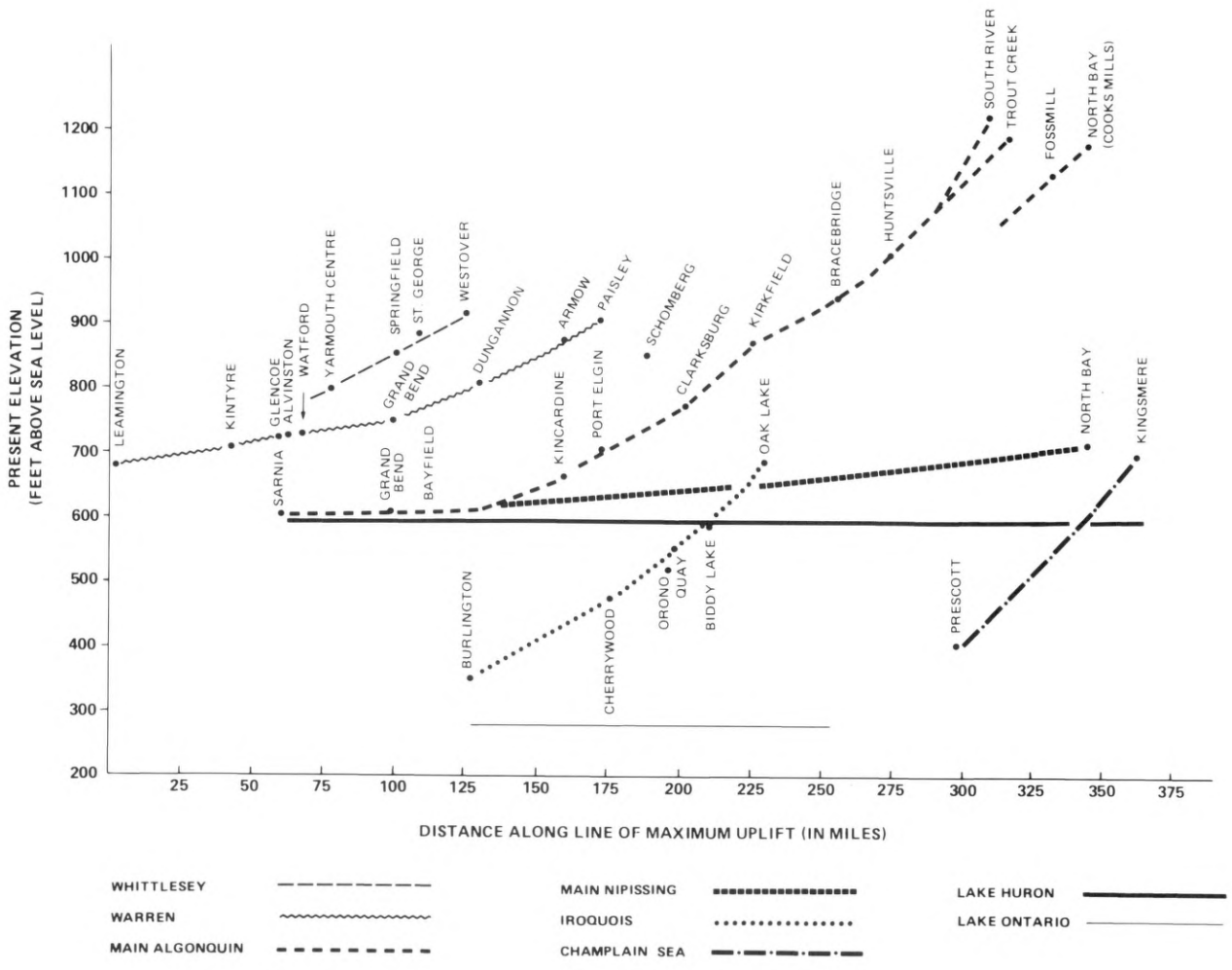


Figure 15. Profiles of warped shorelines of former glacial Lakes Whittlesey, Warren, Algonquin, and Iroquois, the Champlain Sea, and postglacial Lake Nipissing.

Moraine. North of the railroad tracks, west of Komoka, a shorecliff at about 825 feet a.s.l. appears on the end of the Lucan Moraine. Although it seems to be a little too high for Whittlesey levels, the exact tilt of that water plane is not known and leaves this point in doubt. However, it is at the edge of the Caradoc delta.

Between the Thames River and St. Thomas no shore features are found near the 800-foot contour. Three miles west of that city on a ridge where the power line intersects the Michigan Central Railway, two disconnected gravel beaches lie close to the Lake Whittlesey level. Beaches appear in a few places east of St. Thomas so that the levels are established even though the shoreline is indefinite for most of the way. A gravel beach crosses the Edgeware Road north of Yarmouth Centre. South of Mapleton a short beach and a low bluff east of it cross the extreme southwestern corner of South Dorchester Township. The water level at these points was about 780 feet a.s.l. The next beach to be seen lies on the side of the Tillsonburg Moraine; one bit occurs near the railway junction north of Tillsonburg, while a longer one begins a mile and a half southwest of that point and runs south of Highway 3 for four miles. These beaches lie just under 800 feet a.s.l. The moraine south of Tillsonburg, lying between the Canadian Pacific Railway and Little Otter Creek, also has a fragmentary beach encircling it at the same level, and several more short gravel beaches occur south of Otterville against two prominences of the Tillsonburg Moraine. Near Windham Centre on the Paris Moraine at 825 feet a.s.l., or slightly higher, is another gravel beach which probably is the work of Lake Whittlesey. North of this the best evidence found was a gravel beach at about 875 feet a.s.l. lying west of the road two miles north of Scotland. The delta sands continue north of Windham Centre toward Paris; the point where they give place to the stream terraces is not definite but, north of Burford, outwash gravel predominates in the beds.

On the Paris and Galt Moraines, north of Windham Centre and Waterford respectively, gravel bars near the 850-foot contour are too high for Lake Whittlesey and must, therefore, be pre-Whittlesey in age. Karrow's (1963) more detailed surveys of the area east of Cambridge have found and mapped several short beaches at Whittlesey levels.

The two major deltas of Lake Whittlesey in Ontario are well known as the Norfolk and Caradoc sand plains. The first is at the mouth of the Grand River spillway in front of the Paris and Galt Moraines and the second in the Thames Valley west of London. Oddly, there is no good delta in front of the Wyoming Moraine in the Ailsa Craig vicinity.

The Norfolk sands lack the typical deltaic gradation from coarse to fine sands. Medium to coarse sand is widespread. The Whittlesey and Warren deposits are continuous, the Warren deposits being regarded mainly as reworked Whittlesey sediments. There are no separate deltas of Big Creek, Otter Creek, and Kettle Creek in Lake Warren.

Mineralogical studies of the composition of these sands (Chapman and Dell 1963) have found that they contain more calcite than dolomite on the average. The main source of the calcite is the limestones of the Lake Simcoe area beyond the Niagara Escarpment. The outwash in the spillway from Caledon Village to Brantford is also high in calcite, in contrast to the adjacent till.

Stratified silt deposited in Lake Whittlesey occurs east and west of St. Thomas and as a silty "island" surrounded by sand north of Simcoe. The small tract of silt near Kerwood is not connected with the Caradoc delta, the sediments probably being derived from nearby till in which shale as well as limestone is abundant. West of St. Thomas through Southwold, Adelaide, Ekfrid, Metcalfe, and Brooke Townships to Watford, Whittlesey clays bury the till and smooth the surface.

LAKE ARKONA

On the map, a beach is placed between the Whittlesey and Warren beaches in the Arkona-Alvinston vicinity. This is the beach of Lake Arkona which existed prior to Lake Whittlesey when the glacier held a position of retreat before its readvance to the Port Huron Moraine. This lake built three beaches on the west side of Lake Huron northwest of Port Huron, Michigan, in the Black River area. They were submerged under the higher waters of Lake Whittlesey and more or less scattered by wave action. It is mainly on this evidence that Lake Arkona is considered to be pre-Whittlesey in age (Leverett and Taylor 1915).

The only place in Ontario where the Arkona beach is definite is between Arkona and Alvinston. It is best expressed from Birnam to Kingscourt and again from Walnut to south of Alvinston. Other places where beaches are found at Lake Arkona levels are at Glencoe, on the Blenheim Moraine near Clachan and Duart, on the hump west of Leamington, and around the Sparta ridge south of St. Thomas. The one south of Glencoe is the only well-formed beach. At Clachan there is a gravel bar capping high ground, which is not specific evidence of a shoreline. Near Leamington the gravels interpreted as the Arkona beach lie on the north and east sides of the clay ridge, and extend toward Leamington as a spit with its crest above the 725-foot contour. Although the distinct form of a beach may be wanting, except

near Glencoe, these are sizeable gravel deposits, much heavier than the beaches of Lake Whittlesey.

LAKE WARREN

Glacial Lake Warren at its highest stood about 60 feet below the level of Lake Whittlesey. It covered a broad belt north of Lake Erie and a narrower border east of Lake Huron. In the east it was confined by an ice barrier near the top of the Niagara Escarpment, while the crest of the Oak Ridges Moraine was probably uncovered at the time. The western ice barrier stood north of Paisley at the position of the Banks Moraine, although it eased away from that moraine toward the end of the lake's existence. The abandoned shoreline is now tilted so that it rises from near 700 feet a.s.l. in the south to 925 feet at Paisley. East of Ridgetown it rises to 775 feet a.s.l. at Simcoe and 835 feet several miles north of Brantford. There are two beaches, the second being ten to fifteen feet below the first, usually nearby and seldom more than half a mile away.

On the slope east of Lake Huron the Warren beaches are finely formed but fairly continuous. The two strands can be seen and traced on air photos north of Goderich. The northernmost occurrence is a well-developed shoreline around a morainic ridge three miles north of Paisley. A few gravel bars west of Pinkerton are the only evidence of the Warren beach in the Saugeen embayment. Bruce Township does not include a good example of these beaches, although the sand and gravel south of Willow Creek is in line with them where they end south of the Kincardine Township line. The two beaches, a quarter of a mile apart, appear in lots 13 and 14, concession XI of Kincardine, and can be traced southward in spite of some discontinuity right to Wyoming. The beaches generally consist of two or three feet of gravel. Deeper accumulations are eagerly sought as sources of gravel, which is scarce. One of these occurs west of Lucknow near Lothian. West of Dungannon village the stream gravels along the Lucknow River provided material for the waves to work with. Outside Goderich deeper gravels form the sites of two cemeteries and several gravel pits. The shoreline is clear cut south of Goderich; where beaches fade out a small bluff is usually present instead. The two beaches are close together at Blake. They pass through Dashwood and are fairly strong as they cross the road, respectively one-half mile and one mile west of the corner. Some old dunes remain near Mount Carmel along the higher Warren shoreline, and an unusually strong shorecliff and bouldery terrace extends for six or seven miles from Parkhill Creek to the Ausable River.

On the whole of this slope the Warren beach stands at the boundary between the rolling lands above and the level plain below. Lakeward from the beach or the shorecliff for a variable distance, seepage from the higher ground is apt to collect, creating swampy conditions. North of Thedford the gravel in the beaches is characterized by limestone without shale. South of Thedford, brown and blackish shale is found mixed with the limestone and the Precambrian rocks from the north. The two beaches, close together, continue with but few breaks through Forest to a point four miles west of Wyoming. In that section, with the benefit of Lake Huron to the north, the warm gravelly soils of the beach are planted to peach and apple orchards in spite of a tendency to drought. The Warren shoreline surmounts the Wyoming Moraine west of Wyomimg, cutting a small bluff where it passes the crest and building a gravel spit two miles northwest of Marthaville (Copleston). On the southern slope of the Wyoming Moraine the beaches are thin, fading out shortly after crossing the Warwick Township boundary. According to the levels, a bay of Lake Warren extended to the Village of Warwick, but in that protected cove no beaches were left. The silt and fine sand around that village probably are Warren sediments but the beds continue northward along Bear Creek, rising to 725 feet—slightly above the level of the shoreline. The beach gravels along the 725-foot contour east of Kingscourt are thought to be of Arkona age; below that level in the Kingscourt and Sutorville areas the Warren shoreline is very faint or missing. It reappears near Armstrong Station as a single thin beach of shaly gravel. Within two miles of Alvinston the two beaches are again present in fine form, continuing past Alvinston to the bank of the Sydenham River near Grays.

Warren beaches are lacking between the Sydenham and Thames Rivers, however, the edge of the delta extends from Shields Station to Wardsville. Around West Lorne and Rodney the land at 700 to 710 feet a.s.l. is close to the level of the Warren waters. Here, too, in the absence of beaches or bluffs the upper shoreline is placed at the edge of the sands. The Blenheim Moraine was separated from the mainland by three miles of shallow water. The Leamington Moraine also stood out as an island in this lake.

On the Blenheim Moraine the Warren shoreline is generally represented by beaches on its southeastern flank and a shorecliff on the opposite side. From Blenheim through Morpeth and Palmyra a pair of beaches run continuously and the gravel ridges are held in high favour for building sites on the farms through which they pass. East of Duart the beaches have given place to a ten-foot bluff and bouldery terrace. The bluff continues past the county boundary but a beach reappears near Taylor. North of Kintyre a low bluff cut in sand or gravel beds crosses over the 700-foot saddle. The Blenheim Moraine has two

crests in the Kintyre and Clachan section. On both crests the Arkona beach appears in strength, making the task of identifying the Warren beach difficult. The top of the moraine at Clachan is covered by beach gravel. A faint shorecliff crosses the road a few tens of feet south of the corner at Clachan, while a beach crosses north of the corner. These are considered to be the two Warren shorelines. The low bluff extends northeast toward the beach at the schoolhouse on the next sideroad, the elevation at its base being close to 710 feet a.s.l. Between Clachan and Ridgetown the upper Warren shoreline is a bluff, with a few exceptions, but a beach runs from Ridgetown to Blenheim and Cedar Springs. This beach has an abrupt northern face with clay appearing almost immediately below.

The dome west of Leamington is almost encircled by a gravel beach between the 675- and 700-foot contours. MacLachlan (1938) puts the elevation of the upper Warren beach near Ruthven at 680 to 685 feet a.s.l.

There is no shorecliff on the end of the St. Thomas Moraine near Wallacetown, and there are no beaches in the vicinity. East of St. Thomas the shoreline runs through sandy land where the shore features are ephemeral, being subject to wind erosion. The shoreline is tentatively drawn through a line of sand dunes in this area. The one unmistakable occurrence of the twin Warren beaches east of Wallacetown is at the Town of Simcoe (Woodhouse Township, concessions V and VI, lots 3 and 4). Two sandy beaches are present a mile and a half south of Glen Meyer but they have poor continuity. Dunes extend north of Langton, and low bluffs appear south of Wyecombe and extend toward Lynedoch. A line of dunes can be traced for about eight miles west of Simcoe, although some of the high ground west of Simcoe was above the level of Lake Warren. The upper beach at Simcoe stands at 775 feet a.s.l. thence the shoreline runs along the eastern side of the Galt Moraine with bluffs being more common than beaches. However, some land west of the Galt Moraine is just at Warren levels, which allows this to be considered as part of the lake. The dunes at Atherton, Nixon, and Lynnville join with the low bluffs a quarter of a mile east of Lynnville and with another which crosses Highway 24, west of Waterford, to suggest the shoreline of a shallow bay or lagoon north and west of Simcoe.

North of Simcoe the shoreline on the eastern side of the Galt Moraine has good continuity to Waterford. On the northern outskirts of Waterford a short but distinct gravel bar above the 775-foot contour is a Warren beach. North of Waterford the Warren shoreline cannot be followed continuously. The best beach is southeast of Blue Lake in lot 18, concession II of South Dumfries crossing the road three-quarters of a mile south of the corner where it soon gives way to a bluff. Other short gravel beaches appear two miles east of the corner of Highway 5 west of St. George. A beach near Branchton in lot 1, concession VIII, of North Dumfries Township and several other short beaches on drumlins in Beverly Township (now part of the Township of Flamborough) were built by Lake Warren (Karrow 1963).

Gravel beaches on the big kame at Fonthill are doubtless of Warren age, as they have about the right altitude of 850 feet; in other words, a small isolated island appeared in glacial Lake Warren.

The Norfolk sands have already been discussed as deposits of Lake Whittlesey in the delta of that lake, although much of the sand is below Warren level. The sands are continuous and there are no distinct Warren deltas. The beds of silt, sand, and fine sand between Brantford and Campbellville are considered to be deltaic in Lake Warren. The Thames River brought down enough sand to cover 600 square miles below Newbury, most of it spread thinly on the clay floor. The Ausable, Bayfield, and Maitland Rivers built small deltas while in the Saugeen embayment there are four square miles of deep sand beds north of Walkerton.

While silt is valued as the parent material of good soils it is the bane of the road builders. Most of the silts in southwestern Ontario are deposits of Lake Warren. Deep varved silt occurs around Brantford and eastward toward Dundas. Similar deposits are found near Fingal, south of Chatham, and between the Blenheim Ridge and Rondeau Harbour. The Wentworth, Brant, Elgin, and Kent County soil maps (Appendix C) show them as Haldimand loam or Beverly loam and fine sandy loam.

Deep beds of clay, some of it interstratified with silt, make up the surficial beds in the Niagara Peninsula, particularly south of the Grand River. More appears back of Port Rowan. The clay between Paisley and Elmwood is 60 feet thick in places, these beds being notable because the brown and grey varves are so distinct and regular. Shallow deposits on the clay till of the slope east of Lake Huron, and in Lambton, Kent, and Essex Counties tend to smooth these plains. This includes Pelee Island where the surface is quite flat.

In the Niagara Peninsula north of the Grand River, exposures consistently show crumpled clay strata within a few feet of the surface, overlain by a thin sheet of heavy till and sometimes topped by more stratified clay. The crumpled strata are indicative of overriding by the glacier. Air photos of this area show the "marbling" that is usually associated with heavy till. This till contains very few pebbles and boulders, no doubt consisting of material reworked from the lacustrine beds below. Similar

clay till, often overlying crumpled clay strata, occurs on the borders of Lake Huron.

An odd feature of the Warren lake plain east of Lake Huron is a belt of sand running roughly parallel to the beach and usually separated from it by a strip of clay. Occasionally this sand contacts the beach but it also occurs over 100 feet below the beach. It is, therefore, not a lower shoreline even though frequent wave-built bars appear. The deposits are of shallow, stratified sand, two to four feet being the prevailing depth. The surface exhibits peculiar form in the shape of wavy swells running in the same direction as the beach. On air photos they produce a striking ripple pattern as shown in Photo 25. As mentioned in connection with recession of the last glacier this sand was probably brought there by meltwater from the north entering a long narrow bay in the early life of Lake Warren.

Below the Warren levels in the Niagara Peninsula, there are fragmentary shorelines, indicative of temporary water levels, which must be mentioned. The gravel bar at Lundy's Lane (in the City of Niagara Falls), after which glacial Lake Lundy was named (Leverett and Taylor 1915), is on the crest of the Niagara Falls Moraine and stands at 675 feet a.s.l., or about 175 feet below the highest shoreline of Lake Warren which appears on the big kame near Fonthill. Several gravel beaches appear east of Welland at elevations varying from 600 to 650 feet a.s.l., and with too much local variation for them to be regarded as the work of a single water plane. Among the highest is the gravel bar at Ridgeway, on which an elevation of 657 feet a.s.l. was established. This is almost at the same level as the wave-washed limestone mesa near Ridgemount. Another fairly continuous line of beaches appears at 625 to 630 feet a.s.l.

OGS 10 676

Photo 25. Ripple pattern in the Lake Warren plain northeast of Goderich. The dark streaks are due to wet soil in hollows between successive sand bars. The two Warren beaches cross the upper right corner. Photo courtesy of the Canadian Armed Forces.

in the Ridgemount area. Beaches at similar levels appear on the low upland south of Cooks Mills. Low bluffs and beaches also appear just above the 600-foot contour in Wainfleet Township, a few miles west of Port Colborne, while a distinct shorecliff and thin beaches are to be seen at about 595 feet a.s.l. near Stromness in the Town of Dunnville, not far from the Lake Erie bluffs. The strongest and most conspicuous beach of the group, however, is the one followed by the road from Crystal Beach to Sherkston. An elevation of 618 feet a.s.l. was established on its crest in Crystal Beach. This corresponds very well with the upper limit of the deltaic sands near Dunnville on the Grand River, which were deposited in Early Algonquin time (Figure 11j).

At the western end of the Lake Erie basin, the best-formed beach below Warren level is the Essex ridge, a well-known gravel strand followed through Essex by a road between Windsor and Leamington. Between Essex and Cottam the elevation of its crest is just over 650 feet a.s.l. Taylor (1913) related it to the Grassmere beach in Michigan State but it seems rather high to be a true correlative unless MacLachlan's (1938) theory of special local deformation can be shown to apply. Two lower beaches run parallel, a few miles to the west. The upper one at 630 feet a.s.l. has about the same altitude as the heavy storm beach beside Highway 3 from Romney to Port Alma, which may correspond to a Lundy water plane. Strangely enough, this ridge now forms the water divide between the streams flowing north into Lake St. Clair, and drainage into Lake Erie which is less than one-half mile to the south. The crest of the bar near Ouvry is about at the Grassmere level, while others to the east trend upward to Warren levels. At Ravenswood and Camlachie, just south of Lake Huron, there are beach deposits, just on or above 650 feet a.s.l. which may be correlated with the Lundy water plane.

Below the Warren beaches, the shorelines are all rather unobtrusive features of the present landscape. At the Warren, Grassmere, and Lundy water planes, the lakes in the Huron, Erie, and St. Clair basins were continuous, with progressively narrower and shallower straits across the saddles at Sarnia and Windsor. The island north of Leamington stood progressively a little higher and became a little larger with each lowering of the water level. By Lundy time a considerable body of land had emerged in the western part of Essex County but there was a large submerged area to the east. Shallow open water must have persisted in the area from Tilbury to Wheatley until Early Algonquin time.

Once the isthmus near Wheatley became dry land, an almost completely enclosed water body in the Lake St. Clair basin came into existence. It received the drainage of the Thames River and other smaller streams, and it was free to drain either to the north or to the south, depending upon the direction in which the ultimate outlet was established. The best evidence of an established water plane is the shoreline near Dresden. We shall, therefore, refer to this stage in the St. Clair basin as Lake Dresden.

Following the time of Lake Warren there were two lakes east of the Niagara Escarpment, Lake Peel and Lake Schomberg. Lake Peel was probably a correlative of Lake Lundy as shown in Figure 11i. Lake Schomberg may have been contemporaneous with Lake Peel or a later event.

The Peel plain extends northeastward from the Niagara Escarpment, through the Regional Municipalities of Halton, Peel, and York. The evidence for submergence is not as strongly marked as in some lake plains, nor is it always unequivocally present. There are widespread beds of stoneless clay over the till, while in some areas the beds are deep enough to accommodate the soil profile and to preserve some depth of unweathered stratified clay below (Photo 26). An extensive area of this sort was exposed during the building of Lester B. Pearson International Airport at Toronto. Another pocket with 8 to 10 feet of stratified clay near Drumquin was sectioned in 1964 during the rebuilding of the Oakville Seventh Line road. Flat areas with some depth of stratified clay are found near Ashgrove, Brampton, Concord, and Amber. Just south of Unionville, a flat area has surface deposits of stratified sand over clay. The shoreline of Lake Peel is not anywhere marked by continuous beaches or shorecliffs, but small sandy areas in the Credit Valley near Norval, and in the

OGS 10 677

Photo 26. Varved clay over till on the Peel plain north of Streetsville. The base of the two-foot rule rests on till.

Humber Valley near Nashville, appear to have been deltas in this lake. The chief effects of submergence, however, appear to have been the levelling or smoothing of the till surface and the deposition of just enough clay to produce a Peel clay loam, instead of the Chinguacousy clay loam of the adjacent till plain.

EARLY LAKE ALGONQUIN AND ITS CORRELATIVES

The low flat plain which borders Lake St. Clair is one of the more significant features of southwestern Ontario. It is lowest in Dover Township where large areas, actually below the level of the lake, have been reclaimed by diking, ditching, and pumping. The upper limit of this plain is marked by the Dresden shoreline. It consists of low bluffs and thin gravel beaches which can be followed from Dresden to Sombra, at or close to a contour of 605 feet a.s.l. East of Dresden the shoreline of the Thames embayment of this water level is somewhat indistinct. However, the soil patterns over a wide area from Kent Bridge to Lake St. Clair strongly suggest the deposits of a delta. Between the Sydenham River and the Thames River, the surface deposits are sandy and the sands have been subject to wind action both above and below the 605-foot contour. There has been little recent dune formation, but old blowouts, built by westerly winds, are evidence of a shore zone although no distinct beach remains. To the south of the Thames, from Kent Bridge to Chatham, the edge of the deltaic sand is found just above 600 feet a.s.l. and is bounded in places by indistinct shoreline features such as thin beach strands and very low bluffs.

Near Kent Bridge, the early Thames River split into two major distributaries, one of which followed the path of Big Creek while the other followed the course of the present Thames River through Chatham. Both distributaries meandered widely, throwing off minor distributaries and, although the abandoned channels are shallow, they are quite distinct and show up clearly on air photos. The sands which border and lie between them must be regarded as the delta of the Thames in this old lake. These formations have greatly influenced the soils of the area and are clearly reflected on the soil map of Kent County (Appendix C).

From Chatham to Windsor the shoreline of this ancient water plane is somewhat vague but the land below the 600-foot contour is very flat and bears a deeper deposit of lacustrine clay than the clay plain to the south. In the city of Windsor there is evidence of stream cutting below the 600-foot contour, while south of Windsor at corresponding levels, shallow, gritty sand deposits are found on the clay. South of Amherstburg, the thin beach through Malden Centre stands just above 600 feet a.s.l. and no doubt marks this water plane at the western end of Lake Erie.

In the previous editions of this book we stated our belief that both Lake Dresden and the higher level of Lake Erie, which invaded the low area around Dunnville, were contemporaneous with Early Lake Algonquin. We did not at that time dispute the interpretation of Leverett and Taylor (1915), who, in turn, had accepted the conclusion of Fairchild (1907b) concerning the drainage of Lake Dana (hypo-Warren or hyper-Iroquois) waters toward the Rome outlet. In doing so, however, they were at some pains to discredit Spencer (Leverett and Taylor 1915, p.407) who had earlier contended that Lake Algonquin did not drain southward.

In more recent studies, Hough (1963) traced a connection between Early Lake Algonquin and Lake Chicago, thus demonstrating that the water level in the Lake Huron basin was controlled by the bedrock sill at Chicago. He gives this as the reason why the Algonquin beach was formed at 605 feet a.s.l. at Sarnia, instead of at a lower level which must surely have resulted if the drainage had been toward the south. The fact that Fairchild did not actually trace the continuity of his suggested drainage connections and, in addition, the fact that neither Fairchild nor Leverett and Taylor successfully demonstrated that they were dealing with the same water planes in the eastern and western ends of the Lake Erie basin, both strongly support Hough's contention. Allowing for a few feet of crustal uplift we conclude that the Algonquin shoreline and the Dresden shoreline, both at 605 feet a.s.l., are contemporaries. We therefore endorse Hough's hypothesis of northward drainage at Sarnia and control by the Chicago outlet over the water level at the time of the Early Algonguin beach. It follows, of course, that we accept Hough's idea of the Early Algonquin stage in the Lake Erie basin because we had already come to a similar conclusion. However, Hough's portrayal of the situation along the north shore of Lake Erie (Hough 1958, Fig. 67A) is, even on such a small-scale map, completely unacceptable to us.

Although the Dresden water level can be traced past Windsor and Amherstburg into the western end of the Lake Erie basin, it cannot unfortunately be followed to the eastern end. The north shore of Lake Erie, for a long distance, is marked by bluffs which in some places are more than 100 feet in height, while an extended area of old lacustrine formations, including nearly everything below Warren levels, has been eroded away (Chapman and Putnam 1943a, p.117). Thus the nearest land low enough to record the features of Early Algonquin time must be at Long Point and, much more extensive and important, the area from around Dunnville eastward to the Niagara River.

A considerable area of the Erie plain in the Niagara Peninsula lies below 600 feet and it is all remarkably flat. On the western end of this flat plain there are shallow sand deposits over the clay representing deltaic formations of the Grand River. In searching for a shoreline to surround this low ground one finds the fragments in the Humberstone, Crowland, and Crystal Beach areas which have already been mentioned. Of these the strongest and most likely correlative of the Dresden shoreline is the strand from Sherkston to Crystal Beach with its benchmark of 618 feet a.s.l.

The "hinge line" or isobase of zero uplift in Lake Algonquin time (for the 605-foot water plane) as portrayed by both Leverett and Taylor (1915) and Hough (1958) should pass somewhere between Long Point and Dunnville, hence the beach toward the east will be upwarped and quite probably split. This seems to have been the case.

To the north of the Oak Ridges Moraine, there existed another lake or series of pondings to which we have given the name Lake Schomberg. Because it is superimposed upon a strongly drumlinized till plain the Schomberg plain is not so nearly level as the Peel plain but it is characterized by more extensive, and deeper, beds of varved clay. In many parts of this plain the varves are unusually thick, three- or four-inch couplets being not uncommon. In colour, the clay layers are brown, while the silty layers are pale grey. The latter layers also are quite calcareous. Samples of the clay deposits from some areas showed, upon analysis, that the beds contained about 40 to 50% calcium carbonate: mainly rock flour, ground up by the glacier as it overrode the edges of the Paleozoic carbonate formations to the northeast. In some places, as for instance to the east of Newmarket, the material is more largely composed of silt-sized particles, but again in the Lake Scugog area there is less silt and more clay.

The physiographic characteristics of these three areas are somewhat different. The Schomberg area may be described as drumlins and clay flats, the Newmarket area as a dissected clay plain, while the area north of Lake Scugog has shallow clay deposits and resembles the Peel plain, but is more nearly flat and also more poorly drained. The Scugog area is joined to the Schomberg area by a series of narrow valleys through the intervening upland. For the most part they have swampy floors, but along their edges it is possible to trace the same type of calcareous, varved clay that is found in the main areas.

These water bodies did not leave well-formed continuous shorelines, so they were either short lived or had fluctuating water levels. The identification of outlets and, therefore, correlation with recognized stages in the Great Lakes basins is difficult. At a higher level there is some evidence that a spillway across the Oak Ridges Moraine at a present level of 950 feet a.s.l. was in operation at Palgrave, leading past Caledon East and Georgetown. There is a fairly good set of beaches to be found along the western side of Lake Simcoe, indicating a shoreline at about 90 to 100 feet above the Main Algonquin beach in this area. Such a water plane, and in fact any water plane below the Palgrave channel, must have emptied to the east or the west until the Kirkfield outlet was opened. This could only have been when the ice front was receding toward Kirkfield, at least partly in Early Algonquin time.

The outlet of Lake Peel must at first have been over the Niagara Escarpment where a series of gaps are found at different levels. One of the more spectacular of these is the Lake Medad channel between 800 and 825 feet a.s.l. However, there had to be later and lower outlets as the glacier shrank away from the escarpment. A few scattered areas of sand near Mount Nemo and Rock Chapel give indication of water action, but perhaps most of the water escaped through a marginal area of stagnant ice along the escarpment.

LAKE ALGONQUIN AND LAKE NIPISSING

Lake Algonquin was much longer lived than the earlier glacial lakes discussed above. Its main shoreline is about as mature as that of Lake Huron, and is far better developed than any of the earlier shorelines. In fact several of the lower stages of Lake Algonquin are better marked than the shoreline of Lake Whittlesey, and are nearly as prominent as the Warren shoreline. Lake Nipissing produced beaches or bluffs second only in size to those of Lake Algonquin in the Huron basin. The Algonquin shoreline consists of a bluff over most of the 200 miles from Grand Bend to Collingwood, with beaches appearing near the streams, and occasionally elsewhere.

SARNIA TO TOBERMORY: Between Sarnia and Grand Bend, or south of the hinge line, where the Algonquin and Nipissing shorelines are both horizontal, they occur at approximately 605 feet a.s.l. They cannot always be separated. However, the gravel beaches between Sarnia and Vyner lie just above the 600-foot contour and are regarded as Algonquin beaches. The sand dunes between Point Edward and Blackwell may be attributed to both Algonquin and Nipissing. This also applies to the larger belt of dunes between Kettle Point and Grand Bend. Between these belts of dunes the ancient shorecliffs have been undercut by the modern lake except north of Gustin Grove where a 50-foot shorecliff departs from the present shore making a small coastal plain where a few fruit farms have developed.

Behind the two belts of dunes mentioned above are silty flats containing marlbeds, black muck, and shallow lakes. Lake Wawanosh in the Blackwell area has been drained and its bed reclaimed for special cash crops. Occasionally in the spring, ice along the shore of Lake Huron blocks the outlet of the canal, temporarily re-establishing the lake. Part of the larger lagoon in the lower Ausable River valley has been drained and the land reclaimed. It is well known as the Thedford Marsh. North of Thedford the edge of the lagoon is sharply marked by a bluff which is probably an Algonquin feature.

The four miles to one inch map does not show the shorecliff between Grand Bend and Point Clark, which suggests that the Algonquin and Nipissing bluffs have all been undercut by the present lake, although they may have had much to do with the initiation of the high bluffs along this shore. At its best near Goderich the bluff is over 100 feet high and it is seldom less than 50 feet high. Taylor (1913) reported seeing one bit of beach four miles south of Bayfield that appeared to be an Algonquin feature. From Point Clark northward to Port Elgin the Algonquin bluff runs some distance back from the shore of Lake Huron. The terrace below it carries a boulder pavement modified by numerous gravel ridges and sand dunes. The Nipissing shoreline is usually present as a smaller bluff, a line of dunes, or a beach ridge.

Another lagoon in the Saugeen Valley was confined by a massive barrier beach built from the south side of the valley through the outskirts of Port Elgin. The bar is mainly of gravel with some dunes added. It causes the Saugeen River to deflect five miles northward before heading out to the lake. On the floor of the lagoon are level beds of silt and fine sand which, like all the soil materials along the eastern shore of Lake Huron, are highly calcareous.

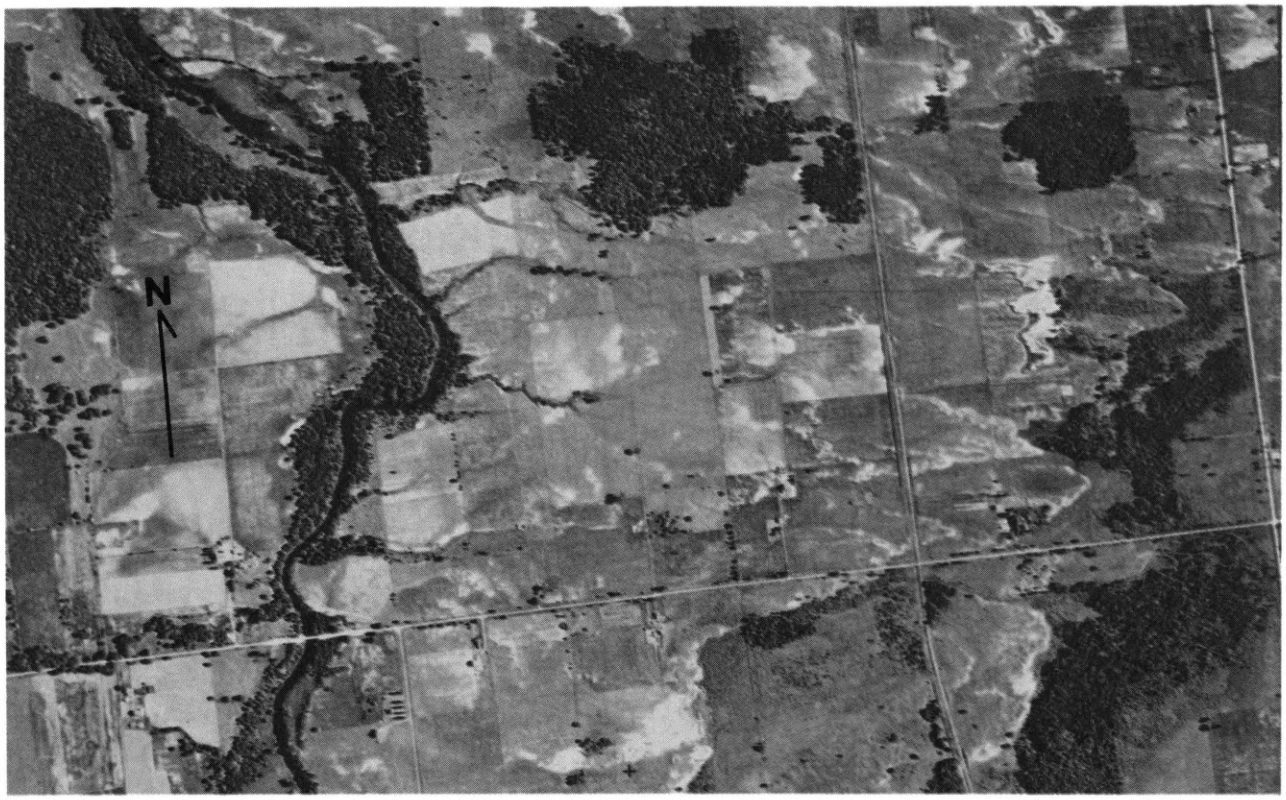
Where it encroached on the drumlins north of Port Elgin, Lake Algonquin cut into their sides, no doubt obliterating some before it retired. Between the drumlins the waves constructed the heavy-storm beaches which impound Marysville and Gould Lakes. From Gould Lake a sand and gravel spit projects toward Hepworth, while behind it a succession of strands fan out around the northeastern end of the lake. From a point east of Park Head a sandy beach swings around Hepworth separating Shallow Lake and McNab Lake, both now drained, from the body of the lake plain. The familiar pattern of wave-cut drumlins connected by beaches reappears east of Clavering. The swampy depression around Hepworth Lake is below Algonquin levels, but that lake is held on the west by drumlins rather than a baymouth bar. Another Algonquin beach lies on the side of a drumlin three miles west of that corner at the border of a scoured, boulder-strewn floor of dolostone. Along Colpoys Bay the dolostone scarp served as the shore. A well-preserved beach of coarse shaly gravel at approximately 810 feet a.s.l. is built across a shallow re-entrant in the scarp west of North Keppel and it runs southeastward in diminished strength.

In the Port Elgin-Southampton area the Saugeen River debouched a large amount of sand into this lake. It appears that sand from this source was swept northward alongshore toward Sauble Beach and Hepworth where it merged with sand brought down by the Sauble River. This sand plain has a full complement of dunes which have become active since the land was cleared. The peculiar form of these blowouts is well illustrated on the air photo in Photo 27. A closeup of the blowout is shown in Photo 28. Near Frenchman Bay the bouldery remnants of a drumlin may be seen.

On much of the limestone plains of the Bruce Peninsula it is common to find lines of rubble running roughly parallel to the length of the peninsula. As seen on the ground the bigger ones look like little moraines. They are visible from aloft and show up clearly on air photos as illustrated in Photo 29.

North of Wiarton the hills above 850 feet a.s.l., mostly on Cape Croker, were islands in Lake Algonquin, but only fragmentary beaches are present. Lower Algonquin beaches of sandstone shingle are common in the Cape Croker Indian Reserve (IR 27). The big gravel bar south of Lion's Head, which is conspicuous from the main road into the village, is one of the lower Algonquin beaches. Several gravel beaches on the road to Tobermory have been used up for highway construction. Inland from Pike Bay there are a couple of odd features in the form of potholes in the bedrock. These round pits which occur in the dolostone are 4 to 6 feet in diameter and of similar depths. They are similar to potholes in the limestone floor of the St. Lawrence River which were uncovered during the construction of the dam at Iroquois.

The Nipissing beach was mentioned in connection with the dunes in front of the Blackwell and Thedford Marshes. From Grand Bend to Point Clark the Nipissing bluff has been entirely undercut by Lake Huron. North of Kincardine this shoreline is near the present shore to beyond Inverhuron, taking the form of gravel strands and sand dunes. At Inverhuron, where the Little Ausable River empties, there is a fine sand beach on the shore backed by a belt of dunes which in turn is delimited by a small bluff. The low shorecliff prevails with very few gaps to Sauble Beach where it gives way to sand dunes that continue for nearly 15 miles to Red Bay. As a rule the dunes rise to a height of 50 or 60 feet. A series of small shallow lakes and swamps lies



OGS 10 678

Photo 27. Air photo showing the crescentic pattern of blow-outs on the sand plain near Hepworth, Bruce County. The river is the Sauble. Photo courtesy of the Canadian Armed Forces.

behind the dunes, while in front a wave-washed floor of limestone is littered with a splendid array of beach strands.

The most important effect of Lake Nipissing on the Bruce Peninsula was to leave the calcareous silt in the flat plain of Eastnor Township. At this point the lake overtopped the peninsula leaving the section to the north an island. The beach at Lion's Head on the border of the silt plain is too high to belong to Lake Nipissing. However, on the Lake Huron side curving beaches west of Spry and near Pike Bay at 640 feet a.s.l. probably belong to this lake. The shoreline north of Stokes Bay and Lion's Head is hardly accessible and we have very few records of it. The Nipissing beach is the upper one of the series of shingle beaches at Hope Bay and Dyer Bay. The related beaches at Dunks Bay are more sandy.

WIARTON TO COLLINGWOOD: From Colpoys Bay to Owen Sound the main stage of Lake Algonquin was confined by the sheer bluff which constitutes the Niagara Escarpment in this sector. The gravel ridge at 735 feet a.s.l. crossing the road at Lindenwood is not the highest beach. Two finely formed beaches can be seen along the road south of Hogg. The higher one curves around the drumlin-shaped outlier of the escarpment one mile south of East Linton; the lower one continues a mile farther then hooks to the base of the escarpment. Both consist of coarse, shingly gravel and are finely formed (Photo 30).

The Algonquin bed around Colpoys Bay and Owen Sound consists of wave-swept shelves of sand-

OGS 10 679

Photo 28. Close-up of dune sands near Hepworth, Bruce County. Photo courtesy of M.B. McLeod.

OGS 10 680

Photo 29. Air photo of little moraines west of Owen Sound. Photo courtesy of the Canadian Armed Forces.

stone and shale. Red shale appears in the Colpoys Range, elsewhere it is not important. The shallow soil is interrupted west of Kemble by a deeper scattering of rocky debris which is either a moraine or an ice rampart.

Between Owen Sound and Annan several drumlins bore the brunt of the Algonquin waves and are surfaced with boulder pavement. A barrier beach lies across Telfer Creek valley. For two miles on either side of Annan the shoreline consists of a bluff which is most prominent on the sides of drumlins. From the end of this bluff a barrier beach with several crests bridged the strait south of Coffin Hill. The clay and shale of the adjacent lake bed is badly gullied near the Nipissing bluff from Leith to Coffin Hill. From Coffin Hill to the mainland on the east the waves failed to close off the little bay. The main force of the waves came from the northeast judging by the gravel spit projecting southward from the northeastern shore of the bay. There is another composite bar which crosses the corner at Balaclava, its crest taking a 775-foot contour on the Owen Sound map sheet (NTS 41 A/10). Around Cape Rich the Algonquin bluff is cut in shale of the Queenston Formation. It has been undercut subsequently at the Claybanks (west of Cape Rich) by Lake Nipissing and Georgian Bay. Beaches were thrown across either end of the crooked valley in the bedrock now identified by Sucker Creek and Mountain Lake; Mountain Lake is held up by the baymouth bar at its eastern end. At three lower elevations near Cape Rich fairly strong Algonquin beaches occur, while another fainter strand a few tens of feet west of Cape Rich corner lies half buried under silt. These beaches are described by Stanley (1937, 1938) and Nichols (1972) who studied the Algonquin shorelines in considerable detail from here eastward.

Between Cape Rich and Collingwood the Algonquin shorecliff coincides with the base of the Niagara Escarpment (Blue Mountain) along the three former headlands separated by the Bighead River and Beaver River valleys. Across the mouths of these valleys, back of Meaford and Thornbury, great curving barrier beaches appear. Being composed of a dozen or more gravel strands, they are splendid examples of their kind, the highest crests being built up well over 25 feet. South of Meaford there is a shorecliff with a series of beaches left on the terrace below.

In front of the barrier beaches just described the Bighead and Beaver Rivers have built deltas of sand and silt (Photo 31). The delta in the Beaver Valley grades typically from coarse sand to fine sand to silt, the silt appearing from Thornbury to the eighth line of Collingwood Township. At the mouth of the Bighead River there is a much larger sandy area. Some sandy ridges, running north and south back of Meaford stand up above the level of the sand plain. They are regarded as glaciofluvial deposits and no doubt account for the extra sand in the Bighead Valley.

The Nipissing bluff is fairly continuous south of Colpoys Bay not far from the shore. It is higher

OGS 10 681

Photo 30. Beach of Lake Algonquin near Hogg, north of Owen Sound.

around Cape Commodore and a series of beaches lies below it. The bluff continues to Owen Sound, usually accompanied by a boulder pavement and shingle beaches, with a spit built from the south occurring at Gravelly Bay. The bluff continues in good form to Collingwood. A barrier beach appears at Leith across Telfer and Keefer Creeks. The Nipissing bluff has been undercut opposite Coffin Hill, at the Claybanks, and again east of Meaford. The Claybanks, it should be noted, are worn in shale, as are the other high bluffs opposite the promontories of Blue Mountain. Near Meaford and Thornbury where they are cut in clay and sand or till, the bluffs are fairly small which is fortunate as they run through both towns. On the bouldery terrace below the bluff a particularly numerous set of sand and gravel strands occurs between Craigleith and Collingwood. Photo 32 shows them as displayed on an air photo.

NOTTAWASAGA BASIN: Between Collingwood and the boundary of the Precambrian bedrock north of Orillia the bed of Lake Algonquin has an area of 1,200 square miles, exclusive of Lake Simcoe. The shoreline is estimated to be 400 miles long. It is highly irregular, with great bays and islands. Not only one but several beaches or bluffs are present. No finer assemblage of abandoned shorelines is to be found in the Province. Maps 2226 and 2228 show the upper shoreline, the stronger lower beaches, and the bouldery terraces. Where several beaches lie close together it is impossible to map them all on either Map P.2715 or the four miles to one inch maps; for instance the broad gravel bar shown at Colwell actually has several strands.

In the Stayner area the Algonquin shoreline lies against the base of the Corn Hill Moraine with a broad, wave-swept, bouldery belt before it. Where it rounds the end of this moraine five miles east of Creemore, a big gravel spit comprising seven distinct strands was built across the valley of Coates Creek. The line of sand dunes south of New Lowell is due to lower stages. In the sandy area north of Everett the Algonquin sands join other sand beds above Algonquin levels and the shoreline is indefinite. The lake south of Alliston was shallow with poor shore features, and the sediments are strongly calcareous.

The sediments in the arm running from Beeton past Cookstown on the east are of calcareous silt with some fine sand and clay interbedded. Around Alliston and northward to Angus the sediments are sandy having come from the terraces on the escarpment down the Boyne, Pine, and Mad Rivers. Three or four feet of fine sand over coarser sand is the common sequence. The Nottawasaga River is well entrenched in Essa Township giving good drainage to the sand plain adjacent. Away from the rivers the water table is higher, even producing bogs on the Camp Borden property and in the col east of Colwell. A glance at a contour map will reveal that the railways made use of the level grades provided by the Algonquin flats.

It would be a fruitless task at this time to

OGS 10 682

Photo 31. Flat lake plain delta of the Bighead River, Grey County. Photo courtesy of M.B. McLeod.

OGS 10 683

Photo 32. Air photo of the country just west of Collingwood showing: top (north), Georgian Bay; upper right, multiple beach strands in the Nipissing lake plain; from upper left corner southeastwards, the Nipissing shorecliff with gullies extending into the Algonquin clay beds above; lower left, the wooded lower slopes of Blue Mountain ending at the Algonquin shorecliff, which is not distinct on this photo. Photo courtesy of the Canadian Armed Forces.

describe all the Algonquin shorelines in Simcoe County. However, some of the really magnificent features must not be missed; beyond that, Map P.2715 (back pocket) or the four miles to one inch map (Map No. 2228), will have to suffice. The big spit at Colwell with multiple strands has already been described and some other good gravel beaches appear along the base of the bluff south of Colwell. The valley-sides west of Barrie were considerably steepened by undercutting of the ancient lake. The Canadian Pacific Railway follows the wave-cut terrace from Colwell to Midhurst and beyond. In this section the bluffs stand over 200 feet high at the maximum. The lake managed to throw a barrier beach across the mouth of the Little Lake depression, and great quantities of gravel have been removed from it by the Canadian Pacific Railway. West of both Hillsdale and Waverley bold bluffs have been cut in the sides of the uplands (Photo 33). Within the long valleys of the Coldwater and Sturgeon Rivers, themselves floored with sand, the shore features are at their weakest. The northern ends of these north Simcoe islands have bold upper shore-cliffs with boulder pavement and in places a series of beaches lower on the slopes. The Penetang Peninsula exhibits a great deal of boulder pavement, the boulders invariably being from the Precambrian bedrock to the north. The sandhills north of Lafontaine hill are old fixed dunes, some of them having started to shift again. Around Lafontaine village deep beds of fine sand and silt underlie a group of good farms.

LAKE SIMCOE BASIN: In the Orillia area the detailed account of the Pleistocene geology by Deane (1946) deals largely, on the map and in the report, with the features of Lake Algonquin. His map shows a corner of the level clay plain in north Orillia Township. The island at Ardtrea is encircled with a startling series of shore features. The crescentic spit which confines Bass Lake and the barrier beach two miles east are both massive beaches. The north-facing promontory between is truncated to provide a terrace and a bluff which rises 70 to 80 feet. The waves completely eroded the top off the hill on which the Huronia Regional Centre is situated giving it a "pancake" top. Wave action produced some boulder pavement on the drumlins east of Orillia while clay was accumulating in the hollows.

OGS 10 684

Photo 33. Algonquin bluff near Waverley, Simcoe County.

On the west side of Lake Simcoe from Orillia to Bradford the Algonquin shoreline is definite and continuous, although not so strongly developed as on the exposures facing Georgian Bay. Beaches are scarce between Orillia and Barrie, at least at the upper level, but they appear at frequent intervals south of Barrie. The shoreline is faint around the Holland Marsh, reappearing in strength as a sandy beach west of Highway 11 near Holland Landing. The sediment in the adjacent plain is sandy; perhaps it may be regarded as a Holland River delta. East of Cook Bay the shoreline is irregular in outline, with several islands appearing. In the wet and sandy depressions that lead southward, the absence of definite beaches makes it hard to distinguish between Algonquin sediments and those at higher levels which are older than Main Algonquin. None of these broad valleys are completely blocked by a barrier beach, but the long spit north of the railway and two to four miles east of Egypt nearly closed one of the entrances. From the point of a drumlin at Wilfrid, a strong gravel beach with two main crests extends northward. Six gravel pits are found on this beach within the same number of miles. Another big pit appears on a spit a mile or more south of Beaverton. Beaches take precedence over bluffs in the area east of Lake Simcoe, the most pronounced bluff occurring along a three-mile stretch directly east of Beaverton. North of here in an area where the limestone often comes to the surface many fragmentary beaches appear in offshore situations mostly on slightly elevated tracts of limestone. Such beaches may be seen just north of Kirkfield. From Balsover, a beach runs with good continuity to the main outlet of Lake Algonquin at Kirkfield.

LAKE NIPISSING EAST OF COLLINGWOOD Lake Nipissing inundated a narrow but continuous border around Georgian Bay east of Collingwood, its abandoned shore being well marked at 50 to 55 feet above the water of Georgian Bay. The lagoon behind the sand dunes at Wasaga Beach is part of the lake plain, while the flats around the Minesing Swamp are an annex at the same level south of the moraine at Edenvale. It is an uninviting strip of land that Lake Nipissing left around Georgian Bay as the soil is usually stony or wet. The deeper beds of sedi-

ments which would have given rise to good soil lie submerged in the bay.

Immediately west of Collingwood the 15-foot bluff of Lake Nipissing is easily identified. Several good farms are situated above it. On the southern approaches to that town a beach divides the Nipissing and Algonquin plains, and several lower beaches appear in the vicinity of the golf course. East of Collingwood a low bluff extends to the point of contact with the Wasaga dunes. In the Jack Lake vicinity two or three of the lower Algonquin beaches are close to or even in contact with the bluff and beach at Lake Nipissing, while in the lagoon two other gravel bars lie partly buried by marl. On the eastern border of the lagoon, also, a beach above the Nipissing beach should be identified with Lake Algonquin, along with a lower beach which is mostly buried in the marl. The latter is the one which Stanley (1936) discussed as the Payette beach.

The barrier across the mouth of the Jack Lake lagoon takes the form of a belt of sand dunes. They are associated with the famous Wasaga Beach. Reflecting the prevailing winds, the crests of the dunes trend 120° to 130°. The majority of them rise to about 100 feet above the bay while the highest crests are 175 feet above.

The Nipissing bluff is bold all around the Penetang Peninsula and on the headlands between Midland and Coldwater.

MANITOULIN ISLAND: All of Manitoulin Island was under the water of Lake Algonquin except the highest part of the tableland east of West Bay. We must report that no beach was found on that promontory to mark the shoreline, but it has an elevation of over 1,000 feet a.s.l. and the upper Algonquin beach should occur at approximately 950 feet a.s.l. (Leverett and Taylor 1915). Fragmentary beaches are found on the island and boulder pavement is prevalent on drumlins. Algonquin sediments provide the best soils on Manitoulin. They are mostly silty but vary from silty clay to fine sand. They occupy the lowlands north and south of Lake Mindemoya, around Wolsey Lake, in Gordon Township, and in smaller patches elsewhere. The sediments are mildly calcareous and are derived mainly from local till. In fact the scanty till has been washed off extensive areas of limestone on this island.

The Nipissing shoreline shows up as low bluffs or sandy beaches and dunes at most points along the south shore of Manitoulin Island, but it is sometimes missing in areas of bare limestone. Low bluffs are cut in the clay south of Manitowaning. A bluff, with dunes on the limestone floor below it, appears at Providence Bay and Burpee. A series of sandy beaches is found near Murray Point and Carroll Wood Bay. Along the precipitous north shore of the island the Nipissing beach often appears at the heads of the bays. A low bluff extends across the settled part of Barrie Island. A small bluff appears five to seven miles west of Little Current, while a distinct shorecliff and bouldery terrace crosses the road just south of Sheguiandah. We have not visited the Duck Islands but what appears to be a Nipissing shoreline is conspicuous on the air photos of Great Duck Island.

COCKBURN AND ST. JOSEPH ISLANDS: Nowhere is there a better display of Algonquin and Nipissing shorelines than on Cockburn and St. Joseph Islands. Both islands have morainic hills or uplands which were high enough to stand up as islands in Lake Algonquin and are encircled by high shorecliffs, except on the west side of the "mountain" on St. Joseph where there are some beaches. At least half of these islands is covered with boulder pavement, while most of the remainder consists of sand plains. The northwestern third of St. Joseph Island contains a good deal of lacustrine clay, interbanded pink and grey in colour, and fine in texture. Lake Nipissing is responsible for particularly bouldery terraces on the borders of these islands, bounded inwardly by bold shorelines at about 640 feet a.s.l. The main beaches are marked on Map P.2715 (back pocket) and the four miles to one inch map and may be referred to easily.

On Cockburn Island the beaches which extend toward the northwest from the central hill are a series of massive gravel strands on the shoulder of high ground. The beaches south of the group of drumlins are also well formed. The boulder pavements are sandy and may be wet or dry, but the water table is generally near the surface. Practically all the stones and boulders are of Precambrian origin from the north. Southeast and south of the central hill some sand dunes appear. The Nipissing shoreline consists of bluffs on the west and north, and a beach, mostly on the east and south side of the island.

On St. Joseph Island the upper Algonquin beaches which impound the little Mountain Lake actually form a terrace, over a quarter of a mile wide, that is a tremendous deposit of coarse gravel. The Main Algonquin beach, at about 900 feet a.s.l., also crosses the road between Carterton and Otter Lake. A good series of lower Algonquin beaches appears on the slope west of Otter Lake. Sand dunes occur in a belt extending westward from the northern corner of the "mountain". Another good set of lower Algonquin beaches is found between 700 and 800 feet a.s.l. on the slope west of Hilton Beach. The Nipissing shoreline mostly takes the form of a bluff. In the northwest it is cut in the clay of St. Joseph Township. It is continuous from Otter Lake to Rains

Lake in the southern end of the island and rises to a height of 50 feet. In the latter vicinity there is a great number of beach strands within Nipissing levels. North of Hilton Beach the Nipissing bluff sometimes coincides with a limestone scarp, but an extremely bouldery terrace is invariably present below it.

KIRKFIELD TO NORTH BAY: The low-lying lands in Muskoka, Parry Sound, and Nipissing, especially for a few miles on either side of Highway 11, may contain stratified deposits of clay, silt, and sand. Generally horizontally bedded, they produce level plains on the surface. The clay and silt beds usually have regular darker and lighter layers of clayey and silty sediments, respectively, which form the characteristic varved clay of glacial lakes. The clays here were deposited in glacial Lake Algonquin in its main and later stages (Leverett and Taylor 1915; Chapman 1954). A minor exception should be mentioned in the flat silt plain bordering Lake Nipissing and small tracts here and there along the shore of Georgian Bay. There the sediments are not varved because the lake in which they were deposited, the Nipissing, was post-glacial. It should be noted also that the Nipissing lake plain is quite flat and does not have the scattered shallow depressions found in Algonquin plains.

The shoreline of Lake Algonquin cannot be traced precisely because of the lack of beaches and shorecliffs, but it has been determined approximately by the upper limit of lacustrine clay and sand, and bare, wave-washed rocks. In areas which were never submerged, the rocks generally have at least a thin covering of soil. There were quite a few offshore islands, as shown on Figure 10.

It is now generally accepted that the weight of ice in continental glaciers causes a depression of the earth's crust, the maximum being under the thickest, inner parts of the ice sheets (Farrand and Gajda 1962). As the glacier melts, isostatic readjustment occurs and the earth's crust rises again, rapidly during the unloading and uncovering of an area, then slowly to a very low rate as a stable position is approached. In keeping with this theory, the lower lands in Muskoka, Parry Sound, and Nipissing were submerged during the recession from the area, even though the present outlet, the St. Clair River, was open at that time. The old shoreline is now found at 605 feet a.s.l. near Sarnia, 883 feet a.s.l. at the outlet east of Kirkfield, rising to 1,220 feet near South River.

The beach at Maple Lake, 10 miles northwest of Haliburton, relates to a small annex of Lake Algonquin extending northeast of Balsam Lake to Kinmount, and to Minden and up the Gull River valley. A good-sized area of silt and fine sand occurs south of Kinmount and there is varved clay at the golf course near Minden.

A few elevations of the highest Algonquin beach between Kirkfield and North Bay are given elsewhere (Chapman 1954; Goldthwait 1910). Because of the scarcity of beaches the three good beaches at the Cobb farm, four miles west of Powassan in lot 3, concession III, Nipissing Township, should be mentioned, even though the highest one is not the highest Algonquin beach. Their elevations were determined at 1,053 feet, 1,041 feet, and 974 feet a.s.l., levelling from the lake nearby. The sandy terrace at the entrance to the Nipissing Ridge ski run may also be a beach. The elevation at the base is 1,106 feet a.s.l. measured from the 715.30-foot bench mark on the road southeast of Nipissing village. Harrison (1972) also mentioned these and comparable beaches on the same hill. A good beach at 1,044 feet a.s.l. a mile south of the Cobb farm is well formed and definite. Beaches at Cooks Mills near the North Bay airport stand at 1,177 feet a.s.l. (Chapman 1954; Goldthwait 1910).

In the northern part of the Algonquin lake plain there are silty clay and sand deposits around Powassan and eastward through Chisholm Township under the 1,100-foot contour. Similarly the varved clay in Bonfield Township is found in hollows nearly up to but not above 1,000 feet a.s.l. In Calvin Township the varved clay seldom occurs above 900 feet a.s.l., and 850 feet is the upper limit southeast of Mattawa.

LAKE IROQUOIS

From the Niagara River to Trenton the Iroquois beach lies two to eight miles from Lake Ontario except at Scarborough Bluffs where it swings in to the present shore. East of Trenton a much wider belt was flooded. The Iroquois shore features are comparable to those of Lake Algonquin; that is, they are unsurpassed in boldness and are about as well developed as those of Lake Ontario.

From Queenston to Toronto the beaches consist of shingle of calcareous siltstone that comes from the local shales, together with limestone gravel and the inevitable sprinkling of granite, quartzite, etc., from the Canadian Shield. Sand beaches are scarce in the Niagara fruit belt, occupying only seven or eight of the 45 miles of shoreline. Highway 8 (Regional Road 81) is built on the beach through St. Catharines and eastward to Homer. This highway also touches part of the massive beach west of Stony Creek where it passes through the cherry orchards that have found the gravelly soil to their liking. In fact this highway closely follows the Iroquois bluff from Queenston to Hamilton. At Hamilton there is the magnificent bar across the lower Dundas Valley which carries the highway, railroad, and the famous Royal Botannical Gardens. The early truck crops for which the Aldershot vicinity is noted are grown on the Iroquois beach. From here to Clarkson the shorecliff is cut in red shale and beaches are limited to a few short

strands. The gravel bar across the mouth of the Credit Valley is 75 feet thick at the maximum, although the bottom part of this deposit is glaciofluvial in nature. Built from the southwest it forces the river northward below Erindale (in the City of Mississauga), and for many years it was the most important source of gravel in that area. From Cooksville (in the City of Mississauga) through to the Dixie district the beach used to be covered with orchards, but it has now become a heavily built-up area. In the Islington area the brow of the bluff has special value as real estate.

Like the Credit, the Humber and Don Rivers are deflected by sand and gravel bars, although these are built from the east rather than from the west. Both bars were used as sources of sand and gravel but the pits are now masked by the houses that occupy the sites. In Toronto the Davenport Road hill is well known as the Iroquois shorecliff while the McLennan hill is the same bluff east of Yonge Street. It has a weak form because of the protected location, and crosses O'Connor Drive, west of Dawes Road.

East of the Scarborough Bluffs the ancient lake encroached upon a rolling till plain so that beaches and bluffs follow each other in close succession. The sandy belt mapped under this shoreline is an offshore terrace which includes a good deal of wet boulder pavement. Much of the sand is less than six feet deep; deep sand occurs in the Ganaraska Valley and is frequent east of Port Hope. While some of the latter sand is deltaic, most of it is derived from local till by wave action. The first heavy beach east of Scarborough Bluffs was the one on which there are now old gravel pits, two miles east of Malvern. It deflects the Rouge River eastward. There were eight barrier beaches across the mouths of small valleys between Rouge Hill (in the City of Scarborough) and Oshawa, most of them now removed for sand and gravel. Between them the shorecliff is definite but not high. North of Bowmanville the beach swings lakeward around several drumlins and at this point the Canadian National Railway, which follows the shoreline to the west and east, takes the direct route through the enclosed lagoon. Highway 2 touches a strong beach three and a half miles east of Newcastle and runs on its crest for two miles east of Newtonville. This beach is built around glacial hills after the manner of the beach north of Bowmanville. Gravel pits have been in operation on two hills northwest of Port Hope, working beach gravels lying below the altitude of the Iroquois beach.

Through Northumberland County there are big drumlins pointing southwestward. The waves levelled them near the Iroquois shore and cut high bluffs along the shoreline itself. Thirty feet below the beach the drumlins again appear intact except for a concentration of stones on the surface.

Probably the best beach between Port Hope and Trenton is at Little Lake, called Biddy Lake on the maps. It is composed of several strands built from the gravel of an esker. Not only does it impound Little Lake but it serves as a drainage divide forcing the overflow from the lake to run north on a roundabout route *via* the Trent River to Lake Ontario. From Biddy Lake to the Murray Hills there are only short bits of beaches, the remainder of the distance is marked by a high bluff and a broad dry sandy terrace which is best developed around the Murray Hills. At its best, the shorecliff on this shoulder of land is 200 feet high.

From the Murray Hills to Hastings the Iroquois shoreline is irregular and the shore features are weakly developed. Cramahe Hill has a distinct terrace cut in its eastern flank, and so has the smaller island lying east of it. The islands north of Campbellford also have distinct bluffs and beaches on their eastern exposures. Wave-built features are absent in the Rice Lake area.

East of the Trent River the hills around Oak Lake stood as an island in Lake Iroquois. Coleman (1937) described it vividly. Oak Lake is confined by a beach on the north and thus remains as it was at the time when its mother lake was in existence. There are gravel bars on either end of the island. The southeastern shore consisted of bluffs up to 100 feet high.

Northeast of Oak Lake near West Huntingdon another hill just managed to break water in Lake Iroquois. Aptly, it is called Pancake hill, because it is flat topped. The gravel bars at the northwest corner represent the most easterly of Iroquois beaches. The remainder of the surface is a boulder pavement. Four more of these decapitated hills may be seen north and east of Frankford complete with gravel bars on their northwest sections. On the West Huntingdon hill a large deposit of gravel, swept over the northwest shoulder of the hill, was completely excavated many years ago at the old Fuller pit.

The sands and gravels in all the beaches east of Oshawa are composed mainly of limestone, contain little or no shale, and make good concrete aggregate.

The sediments in the bed of Lake Iroquois will be discussed later in the descriptions of "Physiographic Regions".

As the glacier receded from Covey Hill, New York, and uncovered outlets lower than the Mohawk Valley the water levels dropped in the Lake Ontario basin. However, none of these water planes produced well-marked beaches along the

north shore of Lake Ontario. The Champlain Sea came into existence when the glacier receded from the lower St. Lawrence Valley far enough to allow access to the sea. Marine fossils are not found west of Brockville so that point is taken as the western limit of saltwater.

CHAMPLAIN SEA

The western limit of submergence of the Champlain Sea is indefinite because of the rocky nature of the slope and consequent lack of shore features. Thus, we can only set its limits at the limits of the stratified clay, bearing in mind the beach at Kingsmere, north of Ottawa, at 690 feet a.s.l., and the beaches containing marine shells northwest of Prescott at about 405 feet a.s.l.

There is, however, an abundance of beaches in eastern Ontario; as the land finally rose above sea level the waves threw up beaches or bars on prominences throughout the area. In the west, on the outcrops of dolostone of the of Beekmantown Formation, the beaches are usually built of shingle. Shales of the Chazy Group also provided shingle for beaches, chiefly in the vicinity of Metcalfe. The drift yielded rounded gravel. Erosion of till on the drumlins or elsewhere created boulder pavements. This is the cause of so much excessively stony land in these eastern counties. Many of the boulder pavements (Photo 34) were cleared when the land was brought under cultivation but the heaviest of them still remain.

The extensive sand beds in the Ottawa Valley around Petawawa are deltaic, brought in by the Petawawa, Barron, and Ottawa Rivers of the time. East of Ottawa similar sands represent the last major deposition of sediments in eastern Ontario. The fairly extensive sand beds in eastern Leeds and Grenville, and in the United Counties of Stormont, Dundas, and Glengarry originated as glaciofluvial deposits.

OGS 10 685

Photo 34. Boulder beach produced by wave action on a till ridge near Greenfield, Glengarry County.

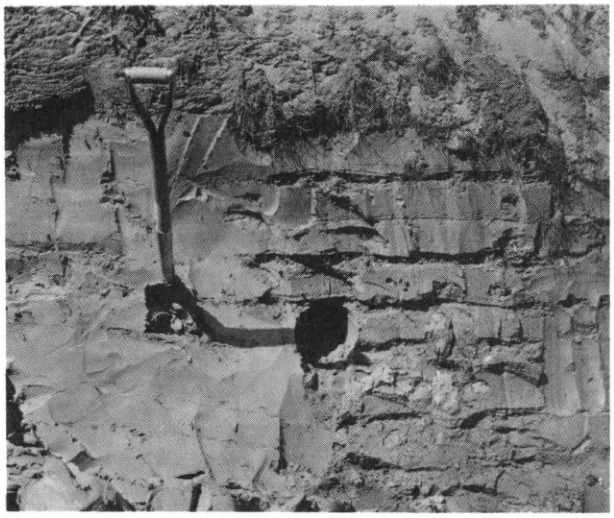
The marine clays of eastern Ontario must be separated into at least three classes, each of which has given rise to specific soil types. There is the grey calcareous clay common to Grenville, Dundas, Stormont, and southern Grenville. Other grey clay containing much less lime is found in Leeds, Lanark, and Renfrew Counties. East of Ottawa the pink and grey clay (Photo 35) is still lower in lime and no doubt from a different source. The latter two types were largely brought in by the early Ottawa River and by streams from the adjacent Laurentian uplands. In some places these clay beds are very deep, with thicknesses of 180 feet, 186 feet, and 220 feet being reported by well-drillers in the Ottawa area. On the other hand there are innumerable small tracts of shallow clay on limestone.

In the Ottawa Valley it should be noted that lake sediments mapped in the Golden Lake and Round Lake areas stand over 100 feet higher than the projected Champlain Sea levels of about 475 feet a.s.l. So they must relate to a separate, likely earlier, lake dammed to higher levels (Burger 1967). The till ridge just east of Mud Lake (formerly Wilber Lake), now cut through by a channel, apparently served as a dam long enough for considerable fine sand and silt to be deposited. The upper end of the Champlain Sea above Pembroke is occupied by sand deposits through which the Ottawa River has cut a great channel.

LOESS (EOLIAN SILT)

In our three articles on the physiography of the south-central, eastern, and southwestern parts of Southern Ontario (Putnam and Chapman 1936; Chapman and Putnam 1940, 1943a), no mention was made of loess, or wind-deposited silt. Deep beds of loess like those of the upper Mississippi Valley are not found in Ontario. However, there are shallow, discontinuous deposits of uniform silt on the till plains which we are now disposed to look upon as eolian material or loess.

The identification of loess where the deposit is shallow is not simple because it must be distinguished from the leached horizons of the soil. Moreover, the loamy calcareous tills so common in the south part of Southern Ontario present a special difficulty. Upon disintegration the limestone pebbles break down to a silt, and it is not surprising that a lively controversy should develop as to the origin of the surficial silt. While one would not deny that silt is produced by weathering in the A horizons of these



OGS 10 686

Photo 35. Pink and grey marine clay, Carlsbad Springs, east of Ottawa.

Grey Brown Luvisolic soils, the variable depth of the silt can hardly be attributed to weathering. Also, the pebbles quite often come right to the surface, probably due to an absence of loess at these points. It must be noted that the B horizon of the soil almost always occurs at the bottom of the silt even if it is six feet deep, but in a limited number of cases the profile was found, formed entirely in the silt, with unweathered silt below.

The Dundalk till plain commonly has a foot or two of silt on the surface, more or less. Deeper deposits of two to six feet occur uniformly in the Redickville-Honeywood area. The gravel beds of the spillways, so numerous between Palmerston and Wingham, often have an upper blanket of silt. Similar deposits on the gravel terraces in the Grand River valley give rise to the soil type called Burford loam. Fifteen to thirty inches of silt is general on the surface of the Woodstock drumlins. In Middlesex, Huron, Perth, and Oxford Counties, and the Regional Municipality of Waterloo the Huron silt loam of the soil maps (Appendix C) outlines the distribution of loess on the surface of the boulder clay of that region, mostly on the Lucan, Mitchell, and Milverton Moraines. It is also found on low ground in areas of Perth and Brookston silt loam.

In central Ontario the slopes bordering the Oak Ridges Moraine carry fine sand and silt generally, on the surface. It is a little more abundant on the southern side, being as deep as seven or eight feet in places. In Northumberland County the deepest of it is related to Dundonald fine sandy loam (Photo 36) on the county soil map, less deep deposits to Bondhead fine sandy loam, and shallow deposits up to two feet to Bondhead loam. In the Regional Municipality of York, over heavier boulder clay, there is silt on the surface which has given rise to King silt loam.

The drumlins of eastern Ontario do not have a silt covering, nor does it appear on any of the marine sands and clays. On the Canadian Shield any loess on the surface is very scanty and may be disregarded.

From the standpoint of the soils and their cultivation, having loess or stone-free silt on the surface is an obvious boon as they would be much more stony without it. Post-holes and drains would also be harder to dig and all tillage more difficult. On clayey tills the covering of silt creates late soils with perched water tables in wet periods. On sand and gravel the blanket of silt produces more productive and durable soils. Thus the overall effect is one of great benefit to the farmer.

SAND AND GRAVEL DEPOSITS

Among the Pleistocene formations are many sand and gravel deposits. The production of sand and gravel for road construction and concrete aggregate in areas designated under The Pits and Quarries Control Act (1971) increased until 1979 to approximately 100 million tonnes but then dropped to 90 million tonnes in 1980 and 1981 (Gene Matten, Mineral Economist, Industrial Minerals Section, Mineral Resources Branch, Ontario Ministry of Natural

OGS 10 687

Photo 36. Wind-blown silt above the brown soil horizon with glacial till below, in Cramahe Township, Northumberland County.

Resources, Toronto, personal communication, 1983). Its value is increasing even more rapidly especially near the larger cities and where reserves are limited.

The individual aggregate deposits indicated in this text are discussed from a generic standpoint and indicate what was originally deposited there. Since 1960, however, many of these deposits may have been mined. For current detailed information on sand and gravel deposits in Southern Ontario refer to the Aggregate Resource Inventory Papers listed in Appendix B.

In there report on gravel, Hewitt and Karrow (1963) include a small map of southern Ontario showing only gravel-bearing deposits. Map P.2715 (back pocket) shows the formations where gravel may be found and is useful in locating sand and gravel. While there may be some difficulty in sorting out the gravel deposits on this map it has the advantage of identifying the other landforms in which gravel is not likely to be found. Soil maps (Appendix C) may also be used for this purpose and are on a larger scale, as are the other maps of Pleistocene deposits which have been published for much of Southern Ontario (Appendix A). Map P.2715 and the four miles to one inch maps are not detailed enough to include isolated little pockets and hills which may yield useful amounts of sand and gravel nor will they show sand and gravel deposits that are buried under a sheet of till. Air photos are invariably used in modern surveys and these often give indications of the presence and the extent of granular materials.

The largest concentration of sand and gravel in Southern Ontario is found in the outwash associated with the Horseshoe Moraines, particularly in the Orangeville to Brantford area. Beds of fairly uniform gravel 20 to 25 feet deep cover broad areas and 40 feet of material is not uncommon. The ancient beaches, the biggest being those of the long-lived Iroquois, Algonquin, and Nipissing lakes, also provide good deposits of fairly uniform material. An added feature of beach deposits is that they provide a good gradation of grain sizes in the sand fraction. The main limitation of beaches usually is the restricted depth and extent of the deposits; mostly they consist of narrow ridges less than 20 feet deep. Unusually deep and wide bars have been built across the mouths of some of the larger stream valleys, or where a large deposit of glaciofluvial gravel has been reworked by the waves, as at Colborne. The material contained in eskers is much more variable than that in river terraces and beaches, and coarse, cobbly, and even bouldery material is to be expected. Kames and related glaciofluvial deposits consist of variable material and may be loaded with coarse gravel and cobbles or fine sands, usually the latter. Nevertheless, some of the most valuable pits are in deposits of this sort. The Oak Ridges Moraine north and northeast of Toronto is dotted with pits and many prospective sites have been tested.

Sand and gravel for concrete aggregate must be almost free of clay, iron oxides, and organic matter. There are definite upper limits of tolerance for sha-

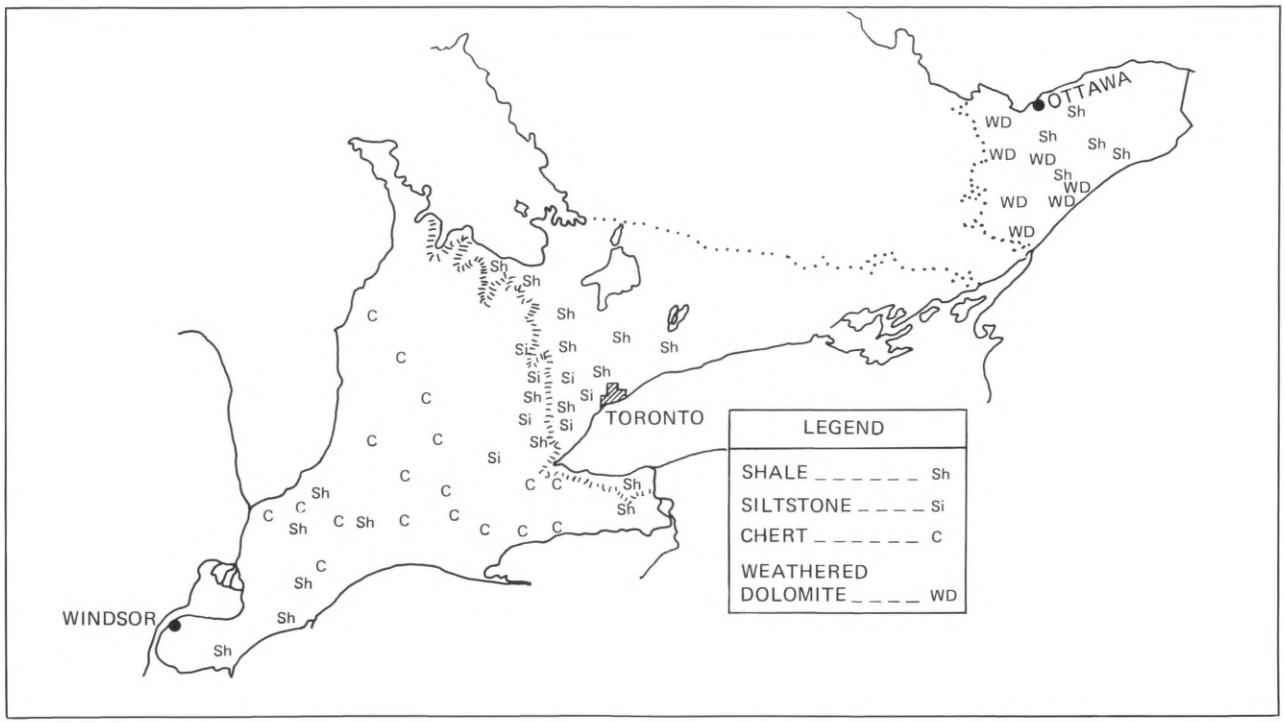


Figure 16. The distribution of deleterious components in gravel in Southern Ontario.

le, chert, weathered silty dolostones, calcareous siltstone, and cemented gravels. In the southern part of Southern Ontario the most widespread offender is shale. It not only disintegrates on freezing and thawing, but may react with the alkalies of cement and eventually cause cracking of the concrete. The deleterious materials in gravel are mapped in a generalized manner in Figure 16. Siltstone is associated with shale, coming from the harder strata in the local shale formations and varies from soft siltstone toward fairly stable arenaceous limestone. It is apparent that there was forward transport of this siltstone from areas of shale onto adjacent limestone and dolostone in eastern Ontario and over the Niagara Escarpment. The outwash deposits extending from Orangeville and Caledon Village to Brantford contain some siltstone, the amount diminishing toward Brantford. There is also some limestone mixed with the dolostone which is the main component. Soft, weathered dolostone is troublesome in much of the St. Lawrence-Ottawa Lowland, the content in some places amounting to more than 15%. High amounts of mica are sometimes found in the sands in the North Bay area.

Chert is the dense, siliceous, flinty material from which arrowheads were made. That found in local limestone is white, cream, brown, or bluish grey in colour. The pieces are irregularly blocky in shape with conchoidal fractures. Chert is prone to shatter on freezing and thawing in the presence of water and sometimes produces alkali reactions in concrete. It is thought to vary in alkali reactivity and brittleness, but at present reactive and nonreactive chert cannot be separated on the basis of appearance, so it is all classed as deleterious.

Gravel of good quality is generally found in the region between Georgian Bay and Lake Simcoe and Kingston. Weathered granite that crumbles readily to sand sizes is common in that area, but since most of it is broken up during crushing it does not constitute a serious problem. There are never more than small amounts of shale and soft siltstones. Limestone is the main component.

The other section of Southern Ontario having very little deleterious material is in the area from Brantford to Durham, and northwestward as shown on Figure 16. Here, sound dolostone is the major component. It is fortunate that good quality and very great reserves of sand and gravel are found together within reach of Hamilton and Toronto.

In the area underlain by Precambrian bedrock, the eskers, kames, and outwash areas shown on Map P.2715 give a lead toward finding useful deposits of aggregate. But a map on the scale of 1:600 000 or four miles to one inch is too small to show all useful deposits. Many of the mapped areas of these features contain too much fine sand and silt for use as aggregate. And an inventory of the tonnage of useful sand and gravel is well beyond the scope of this survey.

In much of Parry Sound, particularly in the areas mapped as "Rock Ridges and Shallow Drift" gravel deposits are quite limited. This holds true in all scattered areas of this type mapped in the southern part of the Georgian Bay-Ottawa Valley region. The central and northeastern parts have generally deeper drift on the bedrock and more gravel.

The most common source of granular material in this northern region is the outwash in the valleys. Railroads, highways, and logging roads follow these level sand terraces as much as possible for obvious reasons. The material in these terraces is mostly sandy, less frequently gravelly, and may be silty. Also, the deposits are usually shallow. Good outwash gravel beds over 15 feet thick are not easy to find. Some of the larger sand and gravel deposits of this type are located as follows:

—at Hickey Settlement on Highway 62 north of Bancroft
—west of Alice along the Indian River west of Pembroke
—at Wylie near Chalk River
—on Highway 17 at Klock
—north of Kawawaymog (Round) Lake, east of South River; this is probably the largest outwash gravel deposit in the Georgian Bay-Ottawa Valley region

Similar to the glacial outwash is the much younger alluvium deposited by the present streams. Usually these alluvial terraces are small and the beds shallow.

Scattered throughout the whole region, kames are also tapped frequently for sand and gravel. In the form of rounded irregular hills and even small humps they consist of gravel, coarse sand, fine sand, and silt irregularly interbedded. There may be boulders, singly or in clusters, as well as masses of dirty, unstratified gravel. Variability is a problem and often leads to selective excavation to take out pockets of gravel leaving the fine sand. Good-sized gravel pits in kames occur along Highway 11 at Powassan, Novar, Emsdale, and Scotia, and in this same area numerous small pockets of gravel occur in the fragmentary sandy moraines. In the southern part of the Georgian Bay-Ottawa Valley region kames are mostly separate and widely distributed. In Algonquin Provincial Park an extensive belt of kames and outwash occurs in the Tim River area away from the main roads and railways. Two more belts of kames occur west of Killaloe and west of Deux-Rivières, both containing generally sandy material.

As with outwash, the main limitation of the material in the kames of this area is the preponderance of fine sand. They include very few large, uniform gravel deposits although uncounted small deposits provide road metal throughout the region.

Eskers are made of material similar to kames. They mostly appear as one or two thin, crooked ridges, long stretches of which would be required to contain a large tonnage of sand and gravel. What appears to be the largest esker in the region is the one extending south of Deux-Rivières and with minor exceptions it consists of very fine sand. Eskers are most numerous in Algonquin Provincial Park, one of the large ones crossing Highway 60 and the railway five miles west of Madawaska village; a pit at that point is in good gravel. In northern Lanark County a very good gravel pit in an esker at White is worth noting. A very small esker in the Irondale River valley east and west of Gooderham provides gravel in an area where other sources are scarce. The longest esker in this northern region, the one which crosses Boulter Township and extends southward, has no large pits in it, even where it is largest in Boulter, Chisholm, Ballantyne, Laurier, and Joly Townships. Although it appears to be mostly sandy there are many exposures of gravel. The extension of this esker southward, modified by wave action, provides sand and gravel for Bracebridge, Gravenhurst, and Washago.

The gravel in this region is usually clean, free-flowing, and of hard, sound material. Weathered granite which readily disintegrates is a problem, particularly where it is abundant as in the North Bay-Mattawa area. Too much mica in the sand also may be a problem in that area. The preponderance of the finer grades limits the usefulness of most of the sand in all parts of this region.

RIVER VALLEYS

River valleys are conspicuous features to which we have so far given little attention apart from a discussion of the preglacial valleys in the bedrock and the glacial spillways. Only the latter appear on the physiographic maps. The valleys of the present streams are being cut in the drift and occasionally into the bedrock below. The peculiar relationships between their courses and the bedrock and glacial formations are of geomorphic interest. The flow volume of the streams, their gradients, and the type of drift determine the size of the valleys and affect the rate of erosion.

River valleys present a contrast to the glacial and lacustrine landforms which they dissect. As a rule they have steep side slopes that terminate abruptly, while glacial forms are generally rounded. Moreover, their orderly branching pattern contrasts to the irregular distribution of morainic knobs and basins, or the regular parallel alignment of drumlins. Very often, the stream valleys constitute the only important relief of till plains, terraces, and lake plains. Where dissection is well advanced there is an intimate association of level land and steep slopes. Dissected terraces are very common. The rolling and hilly topography of moraines and drumlins may also be modified and accentuated by stream valleys or gullies. Incidentally, the formation of gullies is often complemented by deposition in hollows farther down the slope.

The streams carry off slightly more than one-third of the precipitation in Southern Ontario, which is normally 28 to 40 inches per annum, with most of the area receiving about 34 inches. The well-cleared clay plains in the warmest sections have several inches less runoff than the rocky lands farther north where woods and swamps are more plentiful. For example, the two upper branches of the Thames carry away approximately 14 inches of water from their basins while the Beaver and Rocky Saugeen remove about 17 inches annually, the precipitation being 37 to 38 inches per year in both areas. Precipitation is 8 to 10 inches higher on the western slope facing Georgian Bay than on the eastern, lee side of Algonquin Provincial Park and Madawaska Highlands. Mean annual precipitation at Beatrice is 40 inches, whereas at Renfrew it is 30 inches. Similarly, the amount of runoff averages 20 inches annually from the Magnetawan and Muskoka River basins, but it is 10 inches from the Bonnechère basin. April is usually the month of highest flow and August or September the lowest.

The watersheds of Southern Ontario contain few lakes outside the area of the Canadian Shield, with such notable exceptions as the Kawartha Lakes and Rice Lake in the Trent watershed and in the adjoining Severn drainage basin. Lake Simcoe, with an area of 284 square miles, is the largest lake in the south part of Southern Ontario. In contrast, there are numerous lakes in the northern part on the Canadian Shield, the largest one being Lake Nipissing, with an area of 320 square miles.

Southern Ontario may be divided into several major drainage systems and the streams will be discussed under the following headings:

—Northern Georgian Bay Drainage
—Southern Georgian Bay Drainage
—Lake Huron Drainage
—Lake St. Clair Drainage
—Lake Erie Drainage
—Western Lake Ontario Drainage
—Northern Lake Ontario Drainage
—St. Lawrence Valley Drainage
—Ottawa Valley Drainage

Northern Georgian Bay Drainage

The northern Georgian Bay drainage basin is discussed separately from the southern because it includes only those streams that flow entirely on the Canadian Shield. Because it has a central dome the region is drained mostly by short, small streams originating near the centre and flowing to the borders. The rivers generally follow fault lines or other bedrock lineaments and their gradients are related to bedrock structures.

Being young and flowing mostly on Precambrian bedrock the rivers have done only small amounts of grading in their channels. In a few areas the rivers have cut deeply into sand and clay beds and in these areas the land may be dissected by gullies near the river valleys.

SOUTH RIVER

The main section of the South River drains the sand and clay plains south of Lake Nipissing. Near the Village of South River the sand plain stands at over 1,150 feet a.s.l. and the river drops 500 feet in its 40-mile course to Lake Nipissing (640 feet). Three power plants at Elliot Chute, Bingham Chute, and Nipissing together generate 4,300 kilowatts (kW). Near Trout Creek and Powassan the river has cut deeply into sand and clay beds and considerable dissection has resulted in these areas. The river extends beyond the Town of South River into the rocky uplands to the east. It rises at Winifred Lake (circa 1,400 feet a.s.l.), follows a straight swampy valley northwestward, and then turns southwest through outwash sand and gravel, commonly alongside a nicely formed esker. Near South River airport it reaches the level sand plain which is a delta that was formed in glacial Lake Algonquin. The South River empties into Lake Nipissing, which in turn drains into Georgian Bay via the French River.

FRENCH RIVER

The French River drains Lake Nipissing into Georgian Bay through a series of narrow lakes. The river served as a canoe route for Indians and early European explorers. It takes a fairly straight course, often along fault lines, until within about six miles of Georgian Bay and then it turns sharply south through three separate channels. For most of its 75 miles it flows through rocky country with shallow drift. In places the river is confined to narrow slits in the rocks as may be seen where Highway 69 crosses it.

MAGNETAWAN RIVER

The Magnetawan River rises in the western fringe of Algonquin Provincial Park and takes a crooked course to Georgian Bay at Byng Inlet. From over 1,500 feet a.s.l. in the rugged source area, the tributaries fall about 400 feet in the first 10 miles. In the next 30 miles, where this river system drains sand and clay flats, the gradient flattens to about 7 feet per mile on the average. Here the streams are entrenched in modest channels cut in the sand and clay beds. From Magnetawan to Byng Inlet the river drains a region of rock and shallow drift and it has done little erosion. The dam at Magnetawan holds water to 900 feet a.s.l. and from there the river falls to 580 feet a.s.l. at Georgian Bay. In several places there are rapids, but there are no waterfalls.

MUSKOKA RIVER

The Muskoka River is the largest of the rivers draining the Muskoka-Parry Sound area. The north branch of the Muskoka rises on the western edge of Algonquin Provincial Park around McCraney Lake, being called the East River above Huntsville. The East River and its feeders follow valleys in the rock floored with sand; these valleys in the upper part have a trellised pattern. The upper part of the East River has a gradient of about 15 feet per mile, but south of Williamsport where the sediments of glacial Lake Algonquin appear the grade flattens and the river course cuts a striking meandering pattern in a broad sand plain. From Mary Lake (921 feet a.s.l.) to Bracebridge the north branch of the Muskoka flows through a sand plain cutting a trench below High Falls up to 70 feet deep in beds of lacustrine sand and varved clays. In this stretch of the river there are three privately owned power plants at High Falls, Bracebridge, and Wilson Falls, having a combined generating capacity of 2,220 kW.

From Bracebridge to Lake Muskoka (739 feet a.s.l.) the river is entrenched in a clay plain. Below Bala, Lake Muskoka is drained westward by several rivers. The northward-trending Moon River is confined by bare rock ridges to a straight path northwestward to an inlet of Georgian Bay. A southward-trending branch from the Moon River follows a crooked course through rocky country to Georgian Bay via the Musquash, Muskoka, and Go Home Rivers. Two power plants on the Musquash River at Big Eddy and Ragged Rapids have a total instlled capacity of 15,300 kW.

The south branch of the Muskoka River rises near the edge of Algonquin Provincial Park around Canoe Lake (1,379 feet) and Smoke Lake (1,382 feet a.s.l.). From there to Lake of Bays the river follows a meandering course in a sandy valley and is called Oxtongue River. From Lake of Bays (1,034 feet a.s.l.) the river falls nearly 300 feet in the 25 miles to Bracebridge where it joins the north branch. Three Ontario Hydro power plants in this section (at South Falls, Tretheway Falls, and Hanna Chute)

together have a generating capacity of 6,555 kW. The Orillia Power Light and Water Commission owns a plant at Mathias with an installed capacity of 2,700 kW.

Southern Georgian Bay Drainage

The larger streams draining into Georgian Bay from the south—the Severn, the Nottawasaga, the Beaver, and the Bighead—are discussed in some detail. A number of smaller streams are also considered worthy of mention.

SEVERN RIVER

The Severn River flows into the southeastern arm of Georgian Bay. Two-thirds of its 2,250 square mile drainage basin is south of the Canadian Shield. Because its basin includes the great reservoir of Lake Simcoe the flow of this river is fairly uniform. The annual runoff amounts to about 11 inches.

The Severn River drains Lake Couchiching to Georgian Bay, but its main tributary, the Black River, extends from the confluence at Washago northeastward into Haliburton County. Around its source there are areas over 1,200 feet and 1,300 feet a.s.l. Mostly the Black River follows a narrow, swampy or sand-floored valley, and in the Vankoughnet vicinity and several other stretches, the river takes a meandering course. Where the Black joins the Severn just east of Washago village its amber water contrasts strongly with the greenish blue water in the river draining the limestone-floored area to the south. The Severn is channelized to extend the Trent Canal system from Lake Simcoe to Georgian Bay, and a hydroelectric power plant with a capacity of 3,980 kW has been operating since 1911 at Big Chute.

Lake Simcoe drains into Lake Couchiching. The southern shore of Lake Simcoe is low and marshy and most of the streams entering from the south have low gradients and are bordered by marshland for many miles upstream. Most notable is the Holland Marsh along the Holland and Schomberg Rivers, where, in recent years, 7,000 acres of land have been reclaimed and devoted to the production of vegetables. The valleys of these rivers probably originated in the preglacial drainage system, although now deeply mantled by glacial drift. There is little evidence of postglacial erosion except in the headwaters which drain from the Oak Ridges Moraine.

In the early days of settlement, Lake Simcoe and the Severn River system were important transportation routes. They form a link in the Trent Canal system by which small boats may pass from Lake Ontario to Georgian Bay.

COLDWATER CREEK, STURGEON RIVER, AND OTHER STREAMS

Five sluggish streams flow into Georgian Bay from the northern part of Simcoe County. The North River drains the clay flats of Orillia Township. Four others, Coldwater Creek, Sturgeon River, Hog Creek, and Wye River occupy the flat-floored valleys which separate the upland masses of the Penetang Peninsula. They appear to be fed largely by springs along the valley sides, the uplands being practically devoid of streams because of the vertical drainage in the sandy till. These rivers have cut shallow channels, and parts of the broad valleys are still quite swampy. It is probable that these streams were once even more sluggish, since the water level of Georgian Bay has fallen 9 feet in the last 300 years, as is indicated by investigations at old Fort Ste. Marie on the Wye River near Midland.

NOTTAWASAGA RIVER

The Nottawasaga River system drains an area of 1,145 square miles. The main branch is about 90 miles in length as it follows a roundabout course from a point a few miles south of Shelburne to its mouth at Wasaga Beach. Its two longest tributaries, Mad River and Pine River, also rise in the high plain west of the Niagara Escarpment. The border of the cuesta, served by these streams, is much better drained than the main part of the Dundalk plain. All three streams, and a number of smaller tributaries as well, flow down the escarpment in deeply cut rock valleys several hundred feet in depth, with gradients often more than 100 feet per mile. The river profiles are shown in Figure 17. This portion of the escarpment presents some of the roughest topography in Southern Ontario. It is mantled by glacial deposits, and sand or gravel terraces which have been deeply dissected by these rapid streams. The Mad River flows through Devil's Glen, a well-known spot of scenic beauty near Singhampton, while the upper branch of the Nottawasaga makes its way from the escarpment through the Hockley Valley, also noted for its rugged scenery and ski trails.

These rapid streams built great sandy deltas in Lake Algonquin and today they traverse them in flat-floored valleys 25 to 50 feet in depth. The Nottawasaga has not yet established complete drainage of its basin and a number of boggy areas still remain. Most notable of these is the Minesing Swamp depression which is periodically inundated by flood waters. Here the Nottawasaga has built noticeable natural levées along its banks so that its tributary, the Mad River, is forced to follow a parallel course for several miles before finding an entry. Willow Creek behaves in a similar fashion, crossing the central portion of the Minesing Swamp.

Below the Minesing Swamp the river cuts through the Edenvale Moraine in a canyon over 100 feet deep, a quarter of a mile in width, and about four miles in length. The lowland around Jack Lake, to the north of the moraine, is subject to flooding. Formerly it was a lagoon cut off from postglacial Lake Nipissing (in the Georgian Bay basin) by a barrier beach and a line of sand dunes. The river has breached this barrier at the extreme southwestern end and is forced to double back and pass between the dunes and Wasaga Beach for about four miles before emptying into the bay. About a mile upstream from the mouth of the river is Nancy Island Park, an alluvial island developed around the hull of the schooner *Nancy* which was sunk there during the War of 1812.

BEAVER RIVER

The Beaver River follows a deep preglacial valley which has been rounded out by ice action, and provides drainage for an area of about 225 square miles. This valley indents the Niagara Escarpment for a distance of about 25 miles, from the shore of Georgian Bay to Flesherton. The largest branch of the river, however, enters the valley from the east at Eugenia Falls, about four miles below Flesherton, the upper part of the deep valley being occupied by a small stream known as the Boyne River. Hoggs Falls (Photo 37) occurs in this latter section.

The eastern branch of the river is utilized for the development of hydroelectric power. It drains an area of about 100 square miles of rocky land and swamp between the Singhampton and Gibraltar Moraines. The channel is shallow in most of this area because bedrock is near the surface, but for two or three miles west of Feversham the river valley is 50 to 75 feet deep. A dam on the brow of the escarpment creates Eugenia Lake, a reservoir of 1,400 acres at an elevation of 1,422 feet a.s.l. A flume carries the water down the side of the valley to the powerhouse located at about 900 feet, which generates 3,600 kW.

The upper part of the Beaver River drains rocky, well-wooded country and maintains a strong summer flow, the best in the whole area in this regard. Its waters run clear even after heavy summer rains. Farther downstream the river is often muddy, charged with reddish brown clay from the lower slopes of the valley.

From Kimberley to Heathcote the floor of the valley is almost perfectly flat and composed of sand and silt. This area is imperfectly drained and has been largely left in forest. Between Heathcote and Clarksburg the river passes a double barrier consisting of a trans-valley moraine and the great Algonquin beach which, near Clarksburg, exhibits 14 separate strands. Throughout this section the river flows in a narrow winding inner valley about 75 feet in depth at its maximum but becoming shallower as it crosses the old delta to the present shore at Thornbury. The power plants at Clarksburg and Thornbury are no longer operating but water is still used to operate a seed-cleaning plant in Clarksburg. The river is used to a limited extent as a source of water for irrigating apple orchards on the dry gravelly soil of the old beaches.

BIGHEAD RIVER

The Bighead River which enters Georgian Bay at Meaford is somewhat smaller than the Beaver, draining an area of about 120 square miles. It also occupies a broad re-entrant in the Niagara Escarpment and drains a considerable area of wooded upland. Unlike the Beaver Valley, however, the valley of the Bighead has no long extension inland. Above Bognor the river is not large, but many

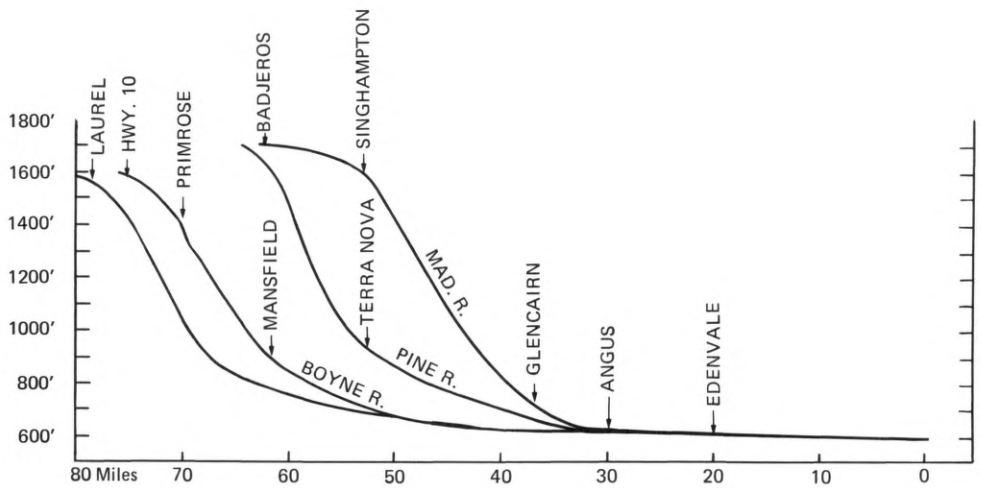


Figure 17. Profile showing elevations along the Nottawasaga River and its tributaries.

streams come down the drumlin-strewn sides of the valley and it grows rapidly between Bognor and Oxmead. This part of its course is crooked as it winds between drumlins, cutting a narrow inner valley in the inter-drumlin beds of clay.

Near Oxmead the river is diverted by the barrier beach of Lake Algonquin and makes a hairpin turn, swinging southward around several more drumlins before breaking through the old beach. For the last mile the river has cut through the sand and clay of Lake Algonquin to Meaford. The river mouth serves as a harbour for small boats and is protected by long concrete piers built out into Georgian Bay.

SYDENHAM AND POTTAWATOMI RIVERS

Two small rivers, the Sydenham and Pottawatomi, empty at Owen Sound. They drain about 110 square miles of rocky or swampy country to the south and west, much of which is wooded. The Sydenham River rises in Williams Lake, a good-sized kettle lake near the source of the Bighead. It flows west past Williamsford, separated from the North Saugeen by the Gibraltar (Chesley) Moraine, then turns north to Hemstock Mills. From there to Inglis Falls it meanders through a swampy outwash plain, cutting a very shallow channel. At Inglis Falls it plunges over the Niagara Escarpment into the beautiful glen in which Harrison Park is situated. The Pottawatomi also enters the lowland at Owen Sound by way of a small scenic waterfall after emerging from the swamp west of the city.

The cutting of deep valleys by these rivers has been prevented by the presence of bedrock near the surface, and the numerous swamps of the watershed are the results of the arrested valley development.

DISAPPEARING STREAMS

The boundaries of the watersheds along the Niagara cuesta must always be in doubt because of the number of disappearing streams in the area (Photo 38). West of the Beaver Valley in Euphrasia Township there are several examples. Wodehouse Creek goes underground near Wodehouse. Another brook disappears near Harkaway while two more find underground channels just north of Goring.

The rocky plains of Keppel Township slope westward, but no stream of any consequence crosses the line into Amabel Township. Hepworth Creek which drains Hepworth Lake, meanders for about

OGS 10 688

Photo 37. Hoggs Falls on the Boyne River in the Beaver Valley.

six miles and finally disappears into the rock about a mile east of Hepworth village.

Other sinks are known in the Niagara Peninsula above the escarpment near Smithville where certain small surface streams find underground exits.

Lake Huron Drainage

The Nottawasaga, Beaver, Bighead, Sydenham, and Pottawatomi Rivers rise on the Niagara cuesta and flow over the escarpment to Georgian Bay. However, the main slope of that high plain is toward the west and south, or toward Lakes Huron and Erie. The drainage of most of the highest portion is toward Lake Erie, chiefly by the Grand River. The westward slope is drained by the Saugeen, Maitland, and Thames Rivers and their tributaries and by smaller rivers such as the Sauble, Lucknow, Bayfield, and Ausable.

These rivers drain an inner plain 1,000 to 1,700 feet a.s.l., which is fluted or drumlinized and crossed by a network of abandoned glacial drainage channels. Surrounding this is a morainic belt consisting of several ridges and a big spillway. The spillway in several cases deflects the rivers southward giving them a trellised effect. Between the moraines and the lake is a sloping clay plain, the lower part of which was modified by the deposits of Lake Warren. North of Inverhuron, Lake Algonquin was responsible for a level sandy plain. Along the shore of Lake Huron, particularly in the central part, the waves have cut bluffs about 100 feet high and the numerous small streams entering the lake have cut deep gullies as they approach the shorecliff. Some of the larger creeks have dissected the slope farther inland, for example the clay plain near Kincardine is deeply trenched by the Penetangore River and its branches, while a few miles to the south the Pine and Eighteen Mile Rivers have accomplished similar dissection. These are streams that dry up in summer and are subject to flash floods at any time of the year.

Except for a few areas near the Niagara Escarpment and in the upper Saugeen basin, these watersheds are deeply covered with drift, and bedrock is not often exposed by the streams.

SAUBLE RIVER

The Sauble River including its northern tributary, Rankin River, drains an area of over 300 square miles. The actual area is hard to estimate because of the sinks and disappearing streams in Keppel Township.

The main branch of the river rises near Desboro in Sullivan Township, Grey County, but the greater part of its course is in Arran and Amabel Townships of Bruce County. It takes an extremely crooked course through two contrasting landscape types, the upper part being among the hills of the Arran drum-

OGS 10 689

Photo 38. A disappearing stream: Hepworth Creek where it enters cracks in the dolostone bedrock east of Hepworth, Grey County, just below the Skinner Marsh Dam.

lin field while the lower portion is across an Algonquin sand plain. The upper portions of its valley are purely accidental, winding through the inter-drumlin swamps in an aimless fashion.

A singular phenomenon occurs about a mile and a half southeast of Tara, in lots 32 and 33, concession IV, of Arran Township, where the river passes completely under a drumlin nearly 50 feet high. At low water the stream disappears into cracks in the limestone in lot 33, and reappears as a huge spring about 1,300 feet westward in lot 32. During high water stages the overflow takes a course around the northern end of the drumlin, adding an extra mile to the length of the river and necessitating two highway bridges.

The inter-drumlin areas contain several important lakes, the largest, Arran Lake, being over three miles in length with an area of 800 acres. Gould Lake, being much smaller, is shaped somewhat like a horseshoe around a large drumlin. Chesley Lake, which has two small drumlin islands, finds a direct outlet to Lake Huron by way of Stoney Creek. The rock plain of Keppel Township also has several lakes. Two of them, Shallow Lake and McNab Lake, have been drained in order to get at the deposits of marl with which they are floored. Hepworth Lake overflows into Hepworth Creek, whose disappearance underground has already been mentioned. The only visible outlet for these lakes is by way of Park Head Creek, a small intermittent stream which flows into the Sauble River.

In the lower part of its course the Sauble traverses the sand plains laid down by Lake Algonquin. At first, apparently, it meandered quite widely but has now become entrenched. The deepest part of the valley is in the region of Park Head and Hepworth, but even here it is only about 30 feet in depth.

SAUGEEN RIVER

The Saugeen River drains an area of 1,565 square miles including some of the highest land in southwestern Ontario. The main branch rises near Dundalk at an elevation of 1,700 feet a.s.l. and falls about 1,100 feet in its course of 115 miles to Lake Huron at Southampton. Its chief tributaries are the North Branch, the Rocky Saugeen, the Beatty, and the Teeswater Rivers which maintain a strong summer flow. The headwater areas contain much rough and rocky land, and the farms have between 30 to 35% in woods and swamp. In addition, a large part of the cleared land is used as permanent pasture. The soil is loamy or gravelly and the streams run clear even after heavy summer showers. The Teeswater drains the great Greenock Swamp which serves to give it a uniform summer flow.

Above Walkerton the several branches of the Saugeen flow in the old glacial spillways which are associated with the Horseshoe Moraine system. These old valleys with their broad gravel terraces have a general trend southwestward toward the Greenock Swamp. At Walkerton the Saugeen River changes its course abruptly to flow northward through the moraine in a valley half a mile wide and 150 feet deep. In view of the well-developed valleys leading westward, this apparent case of capture can only be explained by the presence of an original low place in the moraine. North of the moraine, there is a sand plain of considerable extent in the neighbourhood of Eden Grove, representing a delta built in Lake Warren. Here, the present valley is over 75 feet in depth and reaches a maximum of two miles in width. Within the valley are numerous sand and gravel terraces, remnants of former flood plains. Noteworthy, too, are several isolated hills interpreted as cut-off spurs or meander cores, and there are swamps in the abandoned channels. Upon the present valley floor the river meanders widely, shifting its course from time to time with costly damage to highways and farm property. Below Paisley there is another deep passage through a ridge of clay till, and about two miles below Dumblane the river enters the former lagoon which was enclosed by the massive Algonquin beaches at Port Elgin. From here on, its valley is not more than 50 feet deep except where it swings westward to break through the old beach to enter Lake Huron at Southampton.

While not serious along the headwaters, there is considerable dissection of the valley from Walkerton to a few miles north of Paisley. This is also true of the lower courses of the north branch and the Teeswater which join the main stream near Paisley. There is a definite soil erosion problem in this area. While it is true that much of this sloping land is used for pasture and is thus not so unstable as it would be under cultivated crops, nevertheless one sees considerable gullying and slope-washing even in pastures.

To a limited extent the Saugeen was used as a transportation route in the early days of settlement and an excursion steamship once ran from Port Elgin to Walkerton, a distance of 30 miles. More important have been the power sites which permitted the establishment of grist mills, sawmills, and woodworking plants. Of the original 35 power sites 7 are still in use, a tribute to the uniform summer flow. Together they have a capacity of 636 kW. Another not-to-be-forgotten fact is that the branches of the Saugeen are known to be among the best trout streams in Southern Ontario.

LUCKNOW (NINE MILE) RIVER

The Lucknow (Nine Mile) River drains an area of about 100 square miles, most of which is composed of moraine and spillway with considerable swamp

and woodlot, and therefore it maintains a permanent flow. Its headwaters all flow in the great Lucknow spillway and it breaks through the Wyoming Moraine north of Dungannon, after which it turns toward the west and entrenches itself in the plain which slopes toward Lake Huron. This part of the valley is about 75 feet deep and a quarter of a mile in width. Waterpower has previously been developed at Lucknow, Mafeking, Dungannon, and Port Albert.

MAITLAND RIVER

The Maitland River which enters Lake Huron at Goderich drains an area of 981 square miles lying south of the Saugeen and Lucknow watersheds. With its several branches ramifying through gravel-floored spillways in the till plain above the morainic belt and the lower stretch of the river deeply entrenched in a clay plain, it is a sister of the Saugeen River. The proportion of woodland, swamp, and rough stony land is less in the Maitland drainage area than in that of the Saugeen; nevertheless, a strong summer flow is maintained. The diversion of the river by the great spillway in front of the Wyoming Moraine gives it a trellis pattern.

The main branch of the Maitland is about 90 miles in length, rising at 1,350 feet a.s.l. on the plain near Harriston and falling 770 feet to Lake Huron. Its headwaters are almost intertwined with those of the Conestogo and South Saugeen in a maze of shallow spillways, and in places the dividing line between watersheds is not definite. At Harriston the Maitland Valley is flat, shallow, and swampy, but just west of the town it enters the Teeswater drumlin field and at Newbridge the valley is 50 feet in depth, with remnants of old gravel terraces along the sides. This deeper valley persists for several miles, having a gradient of 100 feet in the next 10 miles which provides power sites at Gorrie and Wroxeter. From thence to Wingham the valley is insignificant as it winds its way through the gravel trains and swamps between the drumlins. The Little Maitland and Middle Maitland which come from the south to join the main stream at Wingham also have shallow channels. In this area these streams are little influenced by the original direction of flow of glacial drainage, often reversing it. Also it seems peculiar that the Middle Maitland should continue northward instead of using the direct westward route *via* Belgrave Creek. In fact, Belgrave Creek may yet capture the Middle Maitland. It is just as odd that the headwaters of Teeswater River flow northward from swamps close to the Maitland in the Wingham area.

From Wingham the river swings southwestward through the morainic hills of East and West Wawanosh Townships. There is a valley up to 100 feet deep in this area, much of it caused by the present stream rather than glacial waters. At Auburn a good exposure of local drift is provided where the river has cut a 75-foot channel without striking bedrock. That exposure exhibits stratified clay, silt, and sand except for the boulder clay in the top few feet.

It is less than 10 miles as the crow flies from Auburn to Goderich, but the river is diverted by the moraines so that it takes 30 miles to traverse this distance. In particular, it fails to take advantage of the cross-channel followed by the Canadian Pacific Railway southwest of Auburn and runs as far south as Holmesville before entering the main spillway along the Wyoming Moraine. It makes a hairpin turn near Holmesville and flows north in the spillway to Benmiller, thus reversing the original direction of flow. Near Benmiller the valley exhibits splendid examples of incised meanders with successions of terraces on long slip-off slopes. About two miles below Benmiller an abandoned oxbow channel is preserved just under 700 feet a.s.l. At Goderich and within a mile of Lake Huron the valley is about 150 feet in depth with steep banks cut in unconsolidated material, except for the bottom six to ten feet, where limestone is exposed.

Tributaries entering the lower stretch of the river are all small except the South Maitland, and they enter the valley through narrow V-shaped gulches. The rejuvenation of these streams has, however, proceeded for only a short distance upstream. For instance, Sharpes Creek, which drains a 12-mile stretch of the spillway north of Benmiller, has a fall of about 100 feet in the last mile. Even the South Maitland has been unable to maintain its cutting at the same rate as the main stream and shows a gradient of 25 feet per mile in the lower 4 miles of its channel.

The headwaters of the South Maitland arise on the highly cleared clay plain north and east of Seaforth. As with the Middle Maitland and Little Maitland, the upper branches sometimes consist of municipal ditches cut through flat, wet land. The South Maitland flows along the eastern face of the Seaforth Moraine for 12 miles before finding a gap toward the west.

The Maitland has had a notable influence on settlement. Its mouth provides the only good harbour for Great Lakes shipping along the whole east shore of Lake Huron. Goderich is a grain port and milling point, and many freighters take shelter in the harbour when navigation is suspended in winter. The river itself has not been much used for transportation, but numerous waterpower sites have contributed to the location and growth of such towns as Wingham, Harriston, Brussels, Fordwich, Bluevale, Blyth, Wroxeter, Gorrie, Auburn, and other smaller points.

BAYFIELD RIVER

The Bayfield River enters Lake Huron at Bayfield, 12 miles south of Goderich. It drains an area of 200 square miles lying between the drainage areas of the Maitland and the Ausable. The characteristics and variations in this area are similar to those of the Maitland and the Lucknow to the north, except that the moraines are smoother and less elevated and the spillways are broader. The same trellis pattern of tributaries prevails in the upper part of the area and the same entrenchment has taken place between the moraines and the lake. The lower Bayfield Valley is about 100 feet deep and half a mile in width, and is enough of a barrier to cause a complete break in the road system. High-level terraces, old oxbows, and even isolated meander cores are found in the valley, giving it some resemblance to that of the Maitland.

AUSABLE RIVER

The Ausable River takes its name from the sand dunes south of Grand Bend through which it makes its way before entering Lake Huron. Its mouth is at Port Franks but no doubt the outlet has changed many times because of the shifting sand. The total area of its drainage basin is estimated to be 160 square miles, and its headwaters gather in the swamps and gravel terraces along the front of the Wyoming Moraine and in the clay plain north and east of Exeter. A great number of these small headwater streams now run in dredged ditches and are completely dry during the summer months. The Ausable River follows the depression in front of the moraine as far as Arkona. There, it is entrenched in a deep and crooked valley which cuts completely through the unconsolidated drift and penetrates many feet into the bedrock, exposing the highly fossiliferous Widder Formation. The valley is about 100 feet in depth. From Arkona the valley runs almost directly north, cutting through the Wyoming Moraine in a gorge 125 feet deep to enter the Thedford Marsh. This was a shallow bay of both Lakes Algonquin and Nipissing in which a great deal of marl was deposited and which, in part, now contains peat beds. Crossing this depression to its northern corner the river entered the sand dunes, making a hairpin turn to flow southwestward between the line of dunes for 12 miles to Port Franks.

In 1875 a canal was cut through the dunes, draining the swamp and providing a direct route to the lake. Between the head of the cut and the mouth of Parkhill (Mud) Creek, the Ausable is dead. The water from Parkhill Creek finds its way directly to the lake through the short canal at Grand Bend. Of the disconnected channel traversing the dunes between Grand Bend and Port Franks we can do no better than to quote W. S. Fox (1958), " 't'aint runnin' no more—at least, so it seems to dull incurious eyes. The truth is that though standing still it flows. After all what are the dunes but a watershed of a kind, a mother of springs and streamlets."

Parkhill Creek rises east of Dashwood and follows a trough between ridges of the moraine, making the same sort of sweep to the west as the larger Ausable. For a few miles east of Parkhill it is entrenched to a depth of about 75 feet and it is this section that serves as a reservoir now that the Parkhill conservation dam has been built.

The largest tributaries of the east bank, Nairn Creek and the Little Ausable, drain the depression lying east of the Seaforth Moraine. Between Lucan and Clandeboye, where the latter stream is crossed by Highway 4, it flows in a valley 75 feet deep, only a small part of which can be the result of its own cutting. In many summers this stream has practically dried up.

The Ausable has a much more irregular regime than the rivers to the north. Low summer flow and spring flood make up its regular program. The damage from floods is mainly experienced in the marsh area which, now drained, is utilized for the intensive production of vegetables and field crops. The river seems not to have been utilized to any extent for power, although a dam and small powerhouse near Arkona operated for three years between 1915 and 1917. The Morrison flood-control dam is on the Ausable River near Exeter.

Lake St. Clair Drainage

The drainage into Lake St. Clair includes the St. Clair River and two other important drainage systems, the Sydenham and the Thames.

ST. CLAIR RIVER

The St. Clair River enters the lake through a number of distributaries which are building a typical bird's-foot delta. The newer part of the delta is low and marshy, but the older portion was built into a slightly higher water level and the water table is now appreciably below the surface. Sufficient depth for navigation by large lake freighters is maintained in the main channel by dredging. It is one of the busiest waterways in the world.

SYDENHAM RIVER

The Sydenham River drains most of Lambton County and the adjacent part of Middlesex, an area of about 1,000 square miles. This is mostly a clay plain of little relief in which poor drainage prevails in the interfluves. The north branch, named Bear Creek above Wilkesport, rises near Arkona between

the Wyoming and Seaforth Moraines. At Wilkesport, there is the Darcy McKeough Dam and Diversion which commenced operation early in 1984. The river drains the south slope of the Wyoming Moraine but turns southward at Brigden across the clay plain toward Wallaceburg. In this latter section its gradient is less than one foot to the mile and the valley is nowhere incised more than 30 feet in depth. The main or east branch is about 100 miles long. It rises between the Lucan and Seaforth Moraines near Ilderton at an elevation of 925 feet a.s.l. and it falls 350 feet to Lake St. Clair. The grades are steeper in the upper section, the last 30 miles having a fall of only 20 feet.

The valley is best developed in the Alvinston area where it is over 50 feet deep and a number of tributaries enter it in narrow V-shaped gullies. These and the tributary gullies have quite intricately dissected the adjacent clay plain

The shallow valleys and low gradient have meant that this river has not been of much use for power, and floods sometimes occur. However, it is navigable up to Wallaceburg giving this town access to the Great Lakes.

THAMES RIVER

The Thames River drains an area of 2,200 square miles and is second only to the Grand among the drainage systems of southwestern Ontario. Its total length, from the source of the north branch near Brodhagen to Lake St. Clair, is about 125 miles.

For purposes of discussion the river may be divided at London. Below this point it traverses fairly level lake plains in a small valley of its own making, and its gradient is low, the total fall from London to its mouth being about 175 feet or less than two feet per mile. Above London two branches drain over 1,000 square miles of till plains and moraines. The north branch, which is the longest, falls about 400 feet at the rate of about 10 feet per mile and the gradient of the south branch is almost as great. The City of London, located at the confluence, often experienced flood conditions. The Fanshawe Dam, on the north branch just north of the city, has helped to control flooding.

The north branch of the Thames originates from the union of several small creeks draining large flat areas in Logan Township and at Mitchell it assumes the characteristics of a river in a well-defined but shallow valley. Below Mitchell the valley deepens rapidly to a depth of more than 75 feet at St. Marys and over 100 feet at Plover Mills. Then the depth and gradient of the valley diminish from this point to London, a distance of 15 miles.

Between Mitchell and St. Marys the North Thames receives several fair-sized tributaries from the east, but only one, Flat Creek, from the west. The Avon River, which flows through the City of Stratford, arises on the edge of the Easthope Moraine in two swampy valleys or depressions which connect with the Nith drainage system to the east. In 25 miles it falls about 175 feet. Its lower valley is much deeper and narrower than the broad swampy valleys in which it rises. Trout Creek, from the east, joins the North Thames at St. Marys, flowing in a valley much too large for it. This is the work of a glacial stream, described elsewhere, formerly connecting the drainage of the upper Grand River with the Thames. It contains a long swamp which now serves as the source of both Trout Creek and the south branch of the Thames. At St. Marys the course of the river is deflected westward for about five miles until, joined by Fish Creek from the north, it breaks through to the south of the moraine which controlled it. The North Thames has no further important tributaries until joined by the Medway also from the north, within the northern part of the City of London.

The south branch of the Thames rises in the long swamp west of Tavistock and flows east as though to join the Grand River system, then swings south and eventually finds the spillway through Woodstock and Ingersoll. This valley is about a mile in width and over 100 feet in depth, being cut to bedrock, thus exposing the low silica, very pure calcitic limestones which are being worked in the Beachville quarries. Cedar Creek, at Woodstock, is the only important tributary entering this section of the river. It drains an area of intermorainal swamp to the south of the city and at times creates minor flood conditions. Near the small village of Putnam, about 13 miles below Woodstock, the river is joined by the Middle Thames on its north bank and by Reynolds Creek from the south.

The Middle Thames is also a misfit in a deep spillway but it is not quite so large as its southern counterpart. The upper portion of this drainage, known as Mud Creek, is, as its name implies, a very sluggish stream. At Embro it is joined by a somewhat more swiftly flowing branch from the north. The deeply cut spillway ends at Thamesford to be replaced by broad gravel terraces extending toward London. It appears that the Middle Thames may at first have held a course westward from Thamesford as marked by a shallow channel, but it has been diverted toward the south.

Reynolds Creek follows a very circuitous route in the spillway fronting the St. Thomas Moraine and has performed very little recent dissection.

From Putnam to Lake St. Clair the valley of the Thames may be considered to be of its own making with exceptions of the upper, broader portion of the gorge between the moraines near Hyde Park, which

undoubtedly carried glacial drainage. The course of the river in Caradoc and Delaware Townships and even as far as the eastern limits of Kent County is particularly noteworthy. Here, following the retreat of the Lake Warren waters, the newly constituted river wandered widely and has since entrenched itself to an average depth of about 75 feet below the old lake plain. The valley, in places, is more than a mile in width and exhibits many excellent examples of slip-off slopes, undercut bluffs, and abandoned channels. Here, too, the tributary streams are cutting down to the base level of the master stream, creating steep-sided narrow gulches along their lower courses. Some of this difficult terrain has been set aside in the Caradoc Indian Reserve (IR 42).

Downstream, the valley is smaller and the river is sluggish, especially below Thamesville. Periodic overflows in Kent County were the bane of farms and villages near the river, but this problem has been somewhat alleviated by diking along the river below Chatham. The alluvial clay from these floods has a weak reddish brown colour in contrast to the greyish brown clay of the region. It is given distinction as the Thames clay loam on the soil map of Kent County (Appendix C). Near Lake St. Clair the level of the river is above that of the adjoining territory which is protected by a system of levées. The Thames is navigable by barges and pleasure cruisers as far as Chatham, a distance of 16 miles from Lake St. Clair.

Flood conditions are most critical in the City of London, which has been partly built upon land which, physiographically, belongs to the river. The total rainfall of the region is nearly 38 inches per year. Gauging stations on the north and south branches of the Thames record a runoff of 14 and 13 inches, about three or four inches less than that of the Beaver and the Saugeen Rivers. The flow, however, is highly irregular. In midsummer 1955 the north branch was reduced to a cubic foot per second (c.f.s.) while in flood times it may carry over 20,000 c.f.s. A flood control dam was built at Fanshawe in 1952 capable of holding back 30,000 acre-feet of water. The regulatory work of this dam is now supplemented by smaller ones at Mitchell, Stratford, and St. Marys, and another dam is proposed for the site three miles north of St. Marys at Glengowan on the North Thames. The Gordon Pittock Dam on the south branch has been built at Woodstock. The south branch shows similar, if not so great, variations. Floods occur on the Saugeen River, also, but it is the scanty summer flow of the Thames which accounts for the difference in runoff. Summer rainfall, for the most part, is lost by evaporation rather than runoff in this river basin.

Lake Erie Drainage

Although the north shore of Lake Erie is over 250 miles long, not counting Long Point, it receives no large rivers except the Grand. The clay plain of Essex County drains almost entirely toward Lake St. Clair or the Detroit River, and only short small creeks enter Lake Erie. Long stretches of this shore, particularly in the great bight between Rondeau and Long Point, consist of high bluffs cut in unconsolidated drift. Near the shore, as along the Lake Huron shore, many small streams are cutting deep, steep-sided gullies. Since this shoreline is receding, these gullies are constantly growing headward under the influence of new gradients. It is clear that Kettle Creek, Catfish Creek, Otter Creek, and Big Creek formerly extended beyond the present shoreline. Several brooks have accomplished some remarkable dissection between Turkey Point and Port Dover. The bluffs are low between Port Dover and the Grand River and the overburden on the limestone is usually less than 25 feet deep; consequently the creeks which drain the clay plain to the north have shallow valleys. East of Port Maitland, as in Essex County, the height of land on the adjacent plain is near the Lake Erie shore and southward drainage may be disregarded.

KETTLE CREEK

Kettle Creek enters Lake Erie at Port Stanley where the bluff is about 125 feet high; consequently the valley is deep and the bordering sand plain cut by gullies. It is quite obvious that some branches have been separated from the truncated river system by the encroaching shoreline which has here receded at least ten miles from its original position (Figure 18). Although very steep sided, the valley is flat-floored and the river meanders widely as far upstream as St. Thomas, about ten miles by river. Here the valley is still over 75 feet in depth. Several headwater streams converge at this point. Some of the drainage originates in the spillways between the morainic ridges. This may be considered as captured, since the whole development is recent and consequent upon the back slope of the moraine. A dam north of the city serves to impound the reservoir supplying St. Thomas. Port Stanley at the mouth of the river, is a summer resort, but also has harbour installations.

CATFISH CREEK

The physical development of this system is quite similar to that of Kettle Creek. Its headwaters take rise in the long troughs between the low till ridges above the shoreline of glacial Lake Whittlesey, and after uniting near New Sarum the waters have cut a deep, steep-sided but flat-floored valley to enter Lake Erie at Port Bruce. Like Kettle Creek, Otter Creek, and

Big Creek, it serves to drain the tobacco lands through which it takes its course and it also provides water for irrigation.

BIG OTTER CREEK

From its source near New Durham at an elevation of 850 feet a.s.l., Big Otter Creek falls nearly 280 feet in a distance of 48 miles to Lake Erie at Port Burwell. It thus has an average grade of about six feet per mile. For the greater part of its course it flows in a steep-sided, rather narrow valley and nowhere has such a wide, flat valley floor as those found in the two previously described systems. In its deepest portion, between Tillsonburg and Bayham, the valley is over 125 feet deep and provides splendid sections of the local surface deposits. Little Otter Creek, a tributary on the east, also flows in a narrow valley which for several miles is over 100 feet deep. Power sites along Big Otter Creek gave rise to a number of early settlements including Otterville, Tillsonburg, Bayham, and Vienna. The mouth of the stream provided the harbour of Port Burwell, which, having been improved and provided with rail facilities, serves as a port for the manufacturing towns of Tillsonburg and Ingersoll.

BIG CREEK

Big Creek rises in the Ingersoll Moraine a few miles southeast of Woodstock at an elevation of 1,000 feet a.s.l. In a total length of 55 miles it falls over 400 feet to Lake Erie. At first its course is easterly toward the wide plains of deltaic sand in Burford Township where the Grand River at one time entered Lake Whittlesey. In a distance of 12 miles it drops 175 feet but has cut no significant valley because of its small volume. The stream wanders for a few miles southward over the old alluvium before it begins to entrench itself near Teeterville. Nine miles farther downstream at Delhi the valley is already 75 feet in depth, a depth which it maintains until within a few miles of its outlet into Inner Bay. The Lehman Dam near Delhi utilizes a section of this valley for water storage, the main purpose of which is to increase the water available for irrigation of tobacco. For the most part the valley floor is narrow with only a few wide areas of flood plain as, for instance, near Carholme (south of Delhi). There are also a number of remnants of alluvial terraces, and the many tributaries that join Big Creek have cut V-shaped gullies in the Norfolk sand plain. For a few miles near its mouth, however, Big Creek is without grade and its margins are marshy; in the last 25 miles of its course the average grade is about five feet per mile. In places, Big Creek and some of its tributaries have been utilized to run grist mills. The only settlement of any size on the banks of the creek is Delhi, now a processing centre for tobacco.

GRAND RIVER AND TRIBUTARIES

The Grand River drains an area of 2,600 square miles on the dip slope of the Niagara cuesta, the largest catchment basin in southwestern Ontario. The main stream rises northeast of Dundalk at about 1,725 feet a.s.l. and runs a course of 180 miles to Lake Erie at Port Maitland. The upper Grand and its branches, Willow Brook, Boyne Creek, and many unnamed streams serve to drain nearly all of the swampy upland around Dundalk and Grand Valley. Its tributaries, the Conestogo and Nith Rivers

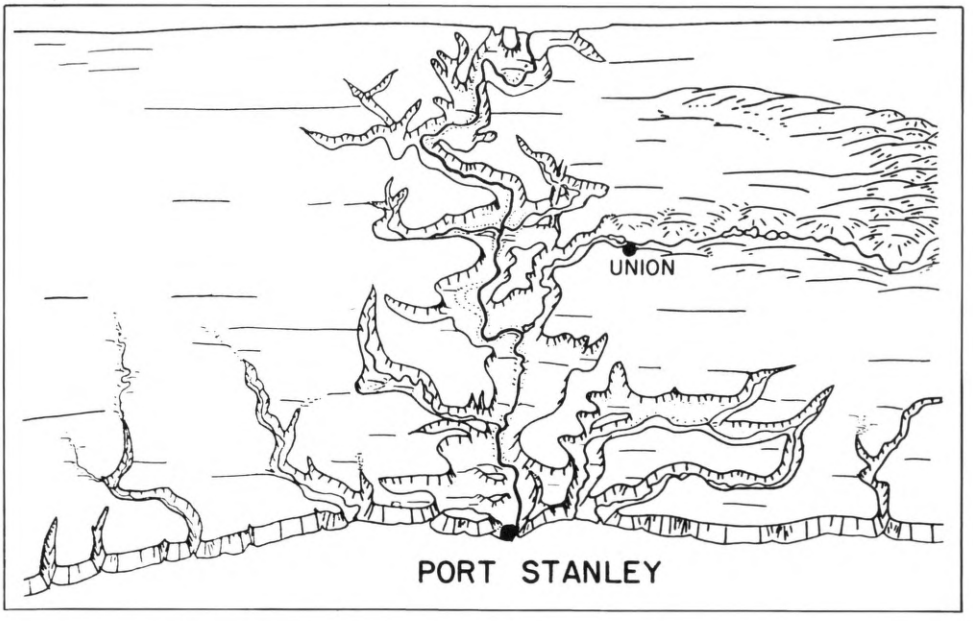


Figure 18. Sketch showing the dissection near Port Stanley, on the north shore of Lake Erie.

drain the extension of that plain west of Arthur and around Milverton. The upper reaches of these streams intermingle with those of the Saugeen, Maitland, and Thames, the divides between them being indistinct, often consisting of a sprawling swamp from which drainage goes in two directions. Entering the main stream from the east at Cambridge (Preston), the Speed River drains the drumlins and gravel trains west of the Paris Moraine. Between Paris and Brantford the Grand River breaks through the Paris and Galt Moraines. Below Brantford, only a narrow belt of the clay plain drains into the Grand and it is confined on the south by the Onondaga Escarpment which forces the river eastward to Dunnville where a sag permits southward passage to Lake Erie.

The Grand is like the Thames in that it may be divided into an upper part where the river and its branches mostly flow in spillways, previously formed in the till plains, and a lower part where the river has made its own channel across a lake plain. The lower section is more nearly level than the upper; above Brantford the average grade of the main stream is eight and one-half feet per mile while it is about two feet per mile below that point.

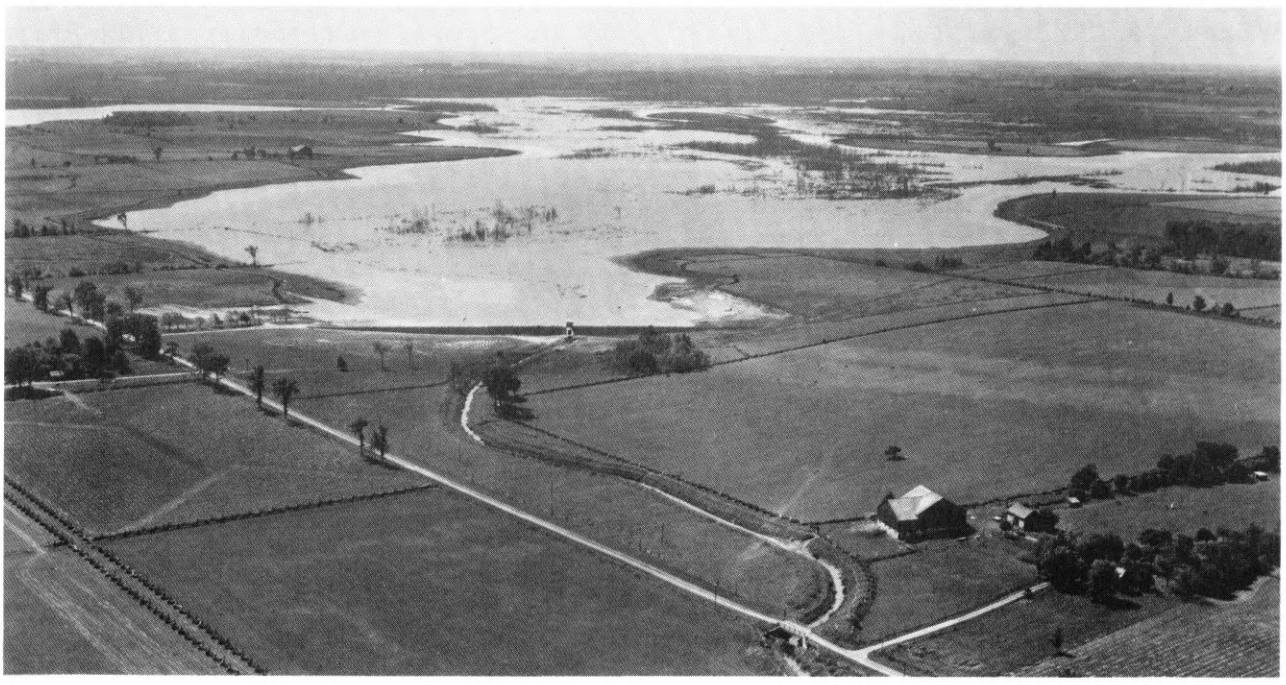
To measure the volume of flow in the Grand River, gauging stations have been maintained at Galt (now part of the City of Cambridge) and Brantford for many years. The mean of 67 years' measurements at Galt is 1,225 c.f.s., the equivalent of 12 inches of rainfall. The mean flow for the flood month April is 3,300 c.f.s. For the driest month, August, it is 434 c.f.s., but in August, 1936, it was only 47 c.f.s., with an absolute low of 26 c.f.s. The maximum flood was 48,000 c.f.s., on October 16, 1954, during Hurricane Hazel.

In the extreme upper reaches there has been little valley cutting. Grades are low and deepening of the main valley is held up by bedrock. Limestone is exposed at Grand Valley about 75 feet below the level of the adjacent plain. Drainage is poorly established on the plain above Grand Valley and swamps are prevalent, the largest of which is the Luther Marsh that covers approximately 10,000 acres. It now serves as a reservoir behind the Luther Dam, built in 1952 (Photo 39).

From Grand Valley to Elora, 20 miles downstream, the bed of the river is controlled by the bedrock and the valley varies from 60 to 100 feet in depth. It is flanked by remnants of gravel terraces indicating its earlier history as a glacial spillway.

In this stretch of the valley, where it cuts through the Orangeville Moraine, the Shand Dam was built at Belwood, starting operations in 1942. Constructed at a cost of over two million dollars, the dam now has a maximum storage capacity of more than 14 million gallons, or 51,700 acre-feet of water, sufficient to provide a minimum of 200 c.f.s. summer flow. It creates a lake six miles long called Lake Belwood which in itself is a recreational asset.

In the vicinity of Elora there occurs a definite break in the slope of the bedrock and both the Grand River and Irvine Creek have cut deep gorges



OGS 10 690

Photo 39. The Luther Dam was built in 1952 to regulate the flow of the Grand River. Photo courtesy of Hunting Survey Corporation.

in the dolostone (Photo 40). Known as the Elora Gorge, the rugged beauty is a noted scenic attraction which has been made the site of a small park. The gorge in the rock ends a short distance below Elora, giving place to a wide winding valley in alluvial gravels or, occasionally, in till. From there to Paris the valley is 75 to 100 feet deep, and between Paris and Brantford the gap in the Paris Moraine is over 150 feet in depth. The alluvial plains in which the river meanders are several miles wide at the maximum. It would be hard to find the equal of the volume of sand and gravel in this section of the Grand River valley.

The Conestogo River rises on the plain north of Arthur as small streams following shallow spillways. Several of these streams join near Riverbank to form the east branch in a valley already 75 feet in depth. Downstream it increases in size until at Hollen it is entrenched 150 feet deep in the till plain. The west branch of the river originates in a similar set of old spillways and has a valley nearly 100 feet deep above its confluence at Stirton.

Two miles south of Hollen the Conestogo Valley is joined by that of Spring Creek from the west. The latter is a remarkably big valley for such a small creek. At the junction with Spring Creek the Conestogo swings sharply to the southeast in a rugged valley which is over 100 feet deep at Glen Allen. The capacity of both these valleys amounting to 45,000 acre-feet is used by the Conestogo conservation dam above Glen Allen. Below Glen Allen the valley becomes shallower, except east of Hawkesville where it crosses a moraine. The river meanders over a flood plain about 500 yards wide and it falls 200 feet in the 25 miles above Conestogo.

The Conestogo drains an area which receives more rain and snow than most of Southern Ontario. Its runoff, 345 c.f.s., is the equivalent of 15 inches of rainfall. However, its regime is highly unreliable, possibly because of the clay soil, a high proportion of which is cleared. In March and April the average flow is around 1,050 c.f.s., but it has fallen to two c.f.s., in dry summers.

The Nith River and its branch, Smith Creek, originate in small intermittent streams or ditches that drain the clay lands of Mornington Township east of the Milverton Moraine. Where they unite near Kingwood the valleys are 50 feet in depth, and at Nithburg the narrow valley reaches its greatest depth of over 100 feet. Below Lisbon the valley is shallower and more open but it is still cut in clay till. The river meanders widely and in places has two or

OGS 10 691

Photo 40. The Elora Gorge, cut into the dolostone bedrock by Irvine Creek.

three channels in operation. About two miles below Plattsville it meets one of the broad gravelly spillways by which glacial drainage escaped from the Grand River basin into the Thames. The Nith now flows up this valley as far as Ayr then turns down another spillway to the southwest. Finally near Wolverton the river swings to the southeast again toward the Grand at Paris. This lower stretch of the valley is 50 to 100 feet deep and is variable in width due to the wide meanders.

The Nith drains over 430 square miles and removes the equivalent of 13 inches of rainfall, which is two inches less than the runoff of the Conestogo River basin. With an average discharge of 380 c.f.s., a flow of about 1,010 c.f.s., during flood months, and mininum flows of slightly under 100 c.f.s., it is more reliable than the Conestogo River. The smaller amount of runoff is probably the result of less snowfall, and the better summer flow due to the more extensive area of porous soils. A proposed dam at Ayr will serve further to regulate the flow downstream, however it is unlikely to be built for some time yet.

The Speed River is remarkable in that throughout its whole length, and that of its tributaries as well, it flows in old spillways. It rises near Orton and drains the main part of the Guelph drumlin field. Many of its feeders come from the north, toward the Grand River; in fact if it were not for auxiliary earthworks Lake Belwood would overflow into the Speed drainage. South of Fergus, the Speed cuts across three fair-sized spillways and beheads Swan Creek, Cox Creek, and Hopewell Creek which flow down these valleys into the Grand. The fact that the Speed River has a fall of nearly 500 feet in 25 miles explains its ability to cut across drainage lines of more gentle gradient. As it is partly floored by bedrock it is not surprising that such a rapid stream did not make a deeper channel.

The Eramosa River is the main branch of the Speed River, following the master spillway in front of the Paris Moraine above Guelph. That swampy channel shows up clearly on the Guelph map sheet (NTS 40 P/9). It is seldom less than half a mile wide and is bordered by gravel terraces except where it encroaches upon drumlins. This tributary has a lower gradient than the Speed River, the fall from Brisbane to Guelph being 275 feet or an average of 12 feet per mile. Bedrock is exposed occasionally and the modern stream has accomplished very little cutting. The Eramosa receives very few tributaries, the most important being Blue Springs Creek which extends from Eden Mills toward Acton in another well-developed spillway through the Paris Moraine.

The City of Guelph is situated at the confluence of the Eramosa and Speed Rivers and that part which is built on lower terraces is subject to flooding. Below Hespeler (part of the City of Cambridge) the river has made a deep channel in the gravel terraces.

The total drainage basin of the Speed River covers over 275 square miles. Its mean flow is about 225 c.f.s. or the equivalent of 11.2 inches of rain, which is almost two inches less than the Nith River. Flood months run up to 1,000 c.f.s., while minimum flows vary from 65 to 100 c.f.s. This river has the most reliable flow of all the larger tributaries of the Grand, no doubt because of the great inter-drumlin gravel beds and swampy valleys. A dam has been built on the Speed River just above Guelph, and two dams are proposed for Everton and Hespeler to help control the flow.

Below Brantford the valley of the Grand is cut in the silt and clay of Lake Warren and the underlying boulder clay. Around Brantford, soft silts have been highly dissected near the Grand and along Fairchild Creek. Prevention of further erosion is a problem. In the last 27 miles of its course the Grand has a fall of 27 feet, a gradient of exactly one foot per mile, and very little valley cutting has occurred. One-third of this fall is accounted for by the dam at Dunnville which was built to supply water to the feeder for the old Welland Canal.

The area drained by the Grand River now has a population of more than 525,000 people and includes the cities of Brantford, Cambridge, Guelph, Kitchener, and Waterloo. Elmira, Elora, Fergus, Paris, and Dunnville and many other centres are also situated on the banks of the river or its tributaries. In the early days of settlement the stream provided power, and power sites formed the nuclei of settlements. Presently, there are three privately owned power plants at Fergus, Preston, and Everton, with a total installed capacity of 229 kW. It was also considered navigable as far upstream as Brantford, while its upper reaches were used for log driving. Now, although this is one of the foremost manufacturing areas of Ontario, local waterpower is of little importance. Nevertheless, the river is very important from the standpoint of water supply and sewage disposal, and for recreation. If the Grand is to continue to serve the rapidly increasing population of its valley, further measures to increase the summer flow will be necessary.

Western Lake Ontario Drainage

The drainage tributary to Lake Ontario includes the Niagara River and a number of smaller rivers. One or two such as the Trent and the Moira have fairly large drainage basins, but the others drain quite small areas. Some of them, however, have an importance, both physiographically and in relation

to the settlements on their banks, quite out of keeping with mere size.

NIAGARA RIVER

The Niagara is a short river joining Lake Erie to Lake Ontario across the Niagara cuesta. In a distance of 32 miles its waters drop 326 feet from the level of Lake Erie (572 feet a.s.l.) to the level of Lake Ontario (246 feet a.s.l.). Approximately half of this drop occurs at Niagara Falls, which, with the steep-sided gorge below is among the scenic wonders of the world (Photo 41).

The river starts at Fort Erie although it is worth noting that the difference in elevation between this point and Lowbanks (on Lake Erie) is very small. Had the river originally taken the latter passage it would have gone down the Welland River to the present channel just above the falls.

The upper 10 miles of the Niagara is a broad quiet river in a valley only about 25 feet in depth. It is split into two arms which enclose Grand Island. The western arm is also divided, enclosing the much smaller Navy Island. Below these islands the river is over one and a half miles in width but narrows to about one mile at the rapids above the falls. Here the river is again divided by Goat Island so that there are two falls, the American, which is about 1,000 feet in width and drops 165 feet, and the Canadian or Horseshoe Falls which drops 158 feet. The rim of the latter is about 2,600 feet in length and in the shape of a great curve bowed upstream because of the rapid erosion in the centre of the falls, amounting to an average of about three and a half feet per annum. Over the falls, the river plunges into a gorge varying between 900 and 1,200 feet in width. This gorge (Photo 42) extends northwards for six and one-half miles to the edge of the escarpment. In it the river flows tumultuously, especially in the narrower part above The Whirlpool. Upon entering the Ontario lowland plain at Queenston, it flows quietly toward Lake Ontario in a channel half a mile in width.

It was thought, at one time, that the Niagara gorge was entirely the result of postglacial cutting and was thus a convenient measure of Postglacial time. It is now known that part of it is the result of the re-excavation of a previously eroded gorge, a still-buried part of which extends from The Whirlpool to St. Davids. The rapids above the falls are thought also to be caused by the uncovering of the slope of this old valley. Moreover, it is now known that the volume of water in the Niagara River has varied greatly from time to time, hence its rate of cutting has been far from uniform. Regardless of its history, however, it is a splendid example of a river gorge produced by the retreat of a waterfall. The steep sides and great depth are produced by the undermining of the soft shale beneath the hard dolomite of the cap rock. The effects of early valley cutting, before the falls had migrated so far upstream, may be seen in the flat area of Niagara Falls Park and in similar remnants of rock terrace farther downstream. Records, kept for many years, show that the flow of the Niagara River has varied from 86,000 c.f.s. to 299,000 c.f.s. The yearly mean is about 205,000 c.f.s. representing an average depth of 10.5 inches of water from an area of 265,000 square miles, 94,000 square miles of which is open lake surface. Month-to-month variations are narrow, giving a reliability which makes the river especially valuable for power production. At Niagara Falls more than 12,000,000,000 kilowatt hours (kWh) of electrical energy is produced annually in the Province of Ontario and approximately 25% more at the Robert Moses-Niagara generating station in New York State.

WELLAND RIVER

The Welland River drains part of the back slope of the Niagara cuesta east of Hamilton. It rises on the side of the sandy moraine near Ancaster at an elevation of about 800 feet a.s.l., and takes a meandering course across the clay plain to the Niagara River at Chippawa. It falls 240 feet in 72 miles, an average gradient of a little over three feet per mile. About 200 feet of the total fall occurs in the first 15 miles, but there the stream is small and only a shallow channel is made in the clay plain south of Mount Hope. Thus, east of Sinclairville the gradient is less than one foot to the mile, making the river little more than a sluggish ditch.

Actually, the Welland River no longer runs into the Niagara River, but out of it. For the last four miles it serves as the intake of the Chippawa-Queenston power canal and as a final indignity it has been forced to crawl beneath the Welland Canal through two inverted siphons in the City of Welland. Upstream from Welland the river still retains its original character. Welland is to be considered more as a child of the canal than of the river.

SCARP-FACE DRAINAGE

A number of small streams descend the Niagara Escarpment through narrow notches and find their way directly to Lake Ontario. For the most part they bear names indicative of the distance from the mouth of the Niagara River. Among these are Four Mile Creek, Twelve Mile Creek, Twenty Mile Creek, Stoney Creek, and Red Hill Creek. Above the escarpment these streams all drain depressions between the clay moraines which parallel the Vinemount Moraine. Mostly, they serve to drain off surface water and are apt to dry up in summer. They

OGS 10 692

Photo 41. Niagara Falls, with the American Falls to the left and the Canadian Falls to the right. Photo courtesy of Ontario Ministry of Tourism and Recreation.

OGS 10 693

Photo 42. The Niagara Gorge was eroded by the Niagara River falling over the Niagara Escarpment. Photo courtesy of Ontario Ministry of Tourism and Recreation.

are sluggish streams and have cut only shallow valleys. In their descent of the escarpment they have their moment of glory, cutting deep V-shaped gorges and in some cases dropping over rock ledges as lovely little waterfalls. On reaching the base of the escarpment they proceed quietly and directly to Lake Ontario. Because of rising levels, the lake has submerged these river mouths. Ponded valleys almost closed off by gravel beaches at the shore are common to most of these streams.

Four Mile Creek is a rather insignificant stream which has its source in the mouth of the old St. Davids gorge and crosses the Iroquois lake plain directly to Lake Ontario. Its valley is entirely postglacial and shallow.

Twelve Mile Creek rises on the north flank of the moraine at Fonthill. Here apparently there is a large drift-filled re-entrant in the Niagara Escarpment. Twelve Mile Creek and its numerous branches have carved this into one of the most thoroughly dissected areas in Southern Ontario. At the edge of the escarpment is located Power Glen in which were built the old DeCew Falls power plant as well as the newer development which helps to make use of the extra water added to the Great Lakes drainage by the Ogoki and Long Lake diversions in northwestern Ontario. The additional water from these diversions totals more than 5,000 c.f.s. At Twelve Mile Creek, DeCew Falls Number 1 and Number 2 have an installed capacity of 147,000 kW.

Above the escarpment in its original state, Twelve Mile Creek meandered in a valley about a quarter of a mile in width and 75 feet in depth, south of the Vinemount Moraine. About four miles from the lake it was joined by a similar branch from the east. The lower part of the valley is drowned, forming a lagoon known as Martindale pond. Both branches as well as the trunk stream have been greatly altered by the works of man. The trunk and the east branch were used in the construction of the old Welland Canal. The west branch has now been straightened and protected by weirs in order to minimize erosion from the greatly increased flow of water from the power plants.

Twenty Mile Creek, draining an area of 113 square miles, descends the escarpment in a deep, narrow, V-shaped gorge in which actual waterfalls still exist. Its upper reaches resemble those of the Welland River since it, also, rises on the flank of the moraine at Ancaster and follows a parallel easterly course until captured by the steeper gradient of the outlet through the escarpment. The lower part of this valley is drowned but cut off from Lake Ontario by a sand bar, forming Jordan Harbour.

Forty Mile Creek issues from the escarpment at Grimsby but is of smaller volume, having captured a much smaller headwater area just in front of the Vinemount Moraine at the top of the escarpment. It has no large harbour at its mouth.

Redhill Creek flows in a rather large preglacial notch in the escarpment at the head of which is Albion Falls. In flood times this is a scenic feature worth visiting.

Though the streams of the Niagara Peninsula are small they have influenced settlement considerably. St. Catharines grew up where the old Indian trail from Niagara crossed Twelve Mile Creek on a crude log bridge. Later, when mills were established and the various Welland canals built, the place became a thriving manufacturing and commercial centre. Now, of course, the early significance of the river has been lost. Port Dalhousie (part of the City of St. Catharines) owes its site to the presence of the drowned valley indenting the lakeshore. Grimsby, is another small town whose rise was occasioned by the crossing of a small stream (Forty Mile Creek) by an early colonization road. Smithville and Saint Anns above the escarpment and Jordan at its foot are related to the early power sites on Twenty Mile Creek, as is the City of Stoney Creek to its own stream.

DUNDAS VALLEY

The preglacial Dundas Valley, now largely drift filled, contains no important streams but does have a number of small ones which have deeply dissected the drift. Spencer Creek finds its source in a number of small streams which drain the back slope of the Galt Moraine into the Beverly Swamp. From this issues a small permanent stream which eventually finds its way over the escarpment into the Dundas Valley. Here, Webster's Falls (Photo 43), a miniature Niagara, forms the nucleus of a splendid little park above the Town of Dundas. A companion feature, Tew's Falls, is found about a mile to the east. Two small branches approach Dundas down the Dundas Valley. Due to steep grades they and their short laterals have accomplished an amount of erosion out of keeping with their small size and the drift within this valley is badly gullied.

A large number of small creeks seam the steep face of the escarpment to the north of Hamilton Harbour, cutting deeply into the red shale which is but thinly covered by till. One of these, Waterdown Creek, flows in a preglacial notch deeply cut into the cap rock. It serves to drain portions of the glacial spillways above the escarpment as well as becoming the master stream of the scarp face, finally emptying into the head of Hamilton Harbour. Waterdown arose at the point where this stream was crossed by Highway 5. Further importance attaches to this valley from the fact that it is climbed by the Guelph line of the Canadian Pacific Railway.

Northern Lake Ontario Drainage

Between Hamilton Harbour and the Bay of Quinte, the area which drains to Lake Ontario is bounded by the Niagara cuesta and the Oak Ridges Moraine, both of which are heights of land setting definite watershed boundaries. Consequently there are many short rivers in this area including Bronte Creek, Oakville Creek, Credit River, Etobicoke Creek, Humber River, Don River, Highland Creek, Rouge River, Duffin's Creek, Lynde Creek, Oshawa Creek, Bowmanville Creek, Wilmot Creek, Ganaraska River, and Cobourg Creek. West of the Humber, the source area is the Niagara cuesta, east of the Humber it is the Oak Ridges Moraine. The Humber, itself, derives water from both sources. Some streams, however, do not tap the source areas but arise from the drainage of the till plain. Such is the nature, for instance of the Don River, and Etobicoke and Highland Creeks.

OGS 10 694

Photo 43. Webster's Falls on Spencer Creek, near the Town of Dundas, where it spills over the Niagara Escarpment.

Coventry (1940) has discussed the variations in flow, drought, and flood conditions in the streams between Toronto and Hamilton. Practically all of the streams having a permanent flow are fed from the area above the escarpment. Notable exceptions are the several spring-fed brooks in the sandy plain west of Port Credit—a benefit to real estate in that attractive area. The underlying rock in this lowland area consists of easily eroded shales and these rivers have cut steep-sided, narrow valleys to a depth of 75 to 100 feet. As they are along the north shore of Lake Ontario, these rivers are drowned at their mouths forming harbours at Bronte, Oakville, and Port Credit. They are all utilized to the full by pleasure craft. Flow of Bronte Creek is regulated by the Mountsberg Dam and the flow of Oakville Creek is regulated in three places: a dam at Scotch Block, the Hilton Falls Dam, and the Kelso Dam and Reservoir (the latter two being near Milton).

CREDIT RIVER

The Credit River is the largest of the group, with a drainage area of 328 square miles. Its total length is 58 miles from northeast of Orangeville to Port Credit. It rises on the Niagara cuesta, giving drainage to borderlands between Caledon Village and Orangeville as does the Nottawasaga River farther north. Thus it rises in a hilly area of moraines, gravel terraces, and swamps in which forest is still fairly abundant. The several branches mostly follow long swampy valleys in the Hillsburg and Orangeville areas where they have failed to cut deep channels.

The Credit leaves the plateau through a deep notch in the Niagara Escarpment at Cataract while the west branch descends through a similar gulch at Belfountain. Both contain waterfalls and rapids. Cataract for a number of years was the site of a small hydroelectric power plant, while Belfountain was developed as a pretty little private park. The streams unite at the Forks of the Credit, a picturesque spot at which the escarpment wall towers 400 feet above the valley floor. All three areas are now popular tourist attractions. Downstream the river has built a wide alluvial plain traversed by two distributaries which combine again before reaching Inglewood. Here the river is joined by a branch from the east which occupies a wide gravelly valley at the foot of the Caledon mountain.

For about ten miles to the vicinity of Georgetown, the river flows in a narrow valley between the escarpment and the till plain. Remnants of a sand and gravel terrace mark this as the route of former ice-border drainage, but the modern valley has been cut deeply into the till and underlying shale. Numer-

ous, small, rapid feeders enter this portion of the Credit from the face of the escarpment. They are actively eroding the shaley slope and in a few places gullying has proceeded so far as to produce veritable badlands.

At Glen Williams the river swings southeastward away from the scarp foot and follows the slope of the till plain toward Lake Ontario with a gradient of more than 20 feet per mile. At Norval it is joined by another deeply entrenched branch which drains a section of the escarpment behind Georgetown and Stewarttown. From this point to Port Credit the valley is cut in the boulder clay and often into the underlying shale. Near Huttonville and Erindale (part of the City of Mississauga) it is over 75 feet deep with steep sides, while a wide alluvial terrace occurs near Churchville and Meadowvale. At Erindale the level of glacial Lake Iroquois is reached. The river cuts through a well-developed terrace into the shale and then is deflected northward by a great barrier beach.

The last mile of the river before entering Lake Ontario is drowned and marshy. The quiet section between the Queen Elizabeth Way and the Canadian National Railway serves for canoeing in summer and provides a huge open air skating rink when frozen over in the winter. Between the railway and Highway 2, the marsh has been filled in and serves as a parking lot and a site for the Port Credit Library. The waves of the lake continue to attempt the building of a bar across the river mouth but have been defeated by continued dredging. Port Credit is now maintained as one of the most efficient and thoroughly used small-boat harbours on the shores of Lake Ontario.

Despite its small size the geographic significance has been considerable throughout the history of settlement. Erindale at one time had a mill and, indeed for a short time, a small hydroelectric generating station. At Streetsville, flour mills were operated by water power, and there were other mill sites upstream. The riverbanks from Port Credit to Streetsville have become favoured residential suburbs of Toronto. Erindale was chosen by the University of Toronto as the location of one of its colleges (Erindale College). At Streetsville and Huttonville parks have been developed, providing recreational facilities attracting people from Toronto and from the surrounding areas. Especially because of its recreational value to this suburban area, the Credit River has received careful study with a view to maintaining a good flow of clean water. To this end a dam was built at Orangeville, and control dams are still in the proposal stage for sites near Georgetown (part of the Town of Halton Hills), and Silver Creek.

ETOBICOKE CREEK

It would unduly prolong this section to discuss each small river in the same detail as the Credit; nevertheless certain points and problems concerning other streams must be mentioned.

Etobicoke Creek, which has a drainage area of only 74 square miles, lies entirely in the lowland. Yet, because portions of Brampton and Long Branch were built upon land which belongs, physiographically, to the river, a single flood has been known to result in damage to the amount of more than half a million dollars. Two major controls have been built by the river authority. In Brampton the stream has been provided with a new concrete-lined channel, diverting the water which formerly menaced the downtown area, part of the old channel being filled and added to the park. In Long Branch the channel has been improved and given a clear exit to Lake Ontario, while the adjoining land has been taken into the Metropolitan park system as Marie Curtis Park.

HUMBER AND DON RIVERS

Two small rivers of great interest to Metropolitan Toronto are the Humber and the Don. Both of them have helped to modify its physical landscape and to influence its growth and development throughout the history of settlement.

The Humber River drains an area of 220 square miles. Its main course is 63 miles in length from the top of the Niagara Escarpment near Mono Mills to the shore of Lake Ontario at the western outskirts of Toronto. In general it parallels the Credit, but with a somewhat more tortuous course. It has several tributaries; chief of which are the west branch which drains a part of the Peel plain, and the east branch which rises in the Oak Ridges Moraine. In the vicinities of Bolton, Kleinburg, and Woodbridge, the Humber Valley is more than 100 feet in depth. The headwaters also have rather intricately dissected the morainic area. Below Thistletown (part of the City of Etobicoke) the river has cut through the unconsolidated Pleistocene overburden into the underlying Paleozoic shales. The vertical valley walls in these stratified rocks are well displayed near Weston.

The Humber was in the main path of Hurricane Hazel on October 14-15, 1954, when up to 8 inches of rain fell, most of it within 16 hours. The resulting flood caused extensive property damage and great loss of life. At Weston a row of houses built on a low terrace near the river was swept downstream, carrying some of their occupants to their deaths, an awful price to pay for having built upon land belonging to the river.

The Don River system is smaller, draining an

area of 143 square miles in the Peel plain and the South slope, but without reaching any part of the Oak Ridges Moraine. It consists of two main branches, the east Don and the west Don which effect a junction just upstream from the point where the waters have cut through the old Iroquois beach to seek the level of Lake Ontario. The valleys of the Don, in some places 100 feet in depth, have been developed into a series of recreational parks. The G. Ross Lord Dam, on the west branch of the Don River at Finch Avenue has helped to reduce flooding. Like that of the Humber, the lower Don has been drowned by the rising waters of Lake Ontario.

Both the Don and the Humber systems are included in the Metropolitan Toronto Conservation Authority which originally planned a series of recreation parks and water-control dams throughout the area. Many recreational areas have been developed but the only one with a water-control dam is located at Clairville (now part of the City of Brampton), on the west branch of the Humber.

Between Toronto and Trenton, many small streams descend the southern slope of the Oak Ridges Moraine, most of them originating in springs at an elevation of about 900 feet a.s.l. There are practically no streams on the sandy crest of the moraine, the rain percolating into the porous beds to reappear again as springs on the shoulder of the ridge. Until they reach the Iroquois shoreline these are rapid streams with high gradients, often of 30 feet or more per mile. Consequently they have cut sharp gullies in the till plain. Towards Lake Ontario these gradients lessen and in time of freshet real floods accumulate in the lower valleys.

GANARASKA RIVER

The Ganaraska is the best known of these streams because of the flood damage which it has caused in Port Hope at its mouth, and because of the pioneer study undertaken by A.H. Richardson (1944). It drains an area of over 100 square miles. Although its main branch is only 22 miles in length, its average gradient is 30 feet per mile and it has a large number of tributaries. Because flooding was a major problem, it was thought that proper reforestation and rehabilitation of the watershed would help greatly. The above-mentioned report suggested that an area of 20,000 acres be set aside as the Ganaraska Forest. Of this, a total of 11,000 acres has been reforested and a dam for flood control has been built at Garden Hill, but major floods still occur every five to ten years, the most recent major flood being on March 21, 1980. That the problem of flooding is, in part, the result of the unwisdom of the townspeople who have occupied land belonging to the river, is certainly true. Structures encroach even upon the channel as well as the whole width of the flood plain.

TRENT RIVER

Several fair-sized rivers drain into the Bay of Quinte, including the Trent which is the largest of all the inland rivers in the south part of Southern Ontario. All of them cross the boundaries of the Canadian Shield, having their headwaters in the region of Precambrian bedrock and their lower courses on Paleozoic limestones which, in this region, have very little overburden.

The Trent drainage area comprises 4,790 square miles. From the rocky forested hills of the Canadian Shield a number of rivers run in a general southwesterly direction toward the Kawartha Lakes which serve as great reservoirs for the Trent system.

The Kawartha Lakes lie along the juncture of the Paleozoic limestones and the crystalline rocks of the Canadian Shield. They occupy portions of preglacial valleys which formerly drained toward the southwest and are probably somewhat overdeepened by ice action (Wilson 1901) but which have been blocked in the south by morainal debris. These lakes drain from one to the other over the lowest saddles in the rock between them, thus accounting for their zig-zag pattern. This was also for a long time the outlet of Lake Algonquin, consequently the connecting streams flow in wide rock-floored valleys which were swept clean by the much greater flow of water. The outlet was not occupied long enough to permit complete grading of the course and a number of waterfalls still remain, as at Fenelon Falls and Burleigh Falls. From Balsam Lake to Katchiwano Lake the total drop is about 78 feet.

South of the Kawartha Lakes the system also receives a number of tributary streams draining that portion of the drift-covered plain north of the Oak Ridges Moraine. These rivers flow in swampy valleys of low gradient. Scugog River, for instance, is twelve miles in length between Lake Scugog and Sturgeon Lake and falls only six feet, practically all of which is accounted for by the dam at Lindsay. Pidgeon River is another sluggish, north-flowing river in a wide swampy valley.

The Kawartha Lakes drain to Rice Lake by way of the Otonabee and Indian Rivers. The Otonabee was undoubtedly the main route of the Algonquin drainage, although the Indian River valley, a few miles to the east, also shows evidence of a former much greater stream. In the 10 miles from Lake Katchiwano to Little Lake in the City of Peterborough the Otonabee River falls 140 feet. This section of the river is made navigable by the Peterborough hydraulic lift lock, the largest of this kind in the world. Downstream the river falls only 9 feet in the 20 miles between Peterborough and Rice Lake.

Rice Lake, which extends for about 23 miles in

a southwest-trending depression, seems also to occupy a portion of a preglacial valley although the rock is completely obscured by drift except at the outlet in the northeast. This body of water is notable for the number of drumlin islands which it contains.

From the outlet of Rice Lake, now controlled by the dam at Hastings, the Trent River flows northeastward in the old valley for a distance of seven miles, and then turns eastward in a rather aimless fashion across a limestone plain for six miles to Healey Falls. Here it tumbles into another old limestone valley approximately 75 feet in depth, making a complete, right-angled turn to flow southward. The northward continuation of this valley contains the stream known as Crowe River which drains three fair-sized lakes situated, like the Kawartha Lakes, on the border of the Canadian Shield. The southward-flowing portion of the Trent is 10 miles in length and falls approximately 155 feet to Percy Reach. The latter name is given to a broad eastward-trending portion of the river, about 13 miles in length and having almost no gradient whatsoever. Bordering the western portion of Percy Reach is a swampy area over four miles in width, while eastward the river divides to enclose the large flat area of Wilson Island. Again the river encounters a southward-trending valley, the upper continuation of which is occupied by Rawdon Creek. From this point to the Bay of Quinte at Trenton, the river has only a shallow channel in limestone. This lower section has a number of tributaries including Mill Creek, Salt Creek, Cold Creek, Squire Creek, and Rawdon Creek, all of which flow in swampy hollows among drumlinized uplands.

The whole Trent River system is an example of the youthful, deranged, non-integrated type of drainage resulting from Pleistocene events. The lakes, broad reaches, and marshy areas contrast sharply with the rapids and waterfalls of the intervening areas. Since a large portion of the drainage area is strongly drumlinized there are a great many linear and oval inter-drumlin swamps as well.

The chain of lakes and the good-sized river led to the idea of a canal between Lake Ontario and Lake Huron. Long before it was finished, however, the need for such a water route was past and the only real benefit conferred has been the by-product of power which has helped the growth of local industry at Peterborough, Hastings, Campbellford, and other places. The only craft on the river and the lakes are those of vacationers and sportsmen, since the Kawartha region is one of Ontario's most accessible and best recreational areas.

MOIRA RIVER

Lying just east of the Trent and paralleling it in many ways, the Moira drainage basin has an area of 1,090 square miles. The headwaters of the Moira rise in the rocky highlands of Hastings, and Lennox and Addington Counties about 60 miles north of the Bay of Quinte. The upper streams are very crooked and pass through a succession of lakes, swamps, and rapids. The Skootamatta for instance, winds over 50 miles in an airline distance of 27 miles and falls more than 700 feet.

Stoco Lake lies approximately on the border between the Precambrian and Paleozoic rocks. From this lake to Belleville the Moira flows over limestone. In the first 13 miles it follows a well-marked valley in the bedrock and falls 110 feet, an average gradient of over 8 feet per mile. At Plainfield the river enters a broader valley with less gradient and turns westward. The tributary in the upper portion of this valley, known as Parks Creek, issues from two marly lakes near Marlbank. Through the sandy area between Plainfield and Foxboro, the Moira is broad and sluggish. From Foxboro it turns south through a shallow channel to Belleville, falling almost 80 feet in the last 5 miles.

The mean discharge measured at Foxboro is 1,052 c.f.s., equivalent to 14 inches of rainfall annually. However, the discharge during individual years has varied from 522 c.f.s. (7 inches of rainfall) to 1,950 c.f.s. (about 26 inches). The lowest flow recorded is 15 c.f.s., and the highest 12,400. For the most part April is the flood month and September the time of weakest flow.

Despite the large forested area and the numerous lakes on the Canadian Shield, the flow of the Moira River is notoriously unreliable. Perhaps the limestone plains of the lower part of the basin are responsible for the flash floods which occur periodically. The problem of flood control on this river is important because the central portion of Belleville is on the narrow flood plain. Low flow augmentation dams have been built at Lingham Lake and Deloro.

SALMON RIVER

Seven miles east of Belleville the Salmon River enters the Bay of Quinte. It has its sources far within the Canadian Shield in several winding streams, the most important of which is Story Creek, draining a series of small lakes near Cloyne. From this source to its mouth the stream course extends approximately 80 miles with a total fall of 700 feet. The system has many lakes lying between the rock ridges of the Canadian Shield, among which may be mentioned Kennebec Lake, Big Clear Lake, Buck Lake, Bull Lake, Horseshoe Lake, and Sheffield Lake. The lattermost is apparently connected with Clare Creek of the Moira system. Lying at the edge of the limestone plain are Beaver Lake and White Lake,

occupying part of the valley which is drained by Parks Creek to the Moira. The Salmon River basin upstream from these lakes might be called territory diverted from the Moira drainage area by the accident of glaciation. Beaver Lake is also worthy of note from the fact that it is almost divided in two by a large esker which runs through the middle of it.

Leaving Beaver Lake in a northeasterly direction, the river wanders rather indefinitely in a swampy area before entering the shallow valley leading south past Tamworth to Croydon. At the latter point it enters the larger valley occupied by Black Creek and, swinging southwesterly, follows this valley to the Bay of Quinte. This valley is well entrenched in the limestone plain, being over 100 feet deep in mid-course. The upper section is broad and swampy, the midsection well drained, while the lower few miles are evidently drowned by the rising water level of Lake Ontario. The gradient of the river in the last 23 miles is about 200 feet or 8.7 feet per mile.

NAPANEE RIVER

The Napanee River enters at the northeastern angle of the Bay of Quinte. It flows in a well-marked valley of preglacial origin, the direction of which is roughly parallel to that of the Salmon River. This valley is from a mile to a mile and a half in width, nearly 150 feet deep in places, and about 25 miles from the Bay of Quinte to the large swampy region on the edge of the Canadian Shield which contains Napanee Lake. The preglacial origin of this valley was suggested many years ago by Mather (1917) because of the till in the floor of the valley near Newburgh. The modern river has removed a large amount of till and other soil from this valley. The chief headwaters of this system are Cameron Creek, Depot Creek, and Hardwood Creek, each of which drains a group of rocky lakes. Flood control dams have been built at Second Depot Lake and Third Depot Lake. Two fairly large lakes should be mentioned, namely Mud Lake and Varty Lake, which occupy depressions in the border of the limestone platform.

In contrast with the Salmon River valley, the valley of the Napanee is lined with settlements including Napanee, Strathcona, Newburgh, Thompsons Mills, Camden East, Yarker, Colebrook, and Petworth. We should also include Bellrock on Depot Creek and Verona on Hardwood Creek. A power plant on Depot Creek at Bellrock has a capacity of 90 kW. Early power sites on the river gave rise to most if not all of these settlements. They have persisted, however, largely because the Napanee Valley is paralleled by both railway and highway.

St. Lawrence Valley Drainage

CATARAQUI AND GANANOQUE RIVERS

The region northeast of Kingston has two main rivers, the Cataraqui and Gananoque, which flow in southerly directions to Kingston and Gananoque respectively.

The Cataraqui River system consists of a series of long, narrow lakes joined by the river. The river serves as the Rideau Canal route from the Rideau Lakes to Kingston. The canal system has seven locks, the greatest change in elevation being at Jones Falls.

Like the Cataraqui, the Gananoque River, for the most part, drains a rugged area underlain by Precambrian bedrock and serves to connect a series of lakes. Two tributaries of the Gananoque, one from the east, the other from the west, drain the flat clay plains near the St. Lawrence River, and have low gradients and shallow channels.

RAISIN RIVER

There are no large rivers emptying into the St. Lawrence River between Brockville and the Quebec Border. The Raisin River is the only sizeable stream, emptying at Lancaster. The headwaters, particularly above Martintown, drain an area dominated by stony uplands. Below Martintown the river flows through low-lying clay plains and its channel is entrenched mostly in marine clay beds. The channel is fairly shallow and, with a gradient of only three or four feet per mile, this section is subject to ice jamming and consequent local flooding. Below Williamstown the gradient is low and the river flows in a shallow channel through the silty Lancaster flats.

Ottawa Valley Drainage

The rivers of this region which will be discussed include the South Nation, Rideau, Mississippi, Madawaska, Bonnechère, Muskrat, Indian, Petawawa, Barron, Mattawa, and Ottawa. Only the South Nation and Muskrat Rivers are entirely within the lowland plain; most of them rise and have parts of their courses in the Canadian Shield, while the Petawawa, Barron, and Mattawa Rivers flow entirely within the area of the Shield. All of them, however, are of geographical significance for the region under discussion.

SOUTH NATION RIVER

The South Nation River drains an area of about 1,430 square miles in eastern Ontario. From its source, a few miles north of Brockville, to its conflu-

ence with the Ottawa, the stream traces a course of 110 miles and descends 275 feet. The average gradient therefore, is approximately 2.5 feet per mile. Except for its slight overall gradient toward the Ottawa, the South Nation owes little to preglacial influences and its geomorphic features all postdate the withdrawal of the Champlain Sea.

In spite of the fact that it drains an almost flat plain, there are regional differences which should be noted. The gathering ground of the headwaters is on a limestone plain which has little overburden apart from peat bogs, and the small streams wander from one swampy depression to another without entrenching themselves. The stream drops 100 feet, however, in the first 7 miles. In the next 23 miles it drops another 75 feet at an average and almost uniform gradient of three feet per mile. In this stretch the river passes through a region of slightly deeper overburden partly composed of till, but more dominantly of water-laid sands overlying clay. The stream has cut a shallow valley (Photo 44). Dams have been installed at Spencerville and Ventnor, but with a very low head. Near the village of South Mountain, however, the river enters the "Nation River valley" or Winchester clay plain, and in the next 17 miles to beyond Chesterville the drop is 25 feet. A low dam has also been built to regulate the flow of water at Chesterville. Between Chesterville and Crysler there is more of an actual valley, deepening below Crysler until the solid rock is exposed at Casselman.

Below this point the river swings west and north again to cut a canyon, 75 feet deep, through a broad sand plain. Within this narrow valley, terraces were left showing the stages of valley cutting. Emerging near Lemieux, the South Nation enters upon the broad, flat, clay plain which forms the floor of the stream-cut channel already described and for the next 15 miles has hardly any gradient and only a very shallow valley, held up by the rock sill at Plantagenet. The Leda clays, through which this part of the South Nation River flows, can be very unstable. One major mud flow blocked the river from May 17 until September 1, 1971.

OGS 10 695

Photo 44. Shallow valley of the South Nation River near Cass Bridge, Dundas County.

The South Nation River has a number of fairly important branches, the largest being Bear Brook and Castor River. Both of these have shallow channels and drain very flat areas. This river has not yet been able to establish drainage in its whole territory, and there are numerous peat bogs including the Alfred, Mer Bleue, Winchester, Moose Creek, and other less well-known bogs.

There are only five incorporated villages in the whole watershed and of these only two, Chesterville and Casselman, are actually situated on the river. Finch is situated on the Payne River where it is crossed by the Canadian Pacific Railway. The other incorporated places also have rail connections. The river and its branches, however, have resulted in the location of many villages and hamlets including Plantagenet, Lemieux, St. Albert, South Mountain, Ventnor, and Spencerville on the main river, Russell and Embrun on the Castor River, and Berwick on the Payne River. The river provides the domestic water supply of some of these settlements.

The river is remembered most for its recurring annual floods. Spring floods are to be expected in a region of heavy snowfall and low winter temperatures. Occasionally, however, as in 1945 and 1972, there are midsummer floods as well. There are two chief flood areas along the main river: the Brinston Flood Area, about ten miles upstream from Chesterville; and the La Pointe Flood Area in South Plantagenet Township. This last is by far the largest area and has experienced flooding to a depth of 18 feet. In the early 1980s channelization works have been done on the river bed in these two areas to allow more rapid draining during the annual spring flood periods. Smaller areas around Crysler, Ventnor, and Spencerville sometimes also experience floods. At one time a scheme was proposed for channelizing the river and joining it to the St. Lawrence, for purposes of navigation; at another time a plan was brought forward for connecting the upper part of the river to the St. Lawrence in order to divert drainage in times of flood.

Physiographically, the South Nation is an inadequate river, a boy trying to do a man's job. It is a stream which is prevented from reaching maturity by its lack of gradient, which even now is less than that of many a senile river. It, therefore, still presents a difficult problem of drainage and flood control.

RIDEAU RIVER

The Rideau River enters the Ottawa River at the

City of Ottawa. At its mouth it falls over a ledge of limestone in a beautiful curtain of water, from which it was given its name by the French explorer Champlain. The river rises on the Canadian Shield in the same general area from which the Salmon, Napanee, Cataraqui, Gananoque, and Mississippi Rivers emanate. Along the boundary between the Precambrian bedrock and the Paleozoic lowland of eastern Ontario in large rock basins, are the Rideau Lakes which serve as reservoirs for this system. These lakes and the others which abound in the neighbourhood constitute one of Ontario's finest recreational areas. They lie at an elevation of about 400 feet a.s.l. and the Rideau in its 62-mile course to Ottawa falls about 225 feet or less than 4 feet per mile. While part of this course is over the limestone plains, a long section is in a shallow valley cut in marine clay or till.

The Tay is a river falling into the lower Rideau Lake a few miles above Smiths Falls. It is 55 miles long and also drains a number of lakes to the northwest of the Rideau Lakes.

The Rideau is remarkable for the fact that it serves as a canal throughout almost its entire length. The Rideau Canal is 126 miles in length between Ottawa and Kingston. It was built by Colonel John By in the years 1827 to 1832 at a cost of about $4,000,000 and was used as a valuable commercial artery until the 1850s. Its construction was fairly simple since there was a minimum of excavation and most of the waterway was secured by constructing dams across the Rideau and the Cataraqui. There are 24 dams and 47 locks, each of the latter being 134 feet long, 33 feet wide, and having 5 feet of water on the sills. In the early days it was a busy waterway and contributed a great deal toward the settlement of the region. The building of railways and the channelization of the St. Lawrence rendered it obsolete within 50 years, but commercial navigation lingered until 1930 when the last "cheese boat" ceased running. Since that time this scenic and historic canal has been used only by pleasure boats and maintenance craft.

The Rideau is in many ways a sister to the Trent, rising on the Canadian Shield then flowing across limestone plains and through areas of deeper drift. It has large headwater reservoirs, complete channelization, and controlled flow.

MISSISSIPPI RIVER

The Mississippi River resembles the Rideau in having numerous headwater lakes in the Canadian Shield and in traversing both limestone and clay plains. The Mississippi has not been turned into a canal, but it has at times suffered improvement to facilitate the driving of logs. From its source at the head of Mazinaw Lake to its confluence with the Ottawa near Galetta its course is over 120 miles in length. Mazinaw Lake lies at 875 feet a.s.l. and the confluence at about 250 a.s.l., giving a total fall of 625 feet, or about 5 feet per mile. However, with rivers in such an ungraded condition, average gradient means very little. Only in the lower 28 miles of its course, below Carleton Place, has the Mississippi had a chance to cut a normal valley, and even here it has uncovered ledges of hard rock. The Clyde River from the north and the Fall River from the south are important tributaries. The latter drains from Sharbot Lake.

A gauging station is located at Appleton, about 24 miles from the mouth. Above this the drainage basin has an area of 1,120 square miles. The mean annual flow is 1,084 c.f.s. and the runoff varies from 6 inches to 24 inches. The minimum recorded flow is 80 c.f.s. and the maximum flood stage is 9,190 c.f.s. September is the month of drought and April the usual month for floods, although occasionally the greatest freshets come in May.

Power sites on the Mississippi have been important since the early days and have given rise to a number of towns and villages. Those on the lower river include Galetta, Pakenham, Blakeney, Almonte, Appleton, and Carleton Place. Lanark is on the Clyde, a few miles above its mouth. Hydroelectric power plants are located at Galetta and at High Falls more than 60 miles up the river. The plant at Galetta is presently out of service. High Falls has an installed capacity of 2100 kW. Other potential power sites exist.

MADAWASKA RIVER

The Madawaska is the largest of the Ontario drainage systems tributary to the Ottawa River, the area being 3,300 square miles. The Madawaska is a long river, the distance from Source Lake in Algonquin Provincial Park to the confluence with the Ottawa at Arnprior being over 200 miles.

The Madawaska rises in the area south of Opeongo Lake (1,323 feet a.s.l.) where the highest lands stand above 1,600 feet a.s.l. It takes a southeasterly course, connecting several good-sized lakes including Bark (1,027 feet) and Kamaniskeg (928 feet). Near Combermere the main river is joined by the York River which drains the Bancroft area flowing northeast across the line of faults in that area. The Madawaska follows faults from Bark Lake to Matawatchan then turns abruptly eastward to the Ottawa River at Arnprior. Some important branches are: the Opeongo which drains Opeongo Lake in the central part of Algonquin Provincial Park; York River, which drains a large area in Haliburton County, northern Hastings County, and northern Lennox and Addington County; and Waba Creek, entering near Arnprior and draining White Lake, a large

body of water on the boundary between Lanark and Renfrew Counties. The Opeongo River appears to follow the route of a much larger river, probably of meltwater during the recession of the glacier, a river which left a train of outwash sand terraces. For a short distance above Arnprior only, the river and its tributary Waba Creek cross the clay plain. Here the river has cut a valley up to 75 feet in depth. Within the Canadian Shield the river flows through many scenic gorges. At Burnstown, for instance, the valley is over 200 feet in depth.

Flow records are kept at several places along the river. At a point 6 miles above Arnprior, the mean annual flow is 3,154 c.f.s. or the equivalent of 14 inches of runoff. Annual flows have varied from 1,320 c.f.s. (5.6 inches) to 5,230 c.f.s. (22 inches of runoff). The lowest flow ever measured was 16 c.f.s. while the highest flood stage carried 22,000 c.f.s. April and May are almost equal as flood months while September is usually the month of weakest flow.

Above Stewartville where a dam and power plant have been built, the river has a steep gradient dropping from 800 feet to 350 feet a.s.l. in 25 miles. The St. Patrick Fault is still effective even if the scarp is not prominent in this area. The five power plants on this river together have a capacity of 523,000 kW. The dam at Barrett Chute has flooded the valley upstream for over 20 miles to Griffith. At Bancroft on the York River there is a small, privately owned plant with a generating capacity of 270 kW.

BONNECHÈRE RIVER

The Bonnechère rises in Algonquin Provincial Park at an elevation of well over 1,000 feet a.s.l. It takes a general southeasterly course largely controlled by the major bedrock faults of the region, finally falling into the Ottawa near Castleford. Its total length is about 100 miles and the area of its drainage basin 935 square miles. Included are a number of lakes, the largest being Golden Lake, Round Lake, and Lake Clear. The course of the stream is almost entirely controlled by the block-faulted relief of the area. The upper part of the valley lies in a graben whose bounding escarpments are more than 500 feet in height. The valley of the river is hardly entrenched at all and drift barriers cause expansion into broad lakes. In the vicinities of Golden Lake and Round Lake, there is a great deal of sand and gravel which was undoubtedly deposited by glacial meltwater. Below Eganville a rather deep valley, interrupted by waterfalls, is cut in the Paleozoic limestones preserved in the floor of the graben. The Bonnechère caves are found in this area. In the clay plain between Douglas and Renfrew the river has cut a narrow valley up to 50 feet in depth. At Renfrew again there are waterfalls below which the river has cut a trench over 100 feet deep in Pleistocene deposits, and here there is a succession of deep lateral gullies.

The Castleford gauging station records the mean flow of the river at 675 c.f.s. which is the equivalent of 10 inches of runoff. The annual flow, however, varies from 268 c.f.s. (4 inches) to 1186 c.f.s. (17.5 inches). August through October is definitely a season of low water, while April and May are months of freshet. The lowest record, 24 c.f.s., was made on August 3, 1964, while the greatest April flood was 10,100 c.f.s., in 1928.

MUSKRAT RIVER

The Muskrat and Indian Rivers, which join to make one entrance to the Ottawa at Pembroke, are small but interesting rivers. The Muskrat is closely aligned with the Muskrat Fault and drains Muskrat Lake, some 10 miles in length and extraordinarily deep. Other smaller lakes are found in this chain also. The Snake River, a tortuous tributary falling into Muskrat Lake, drains Mink Lake and Lake Doré. All of these lakes are in the down-dropped block and associated with limestone outliers.

INDIAN RIVER

The Indian River, on the other hand, issues from the block mountain uplands by way of the deep valley of the Gardez-Pieds cross fault. Along this valley there are very interesting gravel terraces associated with the Fossmill outlet of glacial Lake Algonquin.

The river begins at Kathmore but the valley continues along a fault to St. Andrews Lake. The Fossmill drainage undoubtedly came to St. Andrews Lake from where most of it went down the Barron River. However, at peak flow some may have passed on to Kathmore and down the Indian River. A small delta in the vicinity of Alice occurs where the valley reaches the level of the Champlain Sea.

PETAWAWA RIVER

The Petawawa River and its extension up through Radiant Lake, Cedar Lake, and Cauchon Lake to Mink Lake follow fault lines through much of its course. Around the lakes the gradients are low and there usually are sandy outwash plains. These are separated by narrow valleys with bare rock walls and boulder pavements in the bottom. This was the route followed by the drainage from glacial Lake Algonquin during the Fossmill to Mink Lake stages, and when first opened it no doubt carried a great discharge.

The Petawawa drains an area of 1,590 square miles. Its mean annual flow is 1,645 c.f.s., the equiv-

alent to a runoff of 14 inches. It has, however, been known to vary between 655 c.f.s. (5.6 inches) and 3,170 c.f.s. (27 inches of runoff). The minimum recorded flow of 204 c.f.s. took place in October 1931, while the maximum flood, 14,000 c.f.s. occurred on April 26, 1960. On the average, both September and October are dry months while April and May are usually the flood months.

The Petawawa River and its tributaries flow almost entirely within the forested upland areas of the Canadian Shield and were, at one time, of considerable use in lumbering. They are not used for any hydroelectric power plants.

BARRON RIVER

The Barron River valley served as a second channel for Fossmill drainage below St. Andrews Lake. Between Stratton and St. Andrews Lakes there is a strip of land strewn with big boulders. Leading northward from St. Andrews, the Barron River first drops over a pretty little waterfall about ten feet high which, oddly, is called High Falls. The discharge from Stratton Lake drops down steep rapids just west of the above-mentioned falls and the rocks around the rapids are swept bare. After taking a northward course for two miles the Barron River turns sharply eastward and follows a fault line through a sandy area toward Petawawa, joining the Petawawa River west of the town of that name.

MATTAWA RIVER

At North Bay the divide between drainage to Georgian Bay and to the Ottawa River occurs just east of the city. From that point the Mattawa River follows eastward in the depression along the Coulonge Fault. From Lake Talon to Mattawa this mostly takes the form of a rock-walled canyon up to 300 feet deep. Indeed the north wall rises over 500 feet in places. Several tributaries enter the Mattawa River from the south, draining the clay flats and rock knob complex of Bonfield, Calvin, and Papineau Townships. The largest of these is the Amable du Fond, which rises at Kawawaymog (Round) Lake and proceeds to drain Waskigomog, Wilkes, and Kioshkokwi Lakes where it crosses the abandoned Fossmill outlet channel and drains a section of it northward.

During the life of the Nipissing Great Lakes the Mattawa Valley carried the whole discharge from the upper Great Lakes. Evidence of a much larger river is seen in scoured, bare rock walls and in boulder pavements well above the present stream level. For example, south of the main intersection in the Town of Mattawa the wooded land is littered with big boulders. In the 80 miles between Mattawa and Petawawa the feeders on the south side of the Ottawa River are all small streams which generally drain only the first tier of townships. Between Deux-Rivières and Bissett Creek, two small streams drain a former, alternative channel of the Ottawa River.

OTTAWA RIVER

The Ottawa River forms the eastern boundary of the Province of Ontario for a distance of approximately 360 miles from the head of Lake Timiskaming to the Carillon Rapids. Not only does it provide a natural boundary but it is a most striking physiographic feature. It is, like most of the other rivers which issue from the Canadian Shield, still in a youthful or ungraded state. Despite the fact that for long distances it flows in a deep and rather narrow valley cut into the old peneplain of the Canadian Shield, it inherited most of this from a preglacial ancestor.

Like many other rivers in glaciated territory, the Ottawa seems to consist of a chain of stillwaters or lakes connected by sections of steeper gradient often with rapids and waterfalls. Among the lake-like expansions of the river are Allumette Lake (366 feet a.s.l.), Lower Allumette Lake (352 feet), Coulonge Lake (239 feet), Lac Rocher Fendu (257 feet), Lac des Chats (239 feet), and Lac Deschênes (192 feet). All of these lie in the sections of the river above Ottawa. Between the lakes are various famous rapids including Allumette Rapids, Paquette Rapids, Chute du Rocher Fendu, Chats Falls, and at the foot of Lac Deschênes, the great Chaudière Falls. Below the City of Ottawa, lakes and rapids are fewer but the Long Sault Rapids and Carillon Rapids combine to drop the river from Baie de l'Orignal (131 feet a.s.l.) to Lake of Two Mountains at 73 feet a.s.l.

In recent decades the Ottawa has provided still further wealth in the development of hydroelectric power. There are four Ontario Hydro generating stations, the largest operating at Rapides-des-Joachims to produce nearly 360,000 kW. The Otto Holden and Chenaux plants generate 328,000 kW. The 180,000 kW produced at Chats Falls is shared equally by Ontario and Quebec. The Province of Quebec has built its own plant at Carillon Rapids.

The river drains an area of about 56,000 square miles in Ontario and Quebec. The mean annual flow at Chats Falls is 40,965 c.f.s., which is equivalent to 16 inches of water from the whole area. Yearly records have varied from 26,500 c.f.s., (10.4 inches) to as much as 73,400 (28.8 inches). This degree of regularity is, of course, influenced by the presence of the many lakes and dams along the river and will be further affected when other dams are constructed. The minimum flow was 5,040 c.f.s. in 1942, while the highest flood stage, in 1960, reached 205,000 c.f.s., which is, after all only about five times the mean annual flow value.

For a large river the Ottawa does not have an impressive valley. In some of the more rapid parts, banks up to 100 feet in height are developed. Bordering the Petawawa sand plains there are bluffs 75 feet in height, but they stand half a mile to a mile back from the present very gently sloping riverbank. The shoreline of Lac des Chats, especially toward the lower end, is low and swampy. Elsewhere the river has low banks, 25 to 50 feet in height and out of proportion to the size of the river. However, where the river has uncovered an ancient rock escarpment, as at Parliament Hill in Ottawa, the scenery takes on a more impressive appearance.

The Ottawa River has been an important factor in the historical development of Canada. It served as an important route for the early explorers and fur traders. Later it was the route by which squared timber was shipped to the markets of the world. Even today it carries logs and pulpwood to mills located along its banks. It is navigable by small ships of shallow draught as far upstream as Ottawa, which is also the terminus of the Rideau Canal. At one time it was proposed that the Ottawa be fully channelized to provide a navigational outlet to the upper Great Lakes, but this ambitious project was found to be too costly. The great value of the river today is in its full utilization for the production of hydroelectric power.

The Significance of Southern Ontario Streams

The chief rivers of Southern Ontario and their valleys have been described in this section as physical features, as units in the physiographic pattern. They form boundaries, barriers, and corridors of geographical importance. The rivers, also, have physiogaphic functions. They are the natural agents which, during the Postglacial age, have carried on most of the work of geological erosion and transportation; they are gradually, and in some areas rapidly, cutting into the drift and carrying down the materials to be spread out on the floors of the Great Lakes as well as smaller lake basins. Gradually, also, some shallow retaining basins are being drained as rivers cut down their outlets.

No river, however, has everything its own way, even though it is always in alliance with the force of gravity. It would have, if the glacial deposits remained bare as they were at the disappearance of the last ice sheet. However, in place of ice, the surface soon acquired a cover of soil and vegetation, a matted binder to hold the surface in place. It must be admitted that it has been effective, for most of Ontario's surface is still a glaciated plain, and only a small area is given over to recently cut valleys. In unsettled country, forested country, such as most of Ontario was until a century or so ago, nature preserves a balance and the work of rivers is remarkably slow. Floods, there have always been, and always will be, but under primeval conditions their effects were not excessively severe.

In country such as Southern Ontario now is, a new environment has been created in which the river must become the agent of man as well as the agent of nature. Depending upon capacity and location, we look upon the river for drainage and for water supply. The recreational aspect cannot be overlooked for fishing, boating, swimming, and skating. Some of Canada's best hockey players got their start playing shinney hockey on the river. If large enough, it is used for navigation, or it is channelized; large rivers, also, have become our most important sources of power.

The river has become one of the most important cases where the principle of the multiple use of resources may be put into play, and it must be kept in play if the greatest benefits are to be obtained. It is manifestly impossible to restore primeval conditions since this would involve complete reforestation and population evacuation of the whole area. However, properly managed, contour-farmed croplands and pastures are almost as retentive of moisture as are forests. Add to this the scientific management of the river itself, and it is not inconceivable that the managed regimen might be an improvement upon the original. River valley conservation authorities, Ontario Hydro, and the Ontario Ministries of the Environment and Natural Resources are all part of the machinery by which the people of Ontario are trying to apply scientific principles of river management so as to obtain the maximum benefit from all of Ontario's streams.

PHYSIOGRAPHIC REGIONS

Within Southern Ontario as we have seen, there are many different landforms that may be recognized and mapped. In terms of its gross structure, which is based mainly on the bedrock, the area consists of five natural divisions. These are: (1) the broad half-dome that slopes from the Niagara Escarpment to Lakes Huron and Erie; (2) the Niagara Escarpment itself; (3) south-central Ontario between the edge of the Canadian Shield and Lake Ontario; (4) the lowlands between the St. Lawrence and Ottawa Rivers; and (5) the northern portion underlain by Precambrian bedrock. Within these major divisions there are differences, usually due to the glacial deposits which necessitate further subdivision. While the major distribution pattern is not simple, it is possible to place them satisfactorily in the 55 minor physiographic regions that appear in Figure 19.

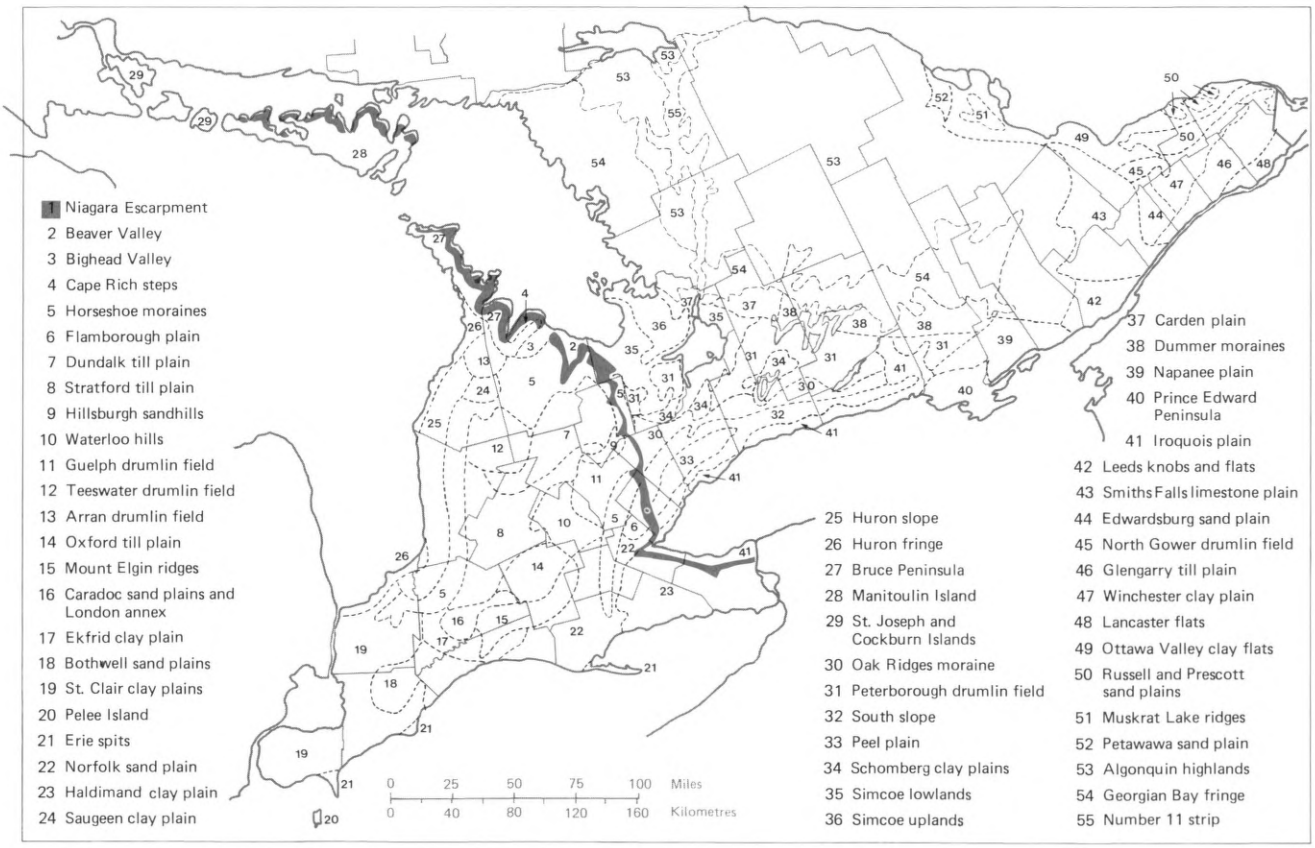


Figure 19. The 55 physiographic regions of Southern Ontario.

Southwestern Ontario is a large unit in which the most striking contrast is between the rolling till plains of the upland and the ancient lake bottoms bordering the Great Lakes. The topographic contrast is accentuated by variations in climate and natural vegetation, and in the specialized agriculture on the sand or clay plains and the more generalized farming of the uplands. The body of this elephant-shaped area is divided into 27 regions which include Manitoulin, Cockburn, and St. Joseph Islands.

The Niagara Escarpment is dealt with as a single unit except that the two large re-entrant valleys, the Beaver and Bighead, and the Cape Rich area are discussed separately.

In south-central Ontario the major relief is provided by the massive interlobate moraine rather than by the bedrock. The crest of this moraine is mapped under the name of Oak Ridges. The north and the south slopes together with the adjacent till plains form two regions, while a third till plain or group of separate till plains comprise the uplands of northern Simcoe County. The Peel and Schomberg are both uniform clay plains, but both the Algonquin and Iroquois plains are highly variable. In discussing the areas of shallow drift on limestone, Prince Edward County or Peninsula seems to stand out by itself and is described separately from the Napanee plain.

Eastern Ontario is mainly dealt with in eight regions with three more small regions taking care of as many odd areas of distinction. The large tract of limestone plains lying adjacent to the Canadian Shield is similar to the Napanee plain and the Carden plain. Only two of the regions are dominated by glacial forms, the bulk of this division being taken up by sand or clay plains.

The fifth and largest of the major divisions is the northern part underlain by Precambrian rocks. This is an area of rough relief with frequent outrops of granite and other igneous and various metamorphic rocks, and shallow, sandy, acid soil; it is mostly non-agricultural. This, together with the lakes and swamps make this area distinctive. However, the main part centred in Algonquin Provincial Park has generally a thicker overburden and fewer bare rock outcrops than a belt bordering Georgian Bay in Parry Sound and Muskoka and extending eastward. This difference in depth of soil is important to forest tree growth and so they are separated. Also, the area astride Highway 11 has extensive areas of sand, silt, and clay deposits. The better, deep soils in this area have resulted in farming settlements which set this small area apart as a third region.

The land use and settlement patterns discussed for each region are based on the 1981 census statistics, and the information regarding the soil types is drawn freely from the Ontario Soil Survey reports, listed in Appendix C. Population values are primarily based on the 1983 Municipal Directory published by the Ontario Ministry of Municipal Affairs and Housing. Recent updates in the names of towns and cities, townships, counties, and regional municipalities are listed in Appendix D. The new names appear on Map P.2715 (back pocket), but the four miles to one inch maps have not been updated.

1 NIAGARA ESCARPMENT

The Niagara Escarpment extending from the Niagara River to the northern tip of the Bruce Peninsula, and continuing through the Manitoulin Islands, displays an association of landforms not found elsewhere in Ontario. Vertical cliffs along the brow often mostly outline the edge of the dolostone of the Lockport and Amabel Formations while the slopes below are carved in red shale. For some distance back from the brow the dip-slope of the cuesta in many places has been stripped of soil and overburden. Flanked by landscapes of glacial origin, this rock-hewn topography stands in striking contrast, and its steep-sided valleys are strongly suggestive of non-glaciated regions. While the escarpment stands out boldly in the Niagara Peninsula and along the shore of Georgian Bay, there is an intervening area in which the slopes are mantled by morainic deposits and, particularly in Mono and Mulmur Townships and the Town of Caledon, long stretches are almost completely hidden.

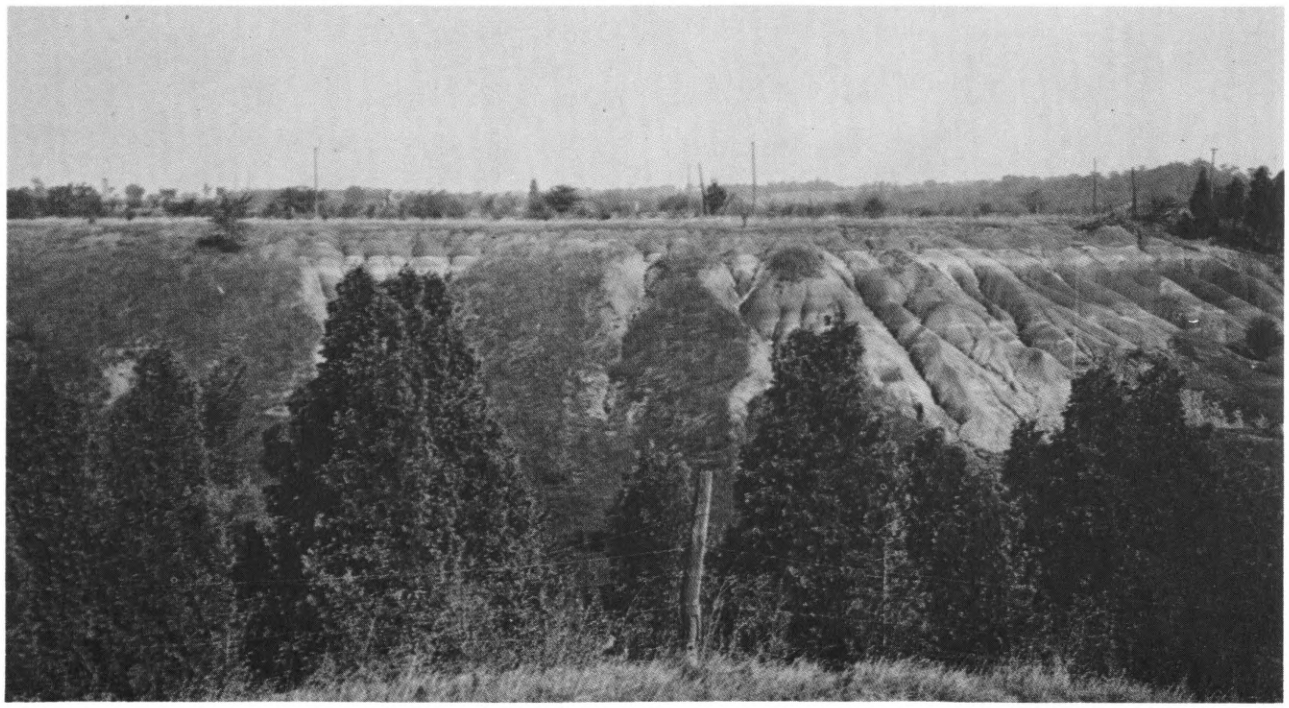
From Queenston, on the Niagara River, westward to Ancaster, the escarpment is a simple topogaphic break separating the two levels of the Niagara Peninsula. In general, the base is followed by the 350-foot contour while the top of the cliff reaches the 625-foot level. In some places, particularly just east and west of St. Catharines, and again near Beamsville, there is a broad sloping bench between the base of the escarpment and the old Iroquois shoreline which is covered by several feet of boulder clay. In other places, as near Grimsby, there is a narrow rock shelf near the top of the escarpment which has a similar but shallower covering. There are a few notable breaks in this stretch of the escarpment. Among them is the valley of Four Mile Creek near St. Davids, a buried former valley of the Niagara River, which affords an easy highway over the cuesta to Niagara Falls. Power Glen, the valley of Twelve Mile Creek, is a preglacial notch of considerable size just west of St. Catharines; its slopes are mantled by highly dissected beds of sand, silt, and glacial till. Another large preglacial valley is the one now occupied by Redhill Creek which tumbles over the

escarpment in a curtain fall which in flood times is quite imposing. Fifteen Mile, Sixteen Mile, Twenty Mile, and Forty Mile Creeks, also descend the escarpment, but by narrow and precipitous valleys which do not afford easy passage.

The Dundas Valley is the most notable break in the southern part of the escarpment, extending inland eight miles from the west end of Lake Ontario. The rim is sharply outlined by rock bluffs but within the valley there is deep drift, the surface of which is deeply cut by many gullies. Worthy of note is the occurrence of beds of sand and silty clay in alternate layers. Agricultural considerations are no longer of much concern, since the valley is nearly all urbanized. It provides some highly attractive building sites. From the days of early settlement this valley has provided the route for roads and railways from Lake Ontario to southwestern Ontario.

From the Dundas Valley northward to Forks of the Credit the brow of the escarpment increases in elevation from 800 feet to about 1,450 feet a.s.l. in a distance of 50 miles. In this section, also, the escarpment is cut by numerous creeks. Several fairly large valleys are found near Waterdown, Lowville, Campbellville, and Limehouse, and there are scenic gorges at Forks of the Credit. With the exception of the valley of Bronte Creek at Lowville, all of these passes are used by both road and railway. In this region a rather broad belt of red shale is exposed and the long lower slopes of the escarpment are highly eroded. North of Aldershot and again north of Cheltenham they have the appearance of veritable badlands (Photo 45). There are several mesa-like outliers of the escarpment. The largest one, located near Milton, has an area of about four square miles and is separated from the main body of the upland by a deep valley partially filled with glacial stream deposits. The promontory at the southern end of this valley is known as Rattlesnake Point. For a mile or more back from the edge of the escarpment there was, apparently, very little drift deposited leaving a very shallow and rocky soil. Much of this area has been left in forest and, wherever possible, the existing forest cover should be maintained for the protection of the Credit River and Bronte and Oakville (Twelve Mile and Sixteen Mile) Creeks.

From the Forks of the Credit, northward for about 30 miles to the valley of Pine River the elevation of the cuesta increases to over 1,600 feet a.s.l. Most of the rock slopes, however, are obscured by hummocky, bouldery, morainic ridges and deposits of sand and gravel. In some places, as at Mono Centre, vertical cliffs of dolomite are exposed where they served as riverbanks for the meltwater floods. Here, too, are found small mesa-like outliers of dolostone of the Amabel Formation. The escarpment slopes are dissected by a number of deep valleys, including those which carry the headwaters of the Humber, the Nottawasaga, Sheldon Creek, the Boyne, and the Pine. These valleys cut through the



OGS 10 696

Photo 45. Badly gullied hillside north of Georgetown on shale of the Queenston Formation. The light horizontal streaks are greenish grey shale interbedded with soft red shale.

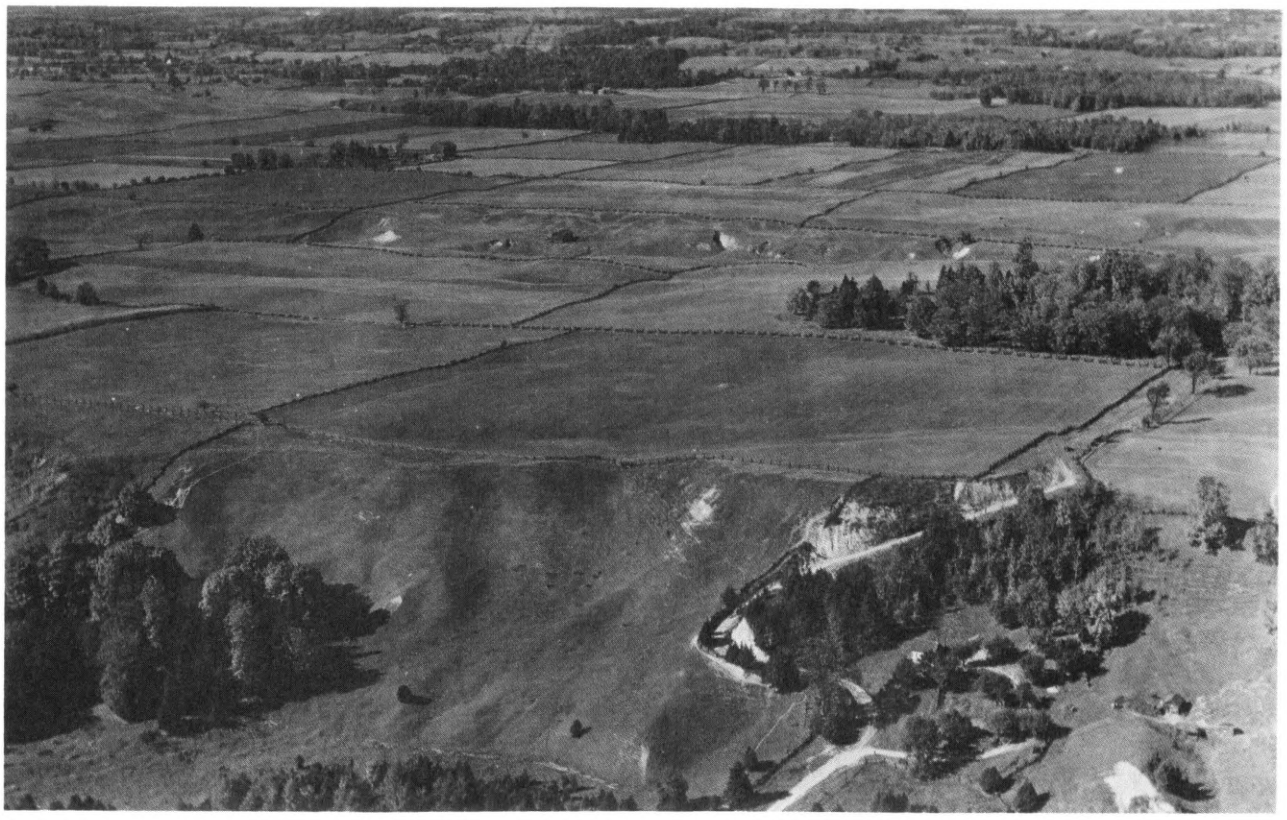
outwash terraces which run parallel to the escarpment. The remaining parts of the terraces, standing as much as 100 feet above the valley bottoms, are prominent features of this area (Photo 46). Short laterals off the main streams now provide drainage in adjacent parts of the former spillways but some intervening sections are poorly drained and swampy. The steep slopes resulting from the extreme dissection are conducive to soil erosion where unwise clearing has taken place.

The highest and one of the more picturesque parts of the escarpment is the Blue Mountain section near Collingwood (Figure 20, Photo 1), which stands over 1,000 feet above the waters of Georgian Bay. Here the dolostone cap rock is exposed in cliffs 150 feet high, while huge blocks breaking away from the wall have left the deep crevasses known as "the caves".

The scenic value of the sector is greatly enhanced by the Pretty River valley, a deep preglacial notch in the rim. The chief members of the Horseshoe Moraine system lie above the escarpment at this point but, during the retreat, the ice pressed against the escarpment for some time and built a strong moraine across the valley. During this period a small lake, several hundred feet deep existed, finding an outlet southwestward through the upper course of the Beaver River. Since the disappearance of the ice, the Pretty River has cut a deep notch in the moraine and has also greatly dissected the floor of the small enclosed basin. In strong contrast to this rugged landscape, the lowland to the east is floored by the flat deposits of Lake Algonquin, the old shoreline of which skirts the base of the escarpment.

Ten miles south of Collingwood, Glen Huron lies in the valley of the Mad River which traverses the escarpment in the same manner as the Pretty River. Here a similar, but not quite so striking, transverse valley moraine was built. The little village of Singhampton lies at the head of the valley, on the plateau. Between the two places runs the narrow, steep-sided, scenic canyon known as the Devil's Glen, where a provincial park and a ski run have been established. A mile and one-half north of Singhampton, overlooking Edward Lake, stands the highest point of the Niagara cuesta, a stony moraine on a rocky butte with a summit approximately 1,790 feet a.s.l. Several other hills in the vicinity also rise above the 1,750-foot contour while fairly large areas lie above 1,700 feet.

Just north of Creemore, there is a curious outlier of the Niagara cuesta consisting chiefly of Ordovician shales without any protecting cap of dolostone of the Amabel Formation. With an area of about five



OGS 10 697

Photo 46. Terraces of outwash sand on the Niagara Escarpment at Dunn Hill, Hockley Valley.

square miles, this upland is separated from the plateau to the west by a deep through-valley. The northern end of the valley, however, is blocked by a moraine which forces the waters of the Mad River to adopt a very circuitous route in order to reach Georgian Bay. This valley is traversed by an abandoned line of the Canadian National Railway, which at one time served the villages along the foot of the escarpment.

In this vicinity a narrow shelf or ledge is often manifest about 100 feet below the edge of the escarpment. This feature is caused by the presence of a second dolostone layer, the Manitoulin Formation, which becomes more important farther north. It is quite noticeable just behind Glen Huron.

West of Collingwood and immediately between Craigleith and Camperdown, occurs the steepest and most mountainous part of the escarpment. This is the highest hill in southern Ontario and is well known now as the site of the Blue Mountain ski runs. In the curious flat-topped mesa at Blue Mountain Peaks (previously Georgian Peaks), the brow of the escarpment approaches within a mile of the Bay, and the wooded slope of this promontory is a well-known landmark.

Immediately west of Blue Mountain Peaks, the edge of the cap rock retreats southward again, in the great re-entrant of the Beaver Valley, which extends for 25 miles into the heart of the upland. A few miles farther west lies the valley of the Bighead River. Between the two valleys stands another promontory, but the dolostone cap at the "Griersville Rock" is over four miles from the shore of the bay. A broad and dissected shale slope intervenes between the "Rock" and the ancient shorecliff of Lake Algonquin. The Bighead Valley is somewhat broader than the Beaver Valley and contains a large number of well-developed drumlins. Because of the interest which attaches to them, these two valleys will be treated as separate regions in this report.

Between the Bighead Valley and Owen Sound, the escarpment advances to Cape Rich where it ends abruptly in a striking shale cliff, the "Clay Banks", which rises sheer from the edge of the water to a height of almost 400 feet. Here the Nipissing shoreline has been undercut by the wave work of the present water level. The Cape Rich promontory comprises a great deal of eroded terrain underlain by the red shales of the Queenston Formation as well as areas of flat mesa on the Manitoulin Formation. The highest point of the peninsula, over 1,375 feet, at the St. Vincent triangulation station (six miles west-northwest of Meaford) is on the Amabel Formation which hereabout is over four miles from the bay.

The eastern border of this upland is marked by the precipitous Algonquin shorecliff, over 200 feet in

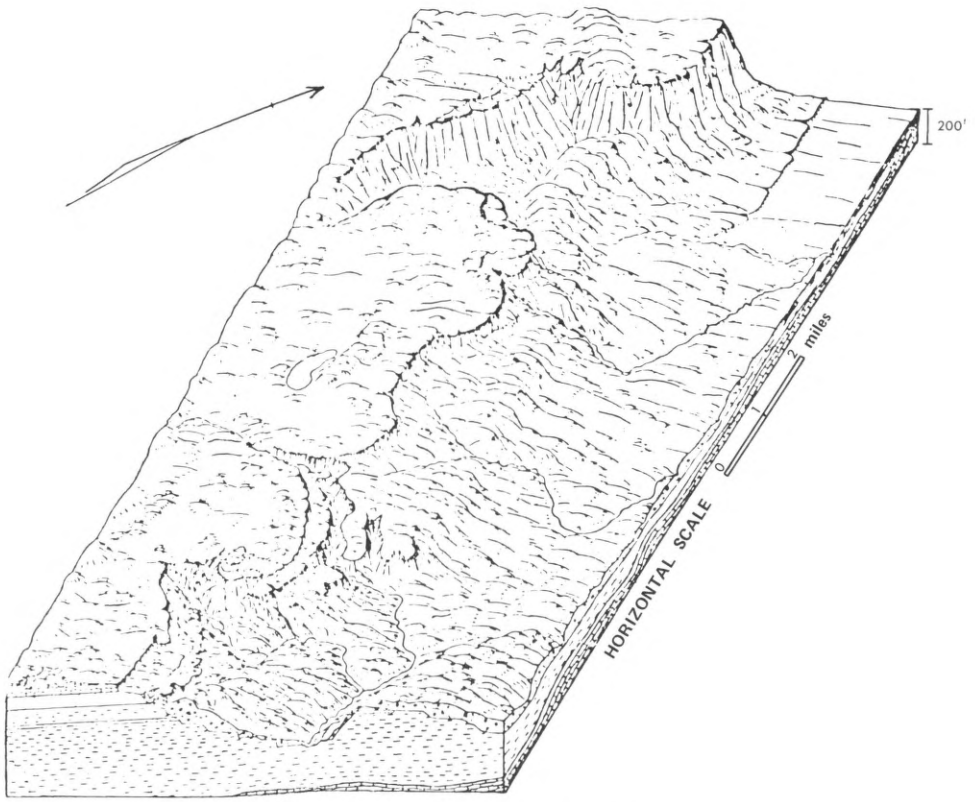


Figure 20. Block diagram of the Blue Mountain, south of Collingwood.

height, while the slopes below, also nearly 200 feet high are mantled by various wave-worked features. The Cape Rich foreland, itself, is composed of Algonquin beach ridges. Mountain Lake (also known as Carson Lake) lies in a deep valley cut in the shale and is impounded by the Algonquin beach. The narrow lowland at Cape Rich was being developed as an orchard area, but in 1942 the whole northern end of St. Vincent Township was acquired by the Government of Canada as a tank range.

The western slope, to the shore of Owen Sound, is more gradual and exhibits a wealth of glacial formations and abandoned beach ridges. The edge of the escarpment, however, can be traced as a cliff, 50 to 150 feet high, which takes a sinuous southwesterly course from Morley to Inglis Falls.

Between Owen Sound and Colpoys Bay occurs "Stony Keppel", a moraine-strewn, though thinly mantled, limestone plateau with an average elevation of 900 feet a.s.l. The higher level on the Amabel Formation is bordered on the north and east by cliffs averaging 150 feet in height, although at Skinner Bluff, Esther Cliff, Halliday Hill, and Dodd's Hill, they are over 200 feet. Pyette Hill is a curious little outlier separated by more than a mile from the main plateau. Below the cliff is another rock plain developed upon the Manitoulin Formation, ranging from half a mile to two and a half miles in width. The surface of this plain is quite smooth and the soils are extremely shallow except where developed upon the Algonquin beach ridge. This Manitoulin shelf is also bordered by a steep cliff which in places is nearly 100 feet in height. Below it is a narrow, sloping remnant of the Algonquin lake plain. In part it is covered with thin water-laid sediments and in part its surface is composed of badly eroded red shales.

Both Owen Sound and Colpoys Bay are deep valleys; soundings taken off Cape Commodore show more than 300 feet of water. The total relief of the Niagara Escarpment in this vicinity is thus over 1,200 feet. Both Owen Sound and Wiarton have well-protected harbours.

On the north side of Colpoys Bay stands the jutting promontory of Cape Croker which is a detached mesa of dolostone of the Manitoulin Formation almost surrounded by water. Other lower remnants of the plateau without the protecting dolostone form three islands (Griffith, White Cloud, and Hay) lying at the mouth of Colpoys Bay. Behind Cape Croker the edge of the dolostone is marked by Malcolm Bluff, Kings Point Bluffs, Jones Bluff, and Sidney Bay Bluff, all of which reach an elevation of about 950 feet a.s.l. Toward the north, Cape Dundas and Lion's Head are slightly lower but none the less impressive (Photo 47). Farther north the escarpment becomes lower; at Dyer Bay the cliffs are only about 125 feet high. The surface of the plateau rises again, however, the west bluff at Cabot Head standing more than 300 feet above the level of Georgian Bay. The cliffs diminish rapidly westward along the north end of the Bruce Peninsula. Finally at Tobermory, the cuesta is entirely broken through, allowing the union of Georgian Bay and Lake Huron. Here on one of the small islands off the coast are found those curious "stacks" or remnants of the dolostone formation which are known as the "Flowerpots" (Photo 48).

OGS 10 698

Photo 47. The Niagara Escarpment at Lion's Head, Bruce Peninsula. In this area only the upper dolomite bluffs are exposed, the lower slopes being under the water.

All along the Bruce Peninsula section of the escarpment there are to be seen many good examples of wave work, construction as well as erosion. At Esther Cliff, for instance, stands a great Algonquin beach ridge behind which there was a bay of about two square miles. A small remnant of this still remains, known as the Slough of Despond. Lower Algonquin beach ridges are well displayed at the heads of both Sydney Bay and Hope Bay. At Barrow Bay a lagoon exists, cut off from the present lake by a wide barrier beach. Beach formations nearly enclose Wingfield Basin at Cabot Head. At the heads of some small bays, notably at Dunks Bay, fine sandy beaches have been built.

Land Use and Settlement

Land use and settlement in the south part of Southern Ontario have been greatly influenced by the presence of the Niagara Escarpment. Its steep slopes and shallow, rocky soils have inhibited agricultural use and tended to preserve the forest. As a topogaphic break it stretches across the whole of peninsular Ontario like a great wall through which there are only a few good "gates", thus tending to concentrate the building of roads, railways, and urban settlements at certain definite points. The largest cities, however, have grown up where the influence of the escarpment was combined with that of a port on the Great Lakes. Water falling over the escarpment is a source of power; the smaller streams, amenable to the manipulations of a pioneer technology, became the foci of early industry and settlement; the development of Niagara power by Ontario Hydro furnishes energy to a large part of Southern Ontario. Worthy of note, also, is the fact that throughout the history of settlement, the escarpment has served as a source of building material including cut stone, lime, shale for the making of brick and tile, and more recently for enormous quantities of crushed limestone and dolostone in all sizes.

The direct effect of the escarpment upon agriculture has been almost entirely negative. In many places the long slopes give rise to problems of soil management and erosion control which are not found elsewhere in Southern Ontario. During the pioneer stages of settlement, steep slopes and shallow soils that should have remained under forest were cleared and cropped. Perhaps the growth of mills and villages in the valleys encouraged cultivation of nearby areas. The hard clay soils developed on the red shales, however, were easily eroded, and much land has been badly gullied. Most of it, of course, has long since been retired to sod, but even under permanent pasture the more steeply sloping fields still suffer from erosion. The change from horses to tractors has been the cause of withholding the plough on many farms, but the operation of most types of machinery has always been difficult in the fields along the escarpment. The present tendency,

OGS 10 699

Photo 48. Stacks formed in dolomite by wave erosion on Flowerpot Island near the tip of the Bruce Peninsula.

especially toward the north, is for land holdings to increase in size while the intensity of use is lessened. Fortunately, cattle thrive on the well-drained pasture.

Nevertheless, the escarpment also affords some gentle slopes, shelves, and terraces, where topography is favourable for the plough. In the Niagara Peninsula such shelves near both the base and the brow of the escarpment are used for vineyards.

The relationship of the Niagara Escarpment to transportation patterns in Southern Ontario is worth a little study. The earliest routes were, naturally, water routes. To these the Niagara Escarpment presented a formidable barrier to be overcome only by taking to the land and establishing a portage route. Most notable of these was undoubtedly the Niagara Portage Road from Queenston to Chippawa established at the request of Lord Dorchester shortly after 1790. It climbed the steep face of the escarpment by a switchback route which required constant improvement. It is reported that during the season of navigation as many as 60 wagons per day would be loaded at Queenston to make the trip. The road was too near the American Boundary, however, and traffic suffered during the War of 1812. This, in addition to the natural difficulties of the route, increased the demand for the building of a canal across the escarpment.

In 1824 a canal across the escarpment was begun under the private initiative of William Hamilton Merritt, a miller on Twelve Mile Creek near St. Catharines. Because of water shortage in the summer months, he planned to divert the Welland River over the escarpment to increase his power supply. Finding support among his friends, the idea was expanded to include navigation facilities. Eventually, a barge canal with wooden locks was opened in 1829, providing a navigable connection between Lake Ontario at the mouth of Twelve Mile Creek and Port Robinson on the Welland River. Difficulties on both the Welland and Niagara led to the building of an extension to Port Colborne which was completed in 1833. Since then the canal has been rebuilt and modernized several times. Besides providing an essential link in one of the greatest waterways in the world, the canal has helped to focus industry and urban development in the escarpment area. Greater St. Catharines in 1982 had a population of 123,644 people, while the Niagara Frontier (the Regional Municipality of Niagara) ranks among the most important manufacturing regions in Canada.

It has seemed logical to many people looking at a map of Ontario that Hamilton, rather than Toronto, should have become the entrepôt and primary city of the region. There were several inhibiting geographical factors in the situation and in fact the urban nucleus of Hamilton was not laid out until ten years after John Graves Simcoe's city had been started. Not till 1826 was a navigable channel actually cut through the Burlington bar; earlier cargoes had all to be transhipped in small boats. The Hamilton waterfront itself was not easily accessible to the roads leading to the newly settled areas to the north and west. In 1837 the Desjardins Canal was cut to the turning basin in Dundas, thus bringing goods several miles farther inland, and giving direct connection to newly developed roads to Guelph, Galt (now part of the City of Cambridge), and Brantford. The opening of the Great Western Railway in 1853 dealt a mortal blow to the Dundas entrepôt, and Hamilton became the centre of a rail net rather than a leading port.

Later, and mainly during the present century, Hamilton has become Ontario's centre of heavy industry, in part because of its central location, and in part because of the escarpment which has furnished great quantities of limestone and dolostone for use as flux in the smelters. Because of the necessity to bring in the iron ore and coking coal the port now handles approximately five times as much cargo tonnage than its rival, Toronto, but is much less diversified. Industrialization enables Greater Hamilton to support a population of more than 400,000, but this is only a small part of the urban region that encircles the western end of Lake Ontario, from Niagara Falls to Oshawa.

The Niagara Escarpment is an enormous and continuous outcrop of useful rock. Its importance to the steel industry of Hamilton has already been noted, but this end use is only a small part of the total market for limestone and dolostone production. In addition there is the use of the underlying shale for the making of brick, tile, and other ceramic products. Also there must be mentioned the great deposits of sand and gravel which have collected in various areas along the escarpment and which are in part derived from it. As might be expected the exploitation of all these materials is carried on much more actively in the south within easy reach of the large centres of population.

The major centre of crushed dolostone production in Southern Ontario lies along the Niagara Escarpment. There are 12 large quarries between Queenston and Georgetown, all having a production capacity ranging from 500,000 to 2,000,000 tonnes of crushed dolostone per year. The centre for the greatest source of construction grade crushed dolostone is produced in the Town of Halton Hills. The most easterly quarry of all is at Queenston; for more than 100 years it was a principal source of building stone for several major Ontario cities. In the northern part of the escarpment small building stone quarries are

worked near Collingwood, Owen Sound, Wiarton, and Lion's Head.

Beneath the dolostone there is a sandstone formation (Whirlpool Formation) which has long been quarried for building stone although its use is not as extensive as it once was. Quarries producing this sandstone, commercially known as the "Credit Valley Sandstone", are still in operation near Georgetown. This rose-coloured sandstone was used in Toronto for the Legislative Buildings at Queen's Park and the former City Hall.

The Queenston Formation which underlies the lower slopes of the escarpment is still an important source of brick-making material in Ontario (Guillet 1967, 1977). Between Niagara Falls and Cheltenham there were at one time more than a dozen plants located on the "Queenston shale" but as of 1984 only three were still operating, due to corporate consolidations and economic conditions. Formerly, there were also brick plants located in the northern part of the escarpment but the only plant still operating is the tile plant near Meaford which uses grey shale.

For vitreous tile, the weathered soil horizons without free carbonates are used; the unweathered shale is unsuited to this product. For sintered, lightweight aggregate this shale will give an expanded product, but the sintering range is too narrow for bloating of the separate pieces to produce coated aggregate.

While not outstanding, Pleistocene deposits of sand and gravel along the escarpment have supplied some of the material used in road construction and concrete. The continuously increasing demand for coarse and fine aggregate has resulted in pits being opened in nearly every outwash deposit between Queenston and Caledon Village. Two of the larger ones in the buried bedrock valley near St. Davids are virtually depleted, and two in the ice-contact delta west of Fonthill are still operating. These have high siltstone contents, are shaley, and are somewhat indurated, but are used because sand and gravel are scarce in the Niagara Peninsula. North of Hamilton, the deposits cannot be mentioned individually, but the major ones are near Lowville, Campbellville, Georgetown, and Caledon Village. Indurated strata and shale are troublesome in some of these deposits but in others the quality is better. North of Caledon Village there are extensive gravelly terraces along the escarpment which supply local needs. Algonquin beaches at the base of the escarpment have been excavated for gravel in the Georgian Bay area.

The prominence, continuity, and special qualities of the Niagara Escarpment have given it a unique place in the discussions on resource conservation and the provision of recreation facilities in Southern Ontario. Coventry (1940) called attention to the fact that the source areas of many permanent streams between Hamilton and Toronto were found to be on the escarpment. The Conservation Branch under the direction of A.H. Richardson, Ontario Department of Planning and Development, made extensive studies of the river systems which take rise along the escarpment including among others, the Sixteen Mile, the Credit, the Humber, and the Nottawasaga. It is necessary only to mention the famous Niagara Parks which were set up by an Act of the Ontario Legislature in 1885 to protect the beauty of Niagara Falls, and later enlarged to include 2,800 acres. A major part of this is the Niagara Parkway development, which extends for 27 miles along the river. The Niagara Conservation Authority has established an additional 33 parks in the Niagara area.

In 1973, the Niagara Escarpment Commission was set up "to provide for the maintenance of the escarpment and land in its vicinity as a continuous natural environment and to ensure only such development occurs as is compatible with that natural environment." According to plans, eventually 125 parks will be established along the escarpment where beautiful spots may be enjoyed. Already, the Province, various municipalities, and conservation authorities have provided public parks in many sections of the escarpment. They are particularly numerous in the Hamilton area. Others at Rattlesnake Point, Belfountain, Glen Haffy, and Devil's Glen also capitalize on the unique scenic qualities of their particular sections of the escarpment, providing facilities for picnics, swimming, and other outdoor recreational activities. A number of private parks have also been established. As well as summer recreation, the escarpment provides the sites for many ski runs such as those of the Hockley Valley, Mansfield, Blue Mountain, and Beaver Valley. Another development is the Bruce Trail which seeks to maintain a foot path along the brow of the escarpment from the Niagara River to Tobermory at the northern tip of the Bruce Peninsula. From the vantage points along this trail many scenic parts of the escarpment may be appreciated which are neither visible nor accessible from the roads.

The Niagara Escarpment is no longer so largely the negative factor on settlement that it once was. In the great urban developments of St. Catharines and Hamilton and in smaller places as well, residential locations with a view, located on the brow or on the slopes of the escarpment, are highly prized. The rural areas of the escarpment are dotted with estates and less pretentious country houses. The Ontario highway system now provides for rapid year-round commuting for those living in the southern portion of the escarpment. Even in the northern and more isolated stretches, many rural residences have

appeared. For many reasons, therefore, the Niagara Escarpment must be regarded not only as the outstanding physical feature of Southern Ontario but also as a highly significant factor of its human geography.

2 BEAVER VALLEY

One of the most scenic features of Southern Ontario, the Beaver Valley, is a small but well-defined region of 77 square miles, occupying a sharply cut indentation in the Niagara cuesta, opening upon Georgian Bay (Figure 21). From Thornbury, on the shore, to Flesherton, at the upper end of the valley, is a distance of 22 air miles. At its widest point, between the "Griersville Rock" on the west and Blue Mountain Peaks on the east, the valley is six and a half miles across. This width is largely maintained to a point halfway between Heathcote and Kimberley, about nine miles from the bay, where the valley suddenly contracts to a width of a little over two miles. Its southward continuation is a narrow, tapering, steepsided notch which comes to an end just below Flesherton. From Heathcote to Kimberley, the flat floor of the valley (about 760 feet a.s.l.) is about 650 feet below the rim.

The upper rim of the valley is the edge of the Amabel Formation which appears as an almost vertical cliff, 50 to 100 feet in height. Below this is the Manitoulin Formation in the form of a flat shelf which, toward the mouth of the valley, may be half a mile in width. This horizontal shelf is particularly well developed at Griersville, west of Heathcote, and along the eastern shoulder of the valley near Duncan, Ravenna, and Loree. The mesa behind Blue Mountain Peaks, already mentioned, is a flat-topped mesa of the Manitoulin Formation, almost completely severed by stream erosion from the rest of the upland. Standing at an elevation of over 1,400 feet a.s.l., its rim is less than a mile from the shore of Georgian Bay (ca. 580 feet) more than 800 feet below. This high shoulder, the apex of the Blue Mountain, effectively shuts off the valley from the east. The edge of the Manitoulin shelf is also marked by an abrupt descent, though usually less sharp than that of the upper rim. Below this the more gently sloping, but nevertheless steep, sides of the valley are carved in softer shales.

The wider, northern part of the valley contains several tributary streams and one fair-sized stream, Indian Brook, which enters Georgian Bay independently, about a mile east of the mouth of the Beaver River. The gradient of the slopes on the shale in this open part of the valley is roughly 125 feet per mile and the streams have cut very sharp juvenile valleys, those of Indian Brook and Duncan Brook being over 100 feet in depth in places. Grier Creek on the western flank of the valley is also actively dissecting the shale formation.

The physiographic development of this valley is quite interesting. The greater part of its erosional history occurred in preglacial times when the forerunner of the Beaver River was a tributary to the stream which carved the deep valley of Georgian Bay. The advance of the glacier up the valley, possibly several times, served to smooth off all the protruding spurs which must have resulted from river erosion, thus leaving it an open, steep-sided, broad-bottomed feature almost comparable to the U-shaped valleys resulting from alpine glaciation.

Across the valley, just north of Heathcote, is a till moraine distinguished by crooked, transverse ribs with some sloughs between them. When the glacier was building this moraine the valley must have contained a long lake in which much of the material of the flat floor between Heathcote and Kimberley was deposited. The steep slopes of the valley are mantled by a thin covering of till, which is red in places because of the incorporation of material from the shales of the Queenston Formation.

In contrast with the Bighead Valley, drumlins are so scarce that they may be pointed out individually. A mile and a half north of Heathcote the twelfth line of Collingwood Township runs over the back of a drumlin; a second one may be seen just

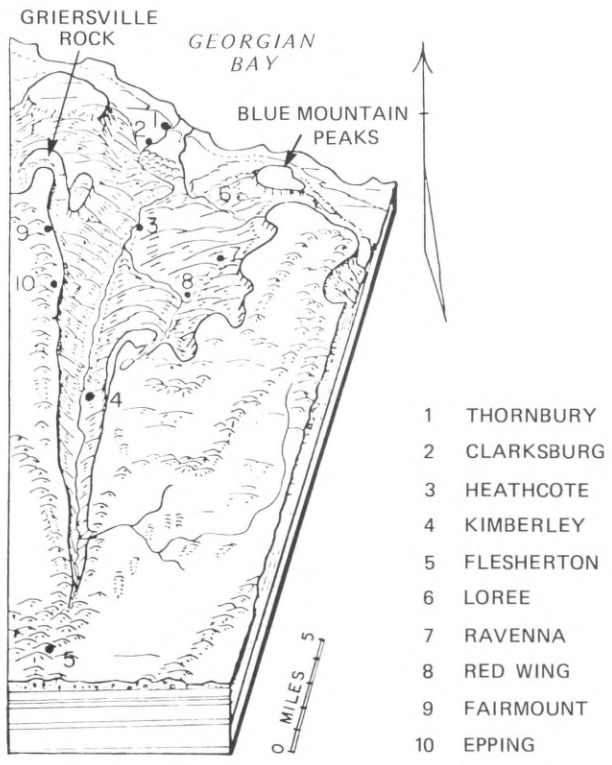


Figure 21. Block diagram of the Beaver Valley.

south of Heathcote in concession X and a couple more appear south of Red Wing.

North of the Heathcote Moraine glacial Lake Algonquin covered all the land below the 775-foot contour. Here there is a well-developed barrier beach, with its highest crest slightly above 775 feet and with at least ten subsidiary strand lines marking successive, lower water levels.

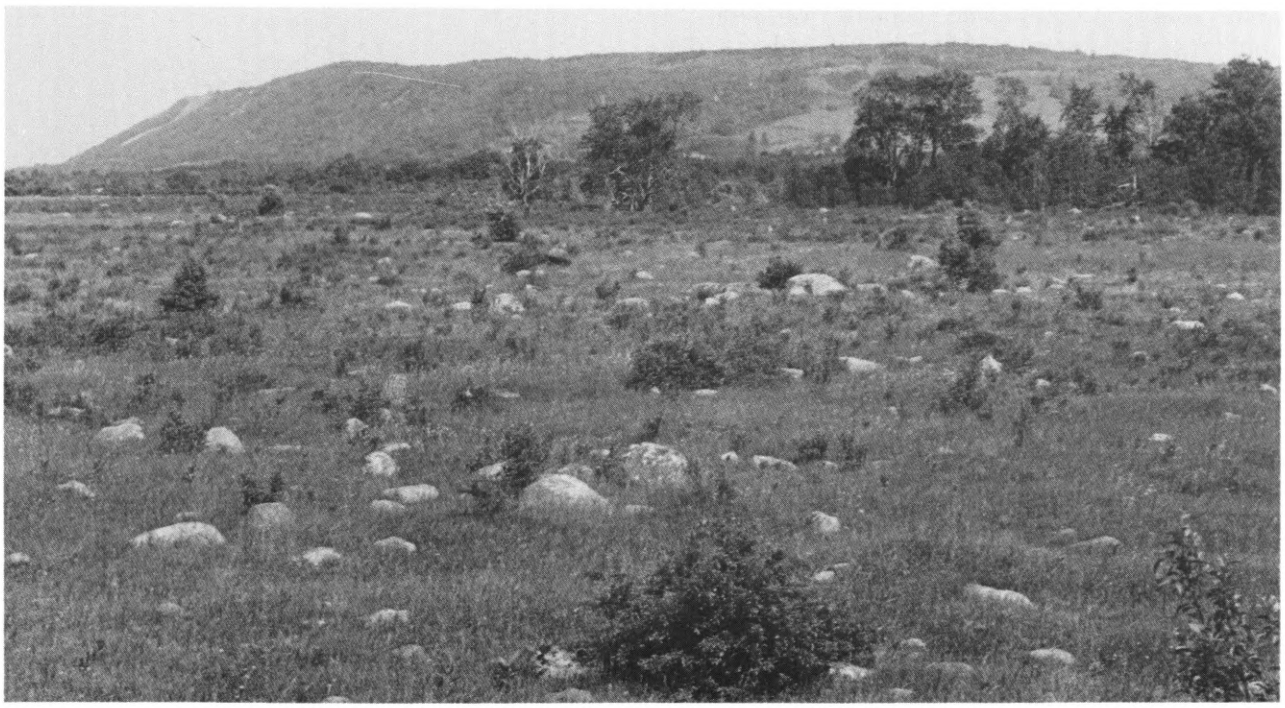
The crescent-shaped lake plain between this beach and the present shore is far from uniform. In fact, it includes just about all the possible components of a lake plain in good form. The barrier beach extends unbroken between the Beaver River and Indian Brook, while beyond the rivers in either direction the shoreline takes the form of a bold bluff with a boulder-strewn terrace at its base (Photo 49). On the eastern flank of the valley this strip of boulder pavement is quite broad. The body of the plain is occupied by a delta in which the texture of the surface materials varies from sand to fine silt.

The plain is terminated near Georgian Bay by a steep bluff marking the shoreline of the Nipissing Great Lakes. The base of this bluff is about 630 feet a.s.l. or 50 feet above Georgian Bay. Below it is a terrace swept out upon limestone bedrock covered with numerous gravel beach strands and strips of boulder pavement derived from the former covering of till. Fortunately the strip of almost agriculturally useless land is only a quarter to half a mile in width. Its main use is for cottages along the shore.

Thus, even though small and obviously a unit, the Beaver Valley exhibits considerable complexity of landforms including lake plains, beaches, moraines, steep valley sides, and vertical cliffs. The coherent ensemble of these elements resembles in many ways the landscapes of the hilly country of northern England and gives it rank among the most scenic areas of the Province.

In the Beaver Valley the soils of the lake plains around Thornbury and Clarksburg resemble those in the broader area of the Algonquin plain in the southern part of Simcoe County. The boulders on the old wave-cut terraces have prevented cultivation of those soils and they are pastured or are covered with cedar thickets. Rose briars and dogwood abound on the stony pastures. A little of the dry gravelly soil of the old beaches has been planted to apples, but much of the gravel has been excavated. The most valuable soils in the area are the deep silt or fine sandy loams above the Nipissing shorecliff, these being preferred for apples except where drainage is poor. These soils allow deep root range and are drought resistent. A broad area with imperfect drainage lies between the Beaver River and Indian Brook. The driest sand on the west of Thornbury produces heavy crops of apples when well fertilized. The gravelly soil on the big barrier beach is poor in dry seasons, and some of it in orchards has been irrigated.

The clay loam soils in the main body of the val-



OGS 10 700

Photo 49. Boulder beach left by glacial Lake Algonquin, located along the south shore of Georgian Bay near Thornbury. Photo courtesy of M.B. McLeod.

ley resemble those on the drumlins in the Bighead Valley although with fewer steep erosive slopes. They are adaptable and durable. On the upper slopes the soils are similar to those of the Niagara Escarpment. The reddish clay soil is hard to till and inclined to droughtiness. On the shelves of dolostone of the Manitoulin Formation the soil is usually shallow and stony.

While most of the valley carries on a generalized type of agriculture very similar to the other hilly areas in that part of the Province, the lake plain below the old Algonquin beach and some of the adjacent till plain have become the scene of intensive specialization. The advantage, already noted, of well-drained loamy soils is coincident with a climatic advantage derived from the sheltering hills and the nearness of Georgian Bay. Consequently this area has a longer and more reliable frost-free season than many areas much farther south. The moderating effect on winter low temperatures is another advantage. Also, the fact that the snow blanket accumulates early and persists is very important to the survival of the rather tender dwarfing rootstocks which are now mostly used. The old general farms have been replaced by apple orchards until, near the bay, very little unplanted land is left. The long open autumn season permits fruit to ripen properly and the apples, Mackintosh and Northern Spies in particular, enjoy a reputation for colour, firmness, and flavour which is second to none. In 1981 Collingwood Township had 3,600 acres of orchard, practically all of which is located in this section of the Beaver Valley. Considerable climatic variation of importance to apples exists in the valley due to distance from the bay and locally to the lay of the land. While apples may be grown anywhere in the valley, nearness to the shore is an advantage. The valley floor behind the Heathcote Moraine is a definite frosty pocket which fortunately, with odd exceptions, has been avoided. Also, the low ground behind the little morainic ridge just west of Thornbury is a frost pocket, although less severe. Mixed farming is still carried on, on the slopes, with emphasis upon pasture for beef cattle. Alfalfa has been found to thrive on the shaly soils probably because of its ability to withstand drought. The greater part of the flat floor of the mid-portion of the valley remains in forest because of the aforementioned imperfect drainage.

This part of the Province has been settled for barely 130 years but it shows considerable adjustment to topographic influence. Here is seen the effect of running a predetermined set of survey lines across a new territory, regardless of local landforms. These survey lines diverge from the axial direction of the greater part of the valley by about 30°. The resulting zig-zag of the highway adds several miles to its length. The angular pattern of farm lines upon the slopes also creates some odd effects.

The small nucleated settlements are, in general, located on the river. Thornbury (population 1,447) has boat-landing facilities, but its site was determined because there was power enough available for a mill. Its railway and highway advantages became important later. Less than two miles upstream were other power possibilities since the gradient of the lower part of the Beaver River is rather steep, and these gave rise to the development of Clarksburg (530). Kimberley and Red Wing are examples of hamlets growing up around mills located on tributary streams while Heathcote seems to have been located simply by the river crossing. Ravenna is a small crossroads hamlet. Eugenia is located where the largest branch of the river falls into the valley. The power possibilities of this site have been developed by the construction of a hydroelectric power plant in the bottom of the valley and a large reservoir covering 1,620 acres located on the plateau.

The Beaver Valley is a picturesque place. The greenish blue waters of Georgian Bay, the orchards near the shore, the mosaic of fields upon the gentler slope and forest belts upon the valley floor, and the steeper slopes just below the dolostone crags, all combine to form a geographic personality and a natural beauty which once seen is not soon forgotten. It is at its best, perhaps, in mid-October, Thanksgiving time, when the ripe apples are on the trees and the hillsides are transfigured by the autumn colours of the maple leaves.

3 BIGHEAD VALLEY

The Bighead Valley is an indentation in the Niagara Escarpment back of Meaford. It is about eight miles in width between "Griersville Rock" and Bayview, and ten or twelve miles in depth. The bed of the Bighead River which drains this box-like valley lies about 600 feet below the shoulders of hard dolostone cap rock. Not so well known or so scenic perhaps as its neighbour, the Beaver Valley, it is in some respects of more interest from a physiographic point of view.

Like the Beaver Valley it was largely eroded in preglacial time, and, in so far as its rocky outlines are concerned, only slightly modified by ice erosion. The depositional effects of the ice, however, are very striking. The shoulders, sides, and floor of this valley are completely covered with drumlins, over 300 being recognizable within an area of about 80 square miles. Oddest of all, perhaps, is the fact that the ice which moulded these oval hills (Photo 50) was not a local lobe advancing up this deep valley, as

seems to have been the case in the neighbouring valley of Owen Sound, but an ice sheet which crossed the valley in a southerly direction, apparently in complete disregard of the underlying topography. Thus the axes of the Bighead drumlins are oriented almost directly south in agreement with those around Durham and the Teeswater drumlins many miles to the south.

Excellent views of this valley are obtainable from a number of points along the southern rim such as the "Griersville Rock" or better still at Blantyre or on the ridge above Minniehill. From either of these lookout points the valley appears almost as a basket of eggs and it seems particularly appropriate to term it "a nest of drumlins". Good views are obtainable from the northern rim, also, but they are not nearly so accessible as those just mentioned.

Other features of this valley should also be noted. Across the mouth of the valley, about two and one-half miles inland from the present shoreline of Georgian Bay and approximately 200 feet higher, is the abandoned shoreline of Lake Algonquin which in this sector is marked by a huge barrier beach. This great gravel bar, over four miles in length, ties together several drumlins and forces the Bighead River to swing close to the southern side of the valley before finding an exit behind Meaford.

At the highest Algonquin level a lagoon of several square miles in area was impounded in the valley. Into this, alluvial silt and sand was dumped by the tributary streams, giving a broad, flat floor from which the crests of the drumlins emerge as "islands", much as they did when surrounded by the waters of the lagoon. No drumlins stand below this beach today, although it seems probable that originally there were some which were completely levelled by Algonquin waves. West of Meaford a sandy ridge standing above the sand plain is probably a fragmentary moraine. Within the Town of Meaford one finds another bouldery terrace backed by a 25-foot bluff marking the highest water level of the Nipissing Great Lakes. The steep-sided valley by which the Bighead makes its way across the old shorelines is more than 50 feet in depth.

The drumlins are formed of a greyish brown calcareous till which shows a considerable admixture of red shale. In this respect it is not unlike that found in the drumlins of New York State south of Lake Ontario.

The well-drained stony clay loam on the drumlins is a productive and adaptable soil. Containing more shale and igneous rocks than most of the drumlins in Southern Ontario, it is a slightly acid soil like the Milliken loam found in the City of Scarborough. Only where the subsoil has been exposed on the steepest slopes is there free lime carbonate in the surface soil. The leached A_e horizon has the pale buff colour which is generally associated with shale. The profiles are 18 to 30 inches deep with a deep B horizon of slightly blocky clay loam.

In the lake plain near Meaford the sandy soils are closely related to those in the Algonguin bed around Alliston, but have a slight reddish cast due to shales of the Queenston Formation. Near the Algonquin beach the water table is high and there is some swamp. Towards the present shore, above the bluff of Lake Nipissing, drainage is better, and the sandy soil is well adapted to apples and truck crops which can pay the cost of fertilization.

OGS 10 701

Photo 50. Typical "whaleback" drumlin form south of Meaford. Photo courtesy of M.B. McLeod.

The Bighead Valley appears as one of the better sections of Grey County. Here, by a fortunate circumstance, the survey pattern conforms with the grain of the country and permits cultivation along the contour rather than diagonally up and down the slopes. Where the drumlins are big, the slopes are too steep for cultivation and a great deal of land is left in grass. In general, the pattern of land utilization appears to be much the same as that of the Guelph and Teeswater areas, the economic mainstay of agriculture being the production of beef and pork.

On the loamy terraces near Meaford, which also have some climatic advantages, many of the farms are specializing in apple growing and the area now has about 2,000 acres of apples. It would seem that here, no less than in the Beaver Valley, considerable opportunity for specialization exists.

Meaford (4,337), although at the edge, is undoubtedly the trading centre of the valley, but some trade from the upper end is drawn toward the City of Owen Sound. Meaford, however, owes as much, if not more, to its position on Georgian Bay as it does to the wealth of its hinterland. Within the valley itself Bognor is the only hamlet of any size. Walters Falls, at the point where Walters Creek breaks over the escarpment, is a little larger. Both of these developed as mill sites, as did Massie in a similar position on the Bighead itself. Water power is still used at Walters Falls.

4 CAPE RICH STEPS

The northern half of St. Vincent and Sydenham Townships stands between Owen Sound and Nottawasaga Bay. In preglacial times it was the upland between two river valleys leading to the master stream that flowed down the Georgian Bay depression. From the water's edge at 580 feet a.s.l. the land rises 500 feet in a series of five steps (Figure 22). The first two are the work of Lake Nipissing and Lake Algonquin, and are narrow terraces near the shore of Georgian Bay. Above the Algonquin level the next "tread" is a broad gentle slope leading up to the edge of the Manitoulin Formation. It is based on red shale and there is very little glacial till on it apart from the few drumlins around Annan. Dolostone of the Manitoulin Formation overlies the red shale on a mesa-like remnant standing 1,100 feet a.s.l., situated halfway between Cape Rich and Meaford in concessions VIII and IX of St. Vincent Township. A narrow saddle of red shale separates this tableland from a shelf of similar dolostone, around the upper cap of the Amabel Formation. A small, low mesa of the Manitoulin Formation lies north of Johnson, on the Owen Sound side. The upper step may be recognized as the brow of the Niagara Escarpment in this section.

The two lower terraces are cut in shale and are strewn with boulders or gravel beaches. Around Cape Rich and Balaclava, stratified clay occurs on the second terrace. The beds are dissected by gullies in the Balaclava area, while just above the two bluffs gullies cut by rapid streams appear frequently.

The only lake in this little region is Mountain Lake (Carson Lake). It is long and narrow, and lies in a preglacial valley dammed at the east end by a gravel beach. Sucker Creek runs for nearly two miles in this same valley farther west.

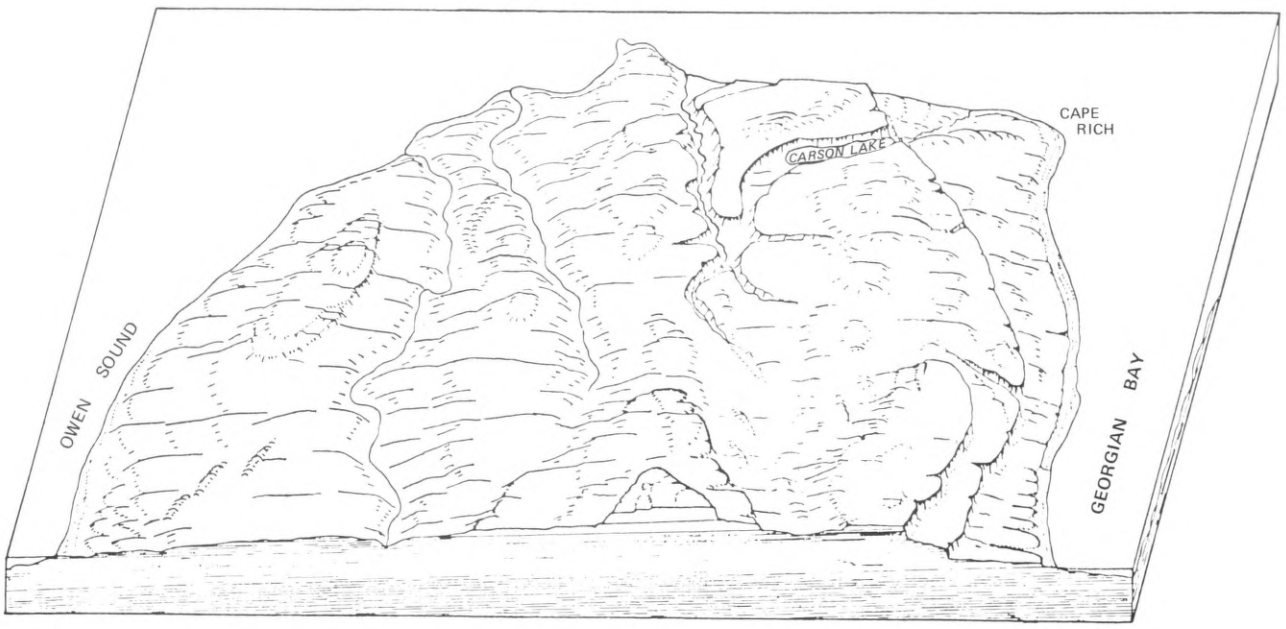


Figure 22. Block diagram of the Cape Rich foreland.

The ancient lake benches south of Cape Rich must be considered as part of the Georgian Bay apple belt, although since 1943 this land has been part of a military reserve. The red clay soil which comprises the greater part of the area may be appraised by the fact that much of it was in grass before 1943 and used only for hay and pasture. The shallow soil on the dolostone is best used for pasture or forest. There is some good land on the drumlins. The southern border of Georgian Bay is somewhat droughty in summer and crops, such as alfalfa, which resist drought or winter wheat that ripens before the hottest, driest part of the summer are best suited to these conditions.

Well water is scarce on many of the farms, which is another reason for not carrying on intensive farming on most of these 50 square miles.

5 HORSESHOE MORAINES

The Port Huron Moraine system forms the core of a horseshoe-shaped region flanking the upland that lies to the west of the highest part of the Niagara cuesta. The associated meltwater stream deposits are also included giving the region two chief landform components: (a) the irregular, stony knobs and ridges which are composed mostly of till and with some sand and gravel deposits (kames); and (b) the more or less pitted sand and gravel terraces and swampy valley floors. The northern section, in Grey County, includes several tracts of shallow, stony drift on the Niagara cuesta and, also, a few scattered groups of drumlins. The "toe" of the horseshoe-shaped region lies on the highest part of the upland south of Georgian Bay at about 1,700 feet a.s.l., while the two "heels" are about 900 feet lower. The total area is approximately 2,158 square miles.

The southwestern limb of the region, typically as seen in the southern part of Huron County, has a fairly simple landscape. Structurally it consists of two, and in some places three morainic ridges composed of pale brown, hard, calcareous, fine-textured till, with a moderate degree of stoniness. The western edge is marked by the low gravel beaches of glacial Lake Warren beyond which the slightly sloping lacustrine plain extends westward to the shorecliff of Lake Huron. The eastern flank is marked by the old spillway containing flat sand and gravel terraces and some linear, undrained swampy areas. The wide sand plain southwest of Hensall represents a delta where the spillway debouched into glacial Lake Whittlesey. South and southwestward the clay ridges become slightly lower and smoother and considerably broader in the northern part of Lambton County. There are small sand plains near Ailsa Craig and Warwick.

Huron clay loam (*see* Figure 23) is the most representative soil type on the morainic ridges and it occurs quite widely in other well-drained areas as well. The average depth of the Huron profile is from 18 to 20 inches. Even though the slopes are generally moderate, the top soil is susceptible to erosion exposing the subsoil here and there, and consequent patchiness in crops. More gently sloping or almost flat areas also occur on the moraines. In these the subsoil does not develop a true B horizon and tends to remain wet and plastic. A variety of crops including wheat, beans, and corn may be grown but extensive areas on these clay ridges are devoted to pasture. North of Clinton this region is more complex. The clay till ridges and the intervening spillways are in good form as far north as the small lake plain containing the Greenock Swamp. East of the clay ridges, there is a belt of gravelly hills, about five miles in width which has been called the Wawanosh Moraine. It contains areas of stony, sandy fluvium interbedded with till as well as areas of well-sorted sandy materials. The soils developed on the complex of till and sand are included in the Donnybrook series, so named from the little hamlet near which the Maitland River breaks through the moraine; the soils of the latter are included in the Waterloo series because of their resemblance to similar soils in the Regional Municipality of Waterloo.

In the Walkerton-Chesley area, the morainic belt consists of two moraines separated by the Saugeen clays. The northern one is not shown on the small-scale map of the physiographic regions (Figure 19).

Instead of the Huron clay loams of the till ridges to the southwest, the till soils of this area are closely related to the Harriston of the Teeswater drumlin field; the soils of the intervening terraces are similar to the Teeswater loams.

The toe of the "horseshoe" lies on the high country or plateau in the central part of Grey County. The townships of Bentinck, Normanby, Holland, Glenelg, Euphrasia, Artemesia, Osprey, and Collingwood are covered by a complex of till ridges, kame moraines, outwash plains, and spillways, interspersed with more smoothly moulded till plains and drumlinized areas. Local relief among the moraines and drumlins is often more than 100 feet. The area also contains many small lakes and streams, and numerous swampy areas. The tills of this area tend to be loamy and contain numerous stones and boulders, in large measure derived from dolostone of the Amabel Formation. From Singhampton south to Caledon Village the moraines lie along the brow and slopes of the escarpment. There are three moraines with trains of outwash between them, the latter sand and gravel terraces often being deeply cut by gullies.

From the edge of the escarpment in the Town of Caledon the moraines trend somewhat west of the Niagara Escarpment forming a belt with moderately hilly relief passing east of Acton and Guelph to Cambridge and Paris. South of Paris the moraines tend to flatten out and finally disappear under the sands of Norfolk County (now the western part of the Regional Municipality of Haldimand-Norfolk). Associated with the moraines is a system of old spillways with broad gravel and sand terraces and swampy floors. These are larger than those already noted in the southwestern limb of the "horseshoe". Good cross-sections of this landscape may be seen along Highway 7 from Rockwood to Georgetown, along Highway 6 south from Guelph to Puslinch, or along Highway 401 across Puslinch Township. Some of it is very hilly with a local relief of more than 100 feet, often with steep irregular slopes and small "kettles" or enclosed basins which contain water in the spring and early summer. The soil material is a coarse, open, stony till composed largely of dolostone with traces of red shale. The soils of these rough and stony surfaces are referred to as the Dumfries series, so named from the townships south of Cambridge. Dumfries profiles are usually from 18 to 24 inches in depth. The soil profile which is often seen in ditches, road cuts, and borrow pits may be represented by the sequence shown in Table 1.

TABLE 1 SOIL PROFILE OF THE DUMFRIES SERIES

A_h	2-4 inches, dark greyish brown, friable, stony loam; pH 7.0.
A_e	7-9 inches, pale brown, friable, stony loam; pH 6.6.
B	6-10 inches, brown to dark brown, blocky, stony, clay loam; pH 7.2.
C	pale brown, sandy, stony loam till; highly calcareous.

The soils of the associated outwash gravels are classified mainly in two series, Caledon and Burford. The former usually has a greyish brown sandy loam surface soil underlain by a deep, light yellowish brown A_e horizon, and a dark yellowish brown B horizon, the whole profile often being three feet in depth. The Burford, on the other hand is usually a gravelly loam with a depth of about 18 inches and slightly darker colours. The surface soils of both series are only slightly acid while the underlying materials are highly calcareous.

Land Use and Settlement

The patterns of land use and settlement have been variously affected by the physical patterns of the Horseshoe Moraines. There is much hilly and droughty land and, whether on the hard Huron clay or the various knobby gravelly areas, this leads to extensive pasturage. Farms therefore tend to be larger than the average for Southern Ontario but since, in many cases, only parts of townships are involved, it is difficult to get a statistical measure of the full effect. Throughout the whole area one sees many abandoned farmsteads and vacant building sites but the land is still in use, more often as pasture than cropland. In Glenelg Township, which represents the extreme condition in the "toe of the horseshoe" in Grey County, only 43% of the total farmland is devoted to crops. In Puslinch Township, on the southern arm, 58% is in crops, and in West Wawanosh, on the western arm, 59% is in crops. In Puslinch and West Wawanosh Townships 12% of the farmland is in woods, while in Glenelg 17% is still wooded.

Throughout this extended region agricultural land is used chiefly for livestock production. In most parts of the area farms average 150 acres in size, with about three-quarters classed as improved land. The census in 1981 for 6 representative townships gives averages of 32 cattle, 35 hogs, 4 sheep, and 350 poultry per farm, a total, perhaps of 43 animal units per 100 acres of farmland or 63 animal units per average farm. (An animal or livestock unit is reckoned as 1 horse, 1 cow, 5 hogs, 7 sheep, or 100 hens.)

There is little doubt that the Horseshoe Moraines now have less than half the rural population which they held at the beginning of the century. In the central part of Grey County there are now only six farm people per square mile. The rural non-farm population has doubled in the last 20 years to about 10 per square mile.

Quite a different story, however, can be told of Puslinch Township. Although most of its area is made up of rough moraines, gravel spillways, and swamps, and only 32% of its area is reported as cropland, it now has a considerably larger total population than it had at the turn of the century. Quite a considerable majority (81% of the total) is non-farm population. This is because the township is a close neighbour to two growing cities, Cambridge (76,505) and Guelph (76,658), and is crossed by two major provincial highways and several county roads. Obviously, agriculture is not the major source of employment, the suitability of the land for agriculture is not a matter of major concern, and even many of the farm families obtain a large part of their living from non-agricultural sources.

Whereas the Niagara Escarpment has been cited as the most important location of rock quarries in Southern Ontario, the moraine and spillway systems which almost encircle the upland of peninsular Ontario provide the largest workable sand and

gravel deposits. Particularly important are the pits in the spillway terraces, in the Grand River valley near Paris, and Cambridge, and along the Speed River near Guelph (Hewitt and Karrow 1963). The Caledon pits have already been mentioned. Another large source of gravel of excellent quality has been worked for many years near Durham in Grey County, and there are, of course, a great number of small pits. The main deleterious constituent in these gravel deposits is siltstone derived from the shale formations below the Niagara Escarpment and it is most abundant near the escarpment. Generally the quality is very good.

Despite the fact that land use in the region, as a whole, tends to support a somewhat sparse rural population, there are a number of urban settlements. The largest and most important of these are the Grand River cities including Brantford (73,264), Cambridge (76,505), Kitchener (141,438), Waterloo (57,412), and the Speed River city of Guelph (76,658). Such centres were not built by and for the moraine-spillway area alone but to serve much wider regions. Indeed they have become part of the great manufacturing complex of Southern Ontario. However, as has already been indicated, they may have an overpowering effect upon land use in nearby moraine areas. Two smaller towns on the eastern limb of the complex are Acton (in the Town of Halton Hills) and Orangeville (13,969).

Even more closely associated with these hilly lands is the northern group of little towns including Walkerton (4,511), Hanover (6,199), Durham (2,430), Flesherton (564), Markdale (1,260), and Chatsworth (410). After driving through the area one is almost pursuaded that the size and prosperity of these settlements is a very direct reflection of the intensity of the agricultural activity in the surrounding countryside. Of course, Walkerton is a county seat and Hanover is well known for its furniture and other manufacturing activity, but the moraine is less bulky and large areas of clay plain and drumlinized till plain provide the basis for better soils. Gravel terraces are more widespread than kamey hills, and the gravels are more deeply covered with loam than in some other places. The course of this section of the Saugeen River is definitely related to the trend of the moraine, and the settlements were originally located near power sites. Their growth and importance, in turn, was the cause of the development of the patterns of railways, provincial highways, and country roads, which serve to connect them with their umlands and with more distant parts of Southern Ontario. Between 1901 and 1961, Glenelg and Bentinck Townships lost 47% of their population but the town of Durham doubled in size. Since 1961, however, the townships' population has increased by 35% and Durham has increased a further 17%. Durham (with a population of 2,430 in 1982), was at one time larger than Hanover (6,199) and, in pre-railway times, had closer connections with urban Ontario. Durham is centrally located to serve four townships but its umland has a lower agricultural potential. It shows less commercial and industrial activity than its downstream neighbours but has long had an emphasis on wood products.

Flesherton, Markdale, and Chatsworth are obviously related to the old colonization road leading to Owen Sound. Railway services were later provided along the same route. Each village has, essentially, a crossroad location with respect to its surrounding area. The region has a low agricultural potential, a fact which is emphasized by the reforestation of a fair-sized area. The surrounding townships lost 10 to 15% of their populations between 1951 and 1961, but have increased 20 to 30% since 1961. The villages, despite improved transportation, have gained less than 30% since 1951.

One cannot leave this area without mention of some of the smaller hamlets. Most of them with a population of 150 persons or less. Many of them were associated with small water-power sites which sustained the sawmills and grist mills. Among these might be mentioned Feversham, Walters Falls, Priceville, and Holstein. Hidden away from the main routes of travel, they perform the ancient role of service centre and help to preserve some of the tradition of rural Ontario.

6 FLAMBOROUGH PLAIN

An isolated tract of shallow drift on the Niagara cuesta northwest of Hamilton has been named the Flamborough plain since it spans Flamborough Township, and extends north to Acton (in the Town of Halton Hills). It is an area of about 150 square miles, bounded on the northwest by the Galt Moraine, and on the south by the silts and sands of glacial Lake Warren. A few drumlins are found scattered over this limestone plain and swamps are plentiful. The limestone has been swept bare in places, particularly near the edge of the escarpment on its eastern border. The plain slopes to the south from 1,200 to about 900 feet a.s.l. What little overburden there is on the bedrock, apart from the drumlins, is either bouldery glacial till or sand and gravel.

Some of the drumlins are well moulded and typical, and those north of Freelton have irregular contours and dimensions. In fact several of them appear to consist of two or three roughly formed drumlins joined together. Gravel bars on some of their crests are added features.

The plain is drained mainly by two small streams. Spencer Creek serves the Beverly Swamp

and the area north of it and flows into the Dundas Valley. The Town of Dundas taps it for its water supply. East of Beverly Swamp four small streams tributary to Bronte Creek serve the section south of Campbellville, while the upper reaches of Oakville Creek take over north of that community. The swamps and gravels of the upland provide these two streams with permanent flows.

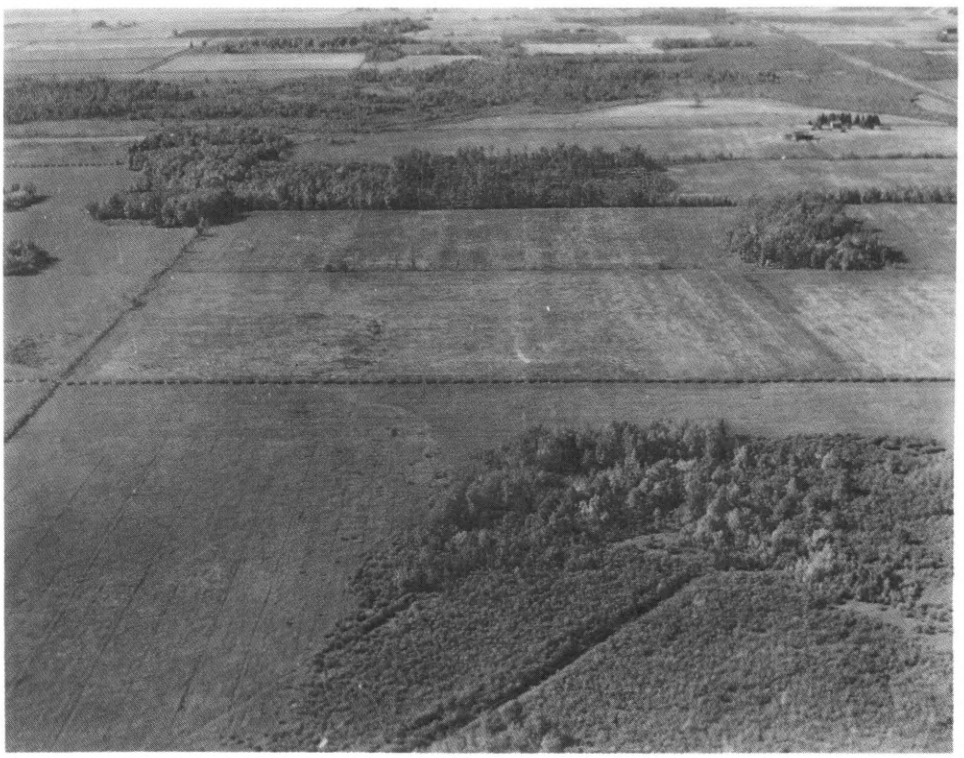
Good soil is not plentiful in this little region: the soil is either wet or stony and shallow. Thus most of the area is still in woods or pasture. The cultivated soil is found mainly on the drumlins and deeper gravel terraces. The swamps serve as water reservoirs and produce cedar posts and other wood. In one instance, black muck and marly soil are dried and sold as soil conditioner, and in another, marl is utilized.

7 DUNDALK TILL PLAIN

The "roof" of peninsular Ontario in the counties of Dufferin, Grey, and Wellington comprises an area of 925 square miles of gently undulating till plain. North and west of Dundalk, low drumlinoidal swells appear with their long axes oriented southeastward. A few low drumlins are also included in the west, adjacent to the Teeswater drumlin field. The main part of the area is a fluted till plain, the flutings running southeastward; in other words the surface appears planed but scored by shallow troughs which are barely perceptible to the eye. The region is bounded on the east by moraines and some morainic ridges lie inside the boundary near Shelburne and Orangeville.

With an elevation of 1,400 to 1,750 feet a.s.l. this region forms the watershed from which issue the headwaters of the Saugeen, Maitland, and Grand Rivers, as well as those of the Nottawasaga which take a shorter exit eastward over the Niagara Escarpment. Numerous, small, flat-floored valleys form a network over the plain and connect with either the Grand or the Maitland spillway systems. The valleys are frequently swampy, containing small underfit streams or no streams at all.

The plain is characterized by swamps or bogs and by poorly drained depressions (Photo 51). Indeed, it is related that the original surveyor, having run his lines around the areas now constituting the townships of East and West Luther and Melancthon, simply entered them on his map as "all swamp". Receiving orders to subdivide them into farm lots he did so, but commented that it was the meanest land he had ever surveyed. He determined to name them after the meanest men he had ever heard of, so being a devout Roman Catholic he could think of none more appropriate than the leaders of the Protestant reformation. Attempts have been made to alleviate the meanness by township



OGS 10 702

Photo 51. Oblique aerial view of the Dundalk plain west of Shelburne, showing numerous swamps.

drainage schemes but without much economic benefit.

One such large scheme involved the drainage of the Luther Marsh, one of the important source areas of the Grand River. While very little farmland was improved, the results had a deleterious effect upon the water supply of the river. After acquiring the land the Grand River Conservation Authority placed a dam across the outlet of the swamp, creating a reservoir of some 10,000 acre-feet with which to supplement the summer flow of the stream.

Most of the area carries a surficial deposit of silt, probably windblown and comparable to the much deeper deposits of loess in the Mississippi Valley, United States. The material is usually less than two feet in depth and often only a few inches so that it is all included in the weathered soil profile. It is deepest north of Shelburne around Hornings Mills and Honeywood where fairly extensive beds four or five feet thick occur.

In the northeast, a small part of this plain is the work of the Lake Simcoe ice lobe. The drumlins in this area point southwestward and thus were built by an ice sheet advancing over the Niagara Escarpment from the east. A small sandy moraine appears four miles west of Redickville to mark the limit of this advance. The till left in this area is more pervious than the Dundalk till. This, coupled with the unusually deep deposits of the uniform eolian silt on the surface resulted in a well-drained soil, especially important in this high, cool region where poorly drained soil is general. This is probably aided by vertical drainage into cracks in the bedrock, a feature of the area just back of the Niagara Escarpment. The effect on the quality of the farms shows up unmistakably between Hornings Mills and Maple Valley. This is an area specialized to potatoes. With its red barns the prosperous appearance of this small area stamps it as an exceptional part of this region. In front of the Singhampton Moraine there are shallow deposits of outwash which vary from gravel to fine sand.

The original vegetation of the better-drained areas was a hardwoods association of maple, beech, and some birch; but swamp forest containing elm, ash, cedar, and tamarack probably occupied a larger area. Although usually classed as a mixed hardwood forest section, the altitude of this region had sufficient effect to bring into both upland and lowland forest a sprinkling of northern species. White and black spruce, white pine, tamarack, balsam fir, alder, white birch, aspen, and willows are fairly common. Many diverse species of sedges and rushes inhabit old sods and roadsides where silverweed also abounds.

In spite of the elevation, drainage is slow on this high plain and gleysolic soils are more extensive than zonal soils. Furthermore, although the zonal profiles must be classed in the Grey Brown Luvisolic group they are more or less modified. The area is one of transition, as might be inferred from the spruce intermingled with the hardwoods. It is moister and cooler than most of the southern part of Southern Ontario and shallower Brunisolic or weak Podzol profiles are found superimposed on the Grey Brown Luvisols. The most noticeable effect of this is the darkening of the upper part of the A_e horizon of the Grey Brown Luvisolic profile.

The soil map of northern Wellington includes large areas classified in the Huron, Perth, Brookston, Harriston, Listowel, and Parkhill series. In all cases the surface soils are loams or silt loams, regardless of the nature of the underlying till. This is due, actually, to the presence of a separate geological deposit, quite probably loess or windborne material which overlies the pebbly till to a depth of 12 to 24 inches. The physical effect of this material, which is more pervious than the boulder clay beneath, is to form a watersoaked layer that is slow to dry out in the spring, thus preventing early cultivation of the land. In many cases, also, this material controls the depth of the weathered profile. In the Redickville-Honeywood area, already mentioned, the soil has good internal drainage, the soil profile is deeper and the surface soil is generally free of stones. A profile description of this Honeywood loam soil type is described in Table 2.

TABLE 2	SOIL PROFILE OF THE HONEYWOOD LOAM
A_h	3-5 inches, dark greyish brown, friable, crumb-structured loam; pH 6.6.
A_e	10-16 inches, brown to pale brown, friable loam; pH 6.2.
B	10-14 inches, yellowish brown, slightly blocky, friable loam; pH 6.8.
C	calcareous yellowish brown loam.

Generally, throughout the Dundalk plain on the lower slopes and in the hollows, except where there is muck or peat, the soils are mapped as Parkhill silt loam and Brookston silt loam. These have very dark humified surface soils which may vary from six to twelve inches in depth, underlain by gley horizons which are light brownish grey with olive mottling and of a sticky consistency. These areas are usually too wet for cultivation and if cleared are devoted to pasture. Usually where they have been neglected a weedy growth of dwarf willows has been permitted. Indeed, the presence of "willow flats" is one of the characteristics of this landscape.

Land Use and Settlement

On much of this undulating till plain, forest forms a very small part of the cover while grain crops, especially if the observation be made at harvest time, seem to form a very large part. Hay and pasture are dominant but at this time of year many sod fields have been ploughed in preparation for next year's seeding. The upturned soil on the slopes is brownish grey in colour, but in the flats it is definitely grey with occasional black patches. The grey colour indicates the dry gley of a poorly drained or gleysolic soil, which in its moist state is a medium olive grey, while the black colour indicates a shallow layer of muck. Only where ditches are maintained is it possible to cultivate this land.

Census figures for four townships within the region throw some light on the agricultural development. Despite the poor drainage most of the land was occupied by pioneer settlers. At the turn of the century the population averaged about 30 per square mile, most of them being resident on farms. By 1931 population had dropped to about 19 per square mile and in 1961 it was less than 16. In 1981 the rural non-farm population was only 6 per square mile. Coincident with the decline in population farm size increased to about 140 acres in 1931, 170 acres in 1961, and 188 acres in 1981. Only 10% of the total area is unfarmed. About 81% of the farmland is improved while 64% is used for the growing of crops. About 32% is in hay, 2% in oats, and 24% in mixed grains (oats and barley sown together). There are small areas of barley, wheat, corn, flax, potatoes, and buckwheat. Less than 1% of the farmland was planted to corn in 1961, but in recent years this has increased to 7% and some large new silos in the area and large cornfields are in evidence. About two-thirds of it is silage corn, but the fact that grain corn is grown at all in this region is remarkable. Fall wheat is seen occasionally in the southern and better-drained fields of the area, as are a few fields of flax, while in the northern part of the area some buckwheat is grown. Only in Melancthon and Mulmur Townships on Honeywood soils are potatoes an important crop. Sod is represented by 26 acres of hay and 14 acres of pasture in each 100 acres of farmland. Only 9% remains in woods but other land, chiefly swamp and rough pasture, makes up about 10%.

The importance of livestock is shown by the fact that, on the average, there are 30 animal units per 100 acres or about 56 per farm. Using 1981 census averages again, each 100-acre lot has 23 cattle (only 4 milk cows), 26 pigs, 3 sheep, and 190 poultry. In comparison with pre-war years the region has almost 60% more cattle, 100% more hogs, and only one-third as many sheep, while draft horses have nearly disappeared, about one remaining for each two farms. Tractor power is universal with an average of two tractors per farm in Dufferin County and an array of associated machinery.

The Dundalk plain has the coolest and shortest growing season of any farming area in the south part of Southern Ontario; consequently many crops which are commonly found in other areas cannot be grown. On the other hand it is preferred over the warmer, drier climates for potatoes. For the most part the soils are a little too heavy and high in lime for this crop; also they are often either poorly drained or stony. However, the crop is an important specialty on the Honeywood soil around Redickville and Honeywood where the well-drained, silty soil supports a group of excellent farms. Aside from this and a slight concentration of dairying around the small towns, the agricultural income of the plain is derived from rather extensive mixed farming with an emphasis on beef cattle, supplemented by the sale of hogs, cream, poultry, and eggs.

This high tableland was somewhat isolated from the early waves of settlement in Southern Ontario, most of the land being taken up during the latter part of the 1800s. Early settlement was more or less tied to the colonization roads, Hurontario Street and the Garafraxa Road, which have now become Highways 10 and 6 respectively. Since these highways trend northwesterly the rectangular north and south township surveys made later had to be fitted around these early surveys. A slight modification of existing nucleated settlement took place after the building of the Toronto Grey and Bruce Railway in the 1870s, but in large measure it sought to service existing settlements along the routes to Owen Sound. The railway tended to parallel the main roads, which in turn have become provincial highways; thus the more important towns have maintained their original positions, while railway junctions such as Fraxa and Saugeen have not developed at all. The chief centres on the plain are Dundalk (1,298), Shelburne (2,972), Arthur (1,699), Mount Forest (3,412), and Listowel (4,968), while Orangeville (13,969), Grand Valley (1,237), Harriston (1,884), Palmerston (1,981), and Drayton (772) are on the margins. A few small settlements developed at railway stations, but for the most part the names on the map are those of former post offices, discontinued when rural mail delivery was instituted.

In comparison with most other sections of Ontario the Dundalk plain has rather a severe landscape (Photo 52) with some resemblance to the plains of Saskatchewan. The forest was almost completely cleared and few farmers planted many trees about their homesteads. Perhaps an old ragged orchard may persist, but the rows of elms and

maples, so characteristic of other areas, are conspicuous by their absence.

With a few notable exceptions farm buildings follow a simple plan. The houses are small and square, with either a pyramidal or gable roof, and are of brick, cement block, or frame construction. Usually the barns are grey and square with a gable roof and a field-stone basement with insufficient window openings. Commonly, there is a low implement shed and a garage, but few other outbuildings. A windmill is sometimes part of the farm equipment.

The austerity of the plain is emphasized by the many square barns standing alone against the sky, by deserted houses, and stone foundations from which the buildings have long since vanished. These vacant farms should not, however, be considered as abandoned lands, for each 100 acres provides pasture for 20 or 25 cattle. The farms should have been larger from the beginning.

These impressions were derived from field notes recorded many years ago, yet they need only a little retouching to bring them up-to-date. Farms are larger and more homesteads have been vacated. Some barns have been painted and the basements whitewashed. New silos have appeared, houses have been repaired, and electric services are now universal. There has, as yet, been very little of the building of rural non-farm residences that dot the concessions and side roads of so many Ontario countrysides. The old rural Ontario still survives on the Dundalk plain.

8 STRATFORD TILL PLAIN

The City of Stratford is situated on a broad clay plain of 1,370 square miles, extending from London in the south to Blyth and Listowel in the north with a projection toward Arthur and Grand Valley. It is an area of ground moraine interrupted by several terminal moraines. The moraines are more closely spaced in the southwestern portion of the region; consequently that part resembles the Mount Elgin Ridges. The northern half of the region is mostly level, modified by one or two moraines. The overall slope is toward the southwest, from approximately 1,500 feet to 900 feet a.s.l. The highest section is drained by the Conestogo and Nith Rivers, tributaries of the Grand. The Maitland River serves another small part, but most of the central and southern portion is within the Thames watershed. The divides between these watersheds are vague, however, at times amounting to belts in which drainage has not been established. This plain differs from the Dundalk till plain in having a faint knoll-and-sag relief rather than a fluted surface.

Throughout this area the till is fairly uniform, being a brown calcareous silty clay whether on the ridges or the more level ground moraine. It is a product of the Huron ice lobe. Some of the silt and clay is calcareous rock flour, probably a good deal of it coming from previously deposited varved clays of the Lake Huron basin. The silt and clay contents vary within certain limits and so does the stoniness, but it is seldom a stony till. Shallow surface deposits of silt are less prevalent than on the Dundalk till plain, but they cover sizable tracts in northern Middlesex County. Sand or gravel is often present in the intermorainal valleys south of St. Marys.

Gravel for road building and other construction is not plentiful in this region. The area north of Seaforth is the best supplied from eskers and kames.

OGS 10 703

Photo 52. Dundalk plain, East Garafraxa Township. The smooth, gently undulating terrain and the scarcity of trees are characteristic.

One occasionally sees kames farther south, but there the most common sources of gravel are the terraces along the Thames River.

The Stratford till plain, being part of the slope east of Lake Huron receives more rain and snow than is usual in Southern Ontario. It is a muddy country and late spring seedings are an unfortunate probability that must be balanced against the advantage of few summer droughts. In winter the difficulties of transport in this snow-belt are well known.

The soils of the Stratford plain may almost all be classified in the Huron catena based on the heavy-textured calcareous till which is so widespread in the region once covered by the Huron ice lobe. The moderate ridges of the Lucan, Mitchell, and Milverton Moraines, as well as some other well-drained areas, have a Huron profile which is a fully developed Grey Brown Luvisol; the gently sloping flanks of the ridges and the slightly undulating parts of the plain also have a Grey Brown Luvisolic profile, and are mapped as the Perth series.The more level parts of the plain, often so flat as to resemble the floor of an ancient lake, are poorly drained and have developed the rusty mottled, olive grey, gley horizon which is characteristic of the Brookston series. These three types of profiles are illustrated in Figure 23. The surface soils may be either silt loam or clay loam depending upon the presence or absence of the surficial silt deposit. Both the Brookston and the Perth soils require artificial drains to permit a fully developed cropping system. Municipal ditches are integral features of the landscape, while tile drains have been installed in thousands of acres and more are being installed every year. The more rolling Huron soils are susceptible to erosion. In many places the surface soil has been washed from the hillsides, leaving sticky brown clay or even the greyish subsoil exposed, with the result that crops on these fields are very uneven.

The situation in the Stratford plain provides a convenient opportunity to demonstrate the soil group known to soil scientists as the catena. The Huron, Perth, and Brookston series form such a natural group developed on similar parent materials, but in well-drained, imperfectly drained, and poorly drained sites, respectively. The differences due to drainage are exhibited in the profile descriptions in Figure 23.

The soils of the Stratford plain have good natural fertility, a good supply of lime in the subsoil, and few obstacles to cultivation once the necessary drainage facilities have been supplied. This is one of the more productive agricultural areas of the Province.

Land Use and Settlement

Census figures show that there is no vacant land. Every rural lot, and some of the areas within urban municipal boundaries, are part of a farm operation. This was the case in the 1920s also, when farm size

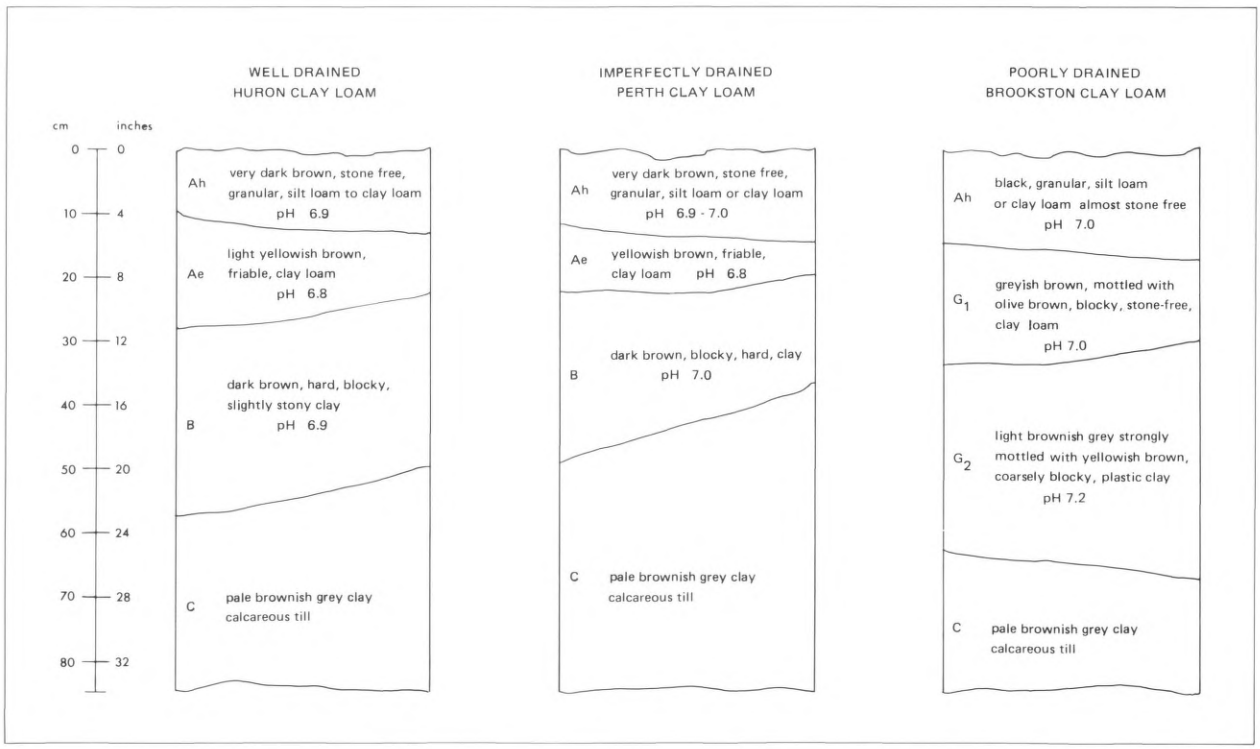


Figure 23. Soil profiles for the Huron clay loam, Perth clay loam, and Brookston clay loam.

averaged 96 acres. Today, the farms are roughly 150 acres in area and there are one-third fewer farms. The total improved land has actually increased from 87.5 to 91%, leaving only 9% to be accounted for by woodlots, marsh, and rough pasture. Crops are grown on 81% of the farm area leaving 19% for pasture, orchards, feed lots, homesteads, and farm lanes. There are only about 1.2 acres of pasture for each grazing animal, not counting the calves. On the average 150-acre farm, 126 acres are in crops: including wheat, 7 acres; oats, 1 acre; barley, 6 acres; mixed grains, 23 acres; hay, 34 acres; grain corn, 38 acres; silage corn, 10 acres; and other crops, 7 acres. In Perth County, in 1960, about five-sixths of the corn acreage was used for silage, but now the production of shelled corn makes up three-quarters of the total. Other crops included flax, beans, soy beans, oats cut green as a soiling crop or dried for hay, and a variety of other forage crops. On this clay plain, as on the ones to the north, livestock raising is important. Each 100 acres of farmland supports about 44 animal units, making about 66 per farm. Each farm has about 42 cattle, including 10 milking cows, 105 hogs, 1 sheep, and 335 poultry. There are only 2 horses for every 3 farms on the plain, while each farm averages 2.4 tractors. Census figures show that the average acre of farmland on this plain yields a 50% greater gross return than the average for farmland in Ontario. This value is more than twice that for the already-discussed Dundalk plain, lying almost continuously with it, so we need to take a close look at the land-use practices and their results. Comparisons might, also, usefully be made with the Guelph, Oxford, and Teeswater till plains which have fluted or drumlinized surfaces and better drainage.

Perth County is usually shown as part of the Southern Ontario dairy belt and it has an important concentration of dairy cattle with almost as many cows as Oxford County; yet in 1961, 40% of the cattle population was kept for beef and this ratio has increased to 52% in 1981. Thousands of steers are brought from western Canada each year to be finished in barns and feed lots or on pasture. The total out-turn of hogs is greater than that of any other county, although the concentration is not so great as in the Regional Municipality of Waterloo. In recent decades this plain has lost little of its farmland and has lost only one-fifth of its farmers. In 1941, the average farm had an area of 124 acres instead of 98 which was the average in 1931. By 1981, the average farm size had increased to 156 acres, an increase of 60%.

The number of full-time farmers, as opposed to operators who also have a job off the farm, is higher in Perth than in any other county in Ontario. It is 50%, while the comparable figure for Grey County is only 6%, and for the whole Province 6%. No doubt this is attributable partly to the fairly uniform tract of good soil and also to the scarcity of outside job opportunities.

There are no large cities on the plain; Stratford (26,197) has gained an average of 300 persons per year since 1960 and shows little tendency to encroach onto adjoining fertile land. The small towns and villages, also, show only modest growth. The population of Perth County (65,712) has gained only 15% in 20 years (18% in 80 years) and it remains one of the more rural counties in Ontario. Neighbouring counties, containing the growing cities of London (266,319), Brantford (73,264), and the Cambridge-Kitchener-Waterloo complex (275,355) help to provide markets for agricultural produce, as do the more distant Metropolitan Toronto (2,140,347) and Hamilton-Wentworth (414,175) urban areas.

The relationship of Stratford to its plain is of some interest, for it is not centrally located. Its inception about 1830 during the days of the Canada Company was as a stopping point and stream crossing on the colonization road, which just happened to coincide with the junction of five survey lines which also became travelled routes. Having thus come into existence it later became the focus of five railway lines to other centres of population in Ontario. One cannot but conclude that the Avon, insignificant as it may be among the rivers of Ontario, is the prime focus of Stratford, and Stratford has made the most of it. Having been dammed to provide a shallow lake in a scenic park it has given Stratford an attraction which many other towns might have copied but have not. No other town but Stratford could have a Stratford Festival, of course, but the existence of the old spillway trough, incised across the clay plain, provides the basis of the scenic qualities of the site. Thus inspired, man has done the rest.

Because of the geographically off-centre location of Stratford, the relationship of the clay plain is that of hinterland, rather than umland. Smaller local centres, therefore have arisen, including the towns of Exeter (3,686), Mitchell (2,745), Listowel (4,968), St. Marys (4,809), and Seaforth (2,141); the villages of Hensall (977), Milverton (1,459); and numerous small unincorporated places of 100 to 500 people. St. Marys is a special case, existing not so much to serve the countryside, but because of its own resources, chiefly quarrying and cement manufacture. In any case, it lies pretty well within London's sphere of influence, as does the southern end of the clay plain.

9 HILLSBURGH SANDHILLS

The Hillsburgh sandhills form a natural boundary on the southeastern flank of the Dundalk till plain.

Extending from Orangeville to Hillsburgh and Belwood, they cover approximately 64 square miles. Although this was the first land to appear as the glacier melted, it must not be concluded that it is the highest part of the upland. However, it is all over 1,400 feet a.s.l. and the highest ridges reach 1,600 feet, which is only 150 feet less than the highest part of the Dundalk plain 35 miles to the north. The rough topography, sandy materials, and the flat-bottomed swampy valley running through the moraine from Orangeville to Hillsburgh are the outstanding characteristics.

The steepest slopes are those along the sides of the big spillway north of Hillsburgh, but knobby hills are general. The point to be stressed about the soil materials is the prevalence of fine sands, which is not typical of kames. In this respect the area is like the Waterloo hills and the sandy ridges of in the Palgrave area. Three miles south of Orangeville, Caledon Lake stands in the bottom of the glacial spillway. It is a shallow, marl-floored lake that appears to owe its existence to a mass of sandy drift dropped in the spillway just south of it. The Grand River cuts through this moraine at Belwood; that section of the valley is now the stretch occupied by the artificial lake created by the Shand Dam. West of Belwood the moraine is smaller and the sand gradually gives way to till.

The Hillsburgh sandhills produce very few potatoes, even though the fine, sandy, loam soil would appear to be well-suited for this crop, except on the steeper slopes. Beef cattle, hogs, and poultry constitute the standard farm produce of the area.

Hillsburgh (1,100), a police village lying on the floor of the old spillway is a railway stop, and the largest rural supply point in the area. Orton and Belwood are smaller centres.

OGS 10 704

Photo 53. The Baden hills, west of Kitchener, are good examples of kames.

10 WATERLOO HILLS

The Waterloo hills region occupies about 300 square miles or 192,000 acres, lying chiefly in the Regional Municipality of Waterloo but extending into the eastern part of the Township of Blandford-Blenheim, and North Easthope in Perth County. The surface is composed of sandy hills, some of them being ridges of sandy till while others are kames or kame moraines (Photo 53), with outwash sands occupying the intervening hollows. The general elevation is from 1,000 to 1,400 feet a.s.l. and in some places the hills are quite rough. A peculiar characteristic is the preponderance of fine sand, particularly on the surface, and in this the region resembles the Hillsburgh sandhills. Adjoining the hilly region is an extensive area of alluvial terraces of the Grand River spillway system which, although more nearly horizontal, contains similar but more uniform sandy and gravelly materials.

The Conestogo River and the till plain lying north of it separate the northern end from the main body of this area. Similarly, the sandhills in North Easthope Township are set apart by the Nith River valley. Both of these outlying moraines have broad swampy valleys associated with them. In the main part of the region a number of kettle lakes appear, for example, Spongy Lake, Hofstetter Lake, and Sunfish Lake. Small swamps are even more numerous.

The Baden hills, so conspicuous from Highway 7, are splendid, though rather extreme, examples of kames. They stand up as domes about 200 feet high and consist entirely of gravel and sand. Around the base is an apron of outwash sand, and a kettle lake north of the highway is a typical complement.

The soils of the hilly areas are well drained and have developed as mature Grey Brown Luvisolic soils. For the most part they may be classified in four series: Guelph, Harriston, Dumfries, and Waterloo. The Guelph and Harriston are found on gentle slopes in the areas where loamy tills occur, while there are some nearly level areas which may have the imperfectly drained London and Listowel soils. Dumfries soils are found in rougher parts where the parent material is a loose gravelly till. Waterloo sandy loam (Table 3) is found on most of the rounded, sandy hills of the area but there are associated small areas of many other types.

The original forest consisted of splendid pines and hardwoods such as sugar maple, beech, wild cherry, and red oak. Only about 10% of the forest cover remains, and that in a depleted condition. However, the sandhills have more remaining forest than the nearby till plains.

TABLE 3	SOIL PROFILE OF THE WATERLOO SANDY LOAM
A_h	3-5 inches, dark brown, friable, slightly stony, sandy loam; pH 6.4.
A_e	10-14 inches, light yellowish brown, very friable, stone-free sandy loam; pH 6.4.
B	8-10 inches, brown, finely blocky, dense, almost stone free, loam; pH 7.0.
C	light grey, loose, calcareous sand.

Land Use and Settlement

Waterloo County (now the Regional Municipality of Waterloo) was settled in the early 1800s by people of German descent who came to Upper Canada from Pennsylvania in their Conestoga wagons. The tradition they brought with them was one of mixed field crop and livestock agriculture. Crops normally occupy about 70% of the farmland but in some cases there is even more. A sample area studied by Lee (1943) was found to have 75% in crop.

Canada Census statistics for 1981 show that each 100 acres of farmland had 3 acres in wheat, 7 acres in barley, 0.3 acres in oats, 20 acres in mixed grains, 16 acres in corn, and 21 in hay. The most noticeable changes in the cropping system in recent years have been the increase in both grain and silage corn, and decrease in oats. Seeded pasture has also decreased from 16% in 1963 to 9% in 1981.

Agriculture is geared to intensive livestock production. Each 100 acres of farmland in Woolwich Township carries about 40 cattle, 1 horse, 1 sheep, 103 hogs, and 777 poultry. This is a total of roughly 69 livestock units. The second highest of any township in Ontario. Needless to say, no farm is an average farm: some specialize in beef production, some in hogs, and a growing number in poultry. The number of dairy farms has decreased although the population of dairy cattle has increased. Hogs have increased greatly in the last 20 years.

Like the rest of agricultural Ontario, Waterloo has lost some of its farm population, but less than the average. Its farm families are about 20% smaller than they were 20 years ago and its farms are only 14% larger.

The whole of the Waterloo sandhills is included in the umland of the greater Kitchener urban complex, which embraces Waterloo, Kitchener, and Cambridge, containing a total of 275,355 people in 1982. There can be no doubt that the market represented by this concentration of consumers is one of the reasons for the intensification of agriculture in the region.

The region is undoubtedly prosperous. Houses and barns are in good repair and usually painted. Much modern equipment is to be seen. Agriculture has made little concession to landform in this area, and greyish patches may be seen on some eroding slopes. The trend toward more corn at the expense of pasture will tend to increase soil erosion. This would appear to be the main concern for the well being of the light-textured soils on sloping land in this outstanding farming region.

11 GUELPH DRUMLIN FIELD

Centring upon the City of Guelph and Guelph Township, the Guelph drumlin field occupies an area of 320 square miles lying to the northwest, or in front, of the Paris Moraine. Within this area, including parts of the Regional Municipalities of Hamilton-Wentworth, Waterloo, and Halton, and part of Wellington County, there are approximately 300 drumlins of all sizes. For the most part these hills are of the broad oval type with slopes less steep than those of the Peterborough drumlins. In this they more closely resemble those of the Teeswater field. They show some variation in the trends of their axes, but all of them are referable to the ice thrust which radiated from the western end of the basin of Lake Ontario. The axes of the main group, near Guelph, bear about 290° while in Puslinch and the northern border of Flamborough Township, to the south, the direction is almost due west.

The drumlins of this field are not so closely grouped as those of some other areas and there is more intervening low ground, which is largely occupied by fluvial materials. The till in these drumlins is loamy and calcareous, and was derived mostly from dolostone of the Amabel Formation so strategically exposed along the Niagara cuesta. In addition it contains fragments of the underlying red shale which is exposed below the escarpment. In consequence it is pale brown in colour, or not so grey as the till of the Peterborough drumlins. Grain size analyses of Guelph till samples have shown an average of 50% sand, 35% silt, and 15% clay. While this represents the composition in the central part of the area, it should be noted that toward the southwest the till is considerably heavier. On the other hand it is progressively more sandy as one proceeds toward the northeast. Moreover, toward the northeast the surfaces of the drumlins are covered by a layer, a few inches thick, of stoneless fine sand and silt which is probably wind deposited. The till throughout is rather stony, with large surface boulders being more numerous in some localities than others.

Over-all, this is a sloping plain between 1,000 and 1,400 feet a.s.l., with an average gradient of about 20 feet per mile from north to south. It is underlain by dolostones of the Amabel and Guelph Formations which dip gently toward the southwest. These rocks are exposed only in the valleys since the drift cover is seldom less than 50 feet in depth and wells are often drilled into the bedrock for water supply.

The ice which moulded this drumlin field advanced from the southeast and the front of the melting receding glacier was at right angles to this, that is, down the slope of the plain. The drainage of the ice front was consequently able to find progressively lower and lower outlets, so that the drumlin field is furrowed by more or less parallel valleys running almost at right angles to the trend of the drumlins themselves. There are also numerous interconnecting cross valleys which occupy deeper depressions between drumlins. Along the sides of these valleys there are broad sand and gravel terraces, while the bottoms are often swampy. The general landform pattern, then, consists of drumlins or groups of drumlins fringed by gravel terraces and separated by swampy valleys in which flow sluggish tributaries of the Grand River. Incidental to this pattern are the several gravel ridges or eskers which cross the plain in the same general direction as the drumlins, with gaps cut through in places by the meltwater spillways. The best example is the one which can be traced from Guelph to West Montrose, while two more are found within five miles to the north. In the presence of so many large stream terraces, these eskers are not so highly regarded as a source of gravel as those of the Dundalk plain where stream gravels are seldom found.

Within this area the dominant soil materials are the stony tills of the drumlins and deep gravel terraces of the old meltwater spillways. Both types of material usually have a shallow veneer of loam which reduces the stoniness of the surface soil.

The soils of the drumlins are classed in the Guelph catena which contains the predominant, well-drained Guelph; the imperfectly drained London; and the poorly drained Parkhill loams. Toward the north some of the soils of the drumlinized plain have been classified in the Harriston catena because of the yellowish brown colour and somewhat more silty texture of the parent material. Otherwise the soils are fairly similar.

The loamy soils of the extensive gravel terraces are referred to the Burford catena and are widely distributed in the Grand River basin. Some of the spillways have poorly drained and even swampy stretches, which for the most part have not been cleared for cultivation.

Both the Guelph and Burford are good general purpose soils. The freely drained subsoil of the Burford is somewhat of a disadvantage in dry seasons, but the Guelph on the other hand suffers a comparative disadvantage when the spring is late or the autumn wet. On the whole it is fertile, easily worked, and adaptable to many crops. It will be a durable soil if proper measures, such as strip cropping and grassed waterways, are used to control surface erosion.

The rather large areas of London loam are also quite fertile, but often need systematic tile drainage in order to be of full use. This is also true of the poorly drained Parkhill areas.

Land Use and Settlement

Agriculture on the Guelph till plain was traditionally of a rather generalized type but at the present time it shows signs of specialization toward the production of beef cattle, hogs, and poultry. According to the 1981 census, the average farm is about 130 acres in area with 80% improved and less than 10% left in woods. About 65% of the land is in crop and 10% in improved or seeded pasture. Considerable areas of unimproved land are also grazed. Much of the former "natural pasture", often poorly drained land, has been improved by drainage and seeding, and now has a high carrying capacity. There are approximately 35 livestock units per 100 acres of farmland, or 45 per average farm. Each farm carries about 32 cattle, 51 pigs, 9 sheep, and 238 poultry. In total, livestock carrying capacity in this area is not far behind the Oxford till plain, long regarded as one of the more productive livestock regions of Ontario. The chief difference is that whereas about two-thirds of all farms in Oxford are dairy farms, only about one-third of those in the Guelph till plain could be so regarded, dairying being relatively well developed only near the City of Guelph.

The City of Guelph (76,658 including the suburbs) is the social, cultural, and commercial centre of this region. Founded in 1827 by John Galt of the Canada Company, it was located on a gravel terrace at the confluence of the Speed and Eramosa Rivers or, what is really more significant, the confluence of the two big glacial spillways which were the forerunners of these small modern streams. As the city has grown it has spread over the surrounding hills. The Roman Catholic cathedral surmounts a drumlin at the end of Macdonald Street, while the Guelph Collegiate Institute is located on a sister summit to the west. The big drumlin to the east of the Speed River is crowned by hospital buildings, while to the northwest, Woodlawn Cemetery and Mary Mount Cemetery lie on drumlin slopes. South of the city, the University of Guelph, including the Ontario

Agricultural College and Macdonald Institute, occupies another couple of drumlins. Guelph rivals Peterborough as a "city of drumlins" but since the slopes are less steep the pattern is less noticeable. Manufacturing firms, for the most part, seek level sites. In an earlier period many of these plants were located in the southeastern part of the city on the gravel terraces adjacent to the Eramosa River. The postwar industrial expansion of Guelph, however, has largely been toward the northwest where extensive flattish areas also exist. The city limits have been expanded to include almost 17,000 acres, and urban building has extended into the township in several directions.

Although Guelph dominates its umland almost completely, there are a few other, much smaller centres. Fergus (6,034) and Elora (2,604) toward the northern edge of the area were founded at mill sites on the Grand River and became service centres for small areas. Because of the development of special facilities for the manufacture of farm equipment, Fergus has become the larger settlement. Eden Mills, Rockwood, and Everton are mill sites on the Eramosa River. Erin (2,247), at the far northeastern corner of the area, is located in a continuation of the same spillway although on a branch of the Credit River.

The Guelph countryside has a pleasing appearance. Through some unknown accident the early surveyors laid out the road in accordance with the grain of the country, that is, the roads are in line with the drumlin shapes. The fields are thus less inconvenient than those of the Peterborough area while the gentler slopes are easier to till and tend to be less erosive. In any case it is easier to arrange and carry out systems of contour cultivation. Roadsides are commonly planted with rows of maple trees. Farmsteads are well built with large barns set on stone foundations. The houses, also, are often built of field stones. Woodland is more plentiful here than on the flat plains to the north and, because of the rolling terrain, it appears to be even more abundant than the 10% recorded in statistics. There are fewer abandoned farms than in the adjacent morainic area. Although one sees some evidence of soil erosion on the steeper slopes, it is kept in check fairly well by the cover of vegetation. The streams in the great spillway valleys, though small, have some water in them even in the driest summers, indicating the great reservoir capacity of the Pleistocene gravel beds. Although a good deal of gravel has been excavated in the vicinity of Guelph, these terraces also still retain a great reserve of useful building aggregate.

12 TEESWATER DRUMLIN FIELD

Taking its name from the Village of Teeswater and from the river which drains a large part of the area, the Teeswater drumlin field occupies approximately 575 square miles in the five counties of Bruce, Grey, Huron, Perth, and Wellington. Lying in front of northwestern limb of the Horseshoe Moraine system, its position is somewhat analogous to that of the Guelph drumlin field with respect to the eastern limb of the Horseshoe. As in the case of the Guelph group, toward the outer margin of the field the drumlins become weaker and gradually fade into an undulating till plain, and are not confined by any well-developed terminal moraine. The orientation of the drumlin axes varies from almost south in the Wingham and Teeswater areas to almost southeast in the country between Palmerston and Harriston.

As in the Guelph field, the characteristic drumlin is a low, broad, oval hill with gentle slopes. The till is loamy in texture, moderately compact, highly calcareous, and pale brown or yellowish brown in colour, since the material is largely derived from the soft, pale brown limestone of the region. The Teeswater till has fewer boulders than the Guelph till because these rocks are softer and were less resistant to glacial grinding than the dolostones of the Amabel Formation which predominate in the Guelph till (Photo 54).

The Teeswater field was traversed by large meltwater rivers draining the ice fronts to the north and west of "Ontario Island" (*see* Figure 11e). They cut the broad valleys which now carry branches of the Saugeen and Maitland Rivers. For the most part these valleys are cut in till but occasionally, as in the case of Formosa Creek, the down-cutting was continued deep into the underlying limestone. Associated with most of these valleys are broad terraces of sand and gravel, filling much of the low ground between the drumlins and creating the same sort of "drumlin and gravel flat" landform pattern that is seen in the vicinity of Guelph. Well-formed drumlins are found in parts of Turnberry, Howick, and Minto Townships but they are rather rare in Normanby, Carrick, Culross, and Wallace, though the rolling till plain everywhere has a drumlinized or fluted aspect.

The continuity of the drumlin field is broken in several places by the presence of kames and associated outwash. One large group of sandhills lies in Carrick Township directly south of Mildmay and Neustadt, while a third is found near Pike Lake, between Clifford and Mount Forest. Sandhills and drumlins are much intermingled along the western border of the plain. On the surface of all of these formations quite generally there are shallow deposits of

silty, stone-free, probably wind-deposited material which tends to give the surface soils a silty texture as well as more than ordinary depth.

On the drumlins, gravel terraces, kames, and moraines, drainage is usually good; however, this drumlin field, like most others, contains many areas of swampy land. Toward the northwest it borders on the Greenock Swamp, while in the southwest near Wingham there are other wide swamps related to the old spillway system. The effect of drainage differences is seen in the distribution of forest vegetation. On both till and outwash the well-drained areas attract sugar maple and beech while the wet lands are clothed largely with elm, soft maple, ash, and white cedar.

The soils of the Teeswater till are similar to those of the Guelph till but have a more definite buff or yellowish brown colour. They are also more silty in texture and somewhat less stony. The soils have been classified by the Ontario Soil Survey (Appendix C) in the Harriston catena which contains the well-drained Harriston and imperfectly drained Listowel series. The surface of the latter is smooth and with less relief than in the Harriston, and many areas require the installation of tile drains to provide the best conditions for crop growth. Depressions and flat areas have been classified as Parkhill loam, indistinguishable from the flat areas associated with the Guelph catena.

The soils of the gravel terraces are similar to those of the Burford catena found in the Grand River basin, but because the parent material is composed largely of limestone rather than dolostone these soils have been placed in a different catena, the Teeswater. The well-drained member, Teeswater loam, is much more extensive than the more poorly drained associates. Its soil profile may be from two to three feet in thickness depending upon the thickness of the silt deposit, but the weathered profile nearly always extends into the underlying gravel. Good drainage makes this a desirable soil for wheat, corn, and alfalfa.

OGS 10 705

Photo 54. Glacial till, Wroxeter, Bruce County. Note the unstratified material and boulders of various sizes and shapes in the mixture.

Land Use and Settlement

The Teeswater drumlin field is considered to be one of the good general farming and livestock districts of Southern Ontario, carrying on a system of agriculture very similar to that of the Guelph drumlin field. Its climate in summer is similar to that of the Guelph area, but in winter it has to contend with 45 inches more snowfall on the average. Economically the region suffers due to the greater distance from the markets of the large metropolitan centres.

Despite the fact that the area contains some poorly drained land as well as some dry, gravelly hills, it was fully occupied by agricultural settlers during the third quarter of the 19th century, reaching its population peak in the early 1880s. Population steadily declined thereafter, largely through the loss of the many members of large farm families who went elsewhere to live. There was little actual land abandonment, the census of 1931 showing an average of 634 acres per square mile still under agricultural occupation. At that time farms averaged 113 acres in area, while 73.5% of the farmland was improved, and 51.3% was recorded as being cropland. The chief crops (and percent of farmland) were: hay (18.5%), oats (18.3%), mixed grains (6.4%), wheat (2.5%), barley (2.3%), and improved pasture (17.5%); about 13% remaining in woods and 14% in other unimproved land.

In 1981 occupied farmland totalled 617 acres per square mile; therefore, in the past 50 years some farms have been abandoned and average farm size has increased by 30% in the last 20 years to about 190 acres. Crops are grown on about 64% of the total farmland, the chief ones being: hay (14%), mixed grains (11%), grain corn (11%), silage corn (10%), and barley (1%), while turnips, wheat, flax, potatoes, and other crops share the remaining 6%. Seeded pasture occupies about 11%, woodland about 13%, and other unimproved land about 22%.

In the last 20 years there has been a 19% increase in corn at the expense of oats and pasture. Very little oats are now grown, except in a mixture with barley.

The livestock population of this region has been greatly increased. In 1931 each 100 acres of farmland supported about 20 animal units, about 16% of the land being required to support the horses which provided the power for cultivation. In 1981 each 100 acres supported 49 animal units, making about 94 per farm. Only a few places in Ontario have a better record for animal production, the average farm carrying about 71 head of cattle, 96 pigs, 5 sheep, and 316 poultry. Less than one-quarter of the operating units could be classed as dairy farms, although milk and cream are also sold from some beef herds.

In recent years, hogs and beef cattle have been on the increase. Only a few flocks of sheep are to be seen. The horse is a rare animal; one would probably have to visit half a dozen farms before finding a working team; 50 years ago horses were as numerous as the human population on these farms.

The Teeswater drumlin area is still one of the more strictly rural parts of Ontario. Its total population is now only about one-half of what it was at the beginning of the century. There are no nearby cities to attract population to adjoining rural areas. The largest towns, Walkerton (4,511) and Wingham (2,931) have both grown considerably in the postwar period. The other small market towns of Harriston (1,884), Palmerston (1,981), Teeswater (1,018), Mildmay (924), Brussels (961), Clifford (610) and Neustadt (500), have changed very little since the beginning of the century. There are a number of small unincorporated places also, including Ayton, Formosa, Fordwich, Gorrie, Wroxeter, Bluevale, and Belgrave. Most of these points were mill sites, some still operating, others simply enlarged crossroads hamlets. Few of these show any growth and some are actually declining.

The early surveyors divided this land into blocks of 1,000 acres, each a mile and a quarter square. The roads are usually well graded and gravelled and many of them are oiled. Not nearly as many of the roadside maple trees have been destroyed as in some other areas. The old farmhouses and barns are kept in good repair and farmsteads are usually surrounded by trees. There is, of course, some change: new silos, poultry houses, hog pens, and cattle-feeding facilities gradually make their appearance, yet probably the native, returning for a visit after many years of absence, will find the charming, rolling landscape but very little changed.

13 ARRAN DRUMLIN FIELD

Between Owen Sound and Southampton, lying mainly in the townships of Arran, Amabel, Keppel, and Derby, is an area of 200 square miles containing several hundred long narrow drumlins. Since the township of Arran is central to the area and is almost entirely drumlinized its name has been applied to the whole field. In part of the area lacustrine clay occurs between the drumlins.

This group lies to the north of the Horseshoe Moraines and is younger than the Teeswater drumlin field farther south. In addition to the difference in shape already noted, these drumlins are oriented almost southwest having been formed by the advance of an ice lobe from the basin now occupied by Georgian Bay. They are thus almost parallel to Owen Sound and Colpoys Bay, two deep indentations in the Niagara Escarpment which undoubtedly influenced the direction of ice flow.

While these drumlins were being uncovered the glacier apparently underwent a series of fluctuations, building eight or ten thin moraines running east and west across the field in the vicinity of Tara and Derby Mills. They are formed of till of the same nature as the drumlins and often from connecting ridges between several drumlins.

The two morainal strands to the south provide a definite boundary to the Arran drumlin field. In the southern part the hollows between the drumlins are usually floored with beds of lacustrine clay.

The Algonquin shoreline in Amabel Township provides a clear-cut western boundary to the drumlin field. The old shorecliff is very steep and some drumlins stand half cut away by wave action. Beyond this line not a single drumlin remains, although the presence of some very bouldery patches on the old lake floor undoubtedly indicates that there were other drumlins which the waves completely destroyed. This is in contrast to other parts of the Algonquin shoreline where drumlins remained as islands and indicates the strength of wave action in this vicinity.

The till of this drumlin field is a highly calcareous, heavy loam containing a great many stones and boulders of both dolostone of the Amabel Formation and Precambrian rocks. The mantle of ground moraine is not very deep and many of the drumlins, especially toward the northeast, stand isolated upon the dolostone bedrock. As in other drumlinized areas, the inter-drumlin depressions are often occupied by swamps, but a few of them contain small lakes including Gould Lake (Photo 55), Chesley Lake, and Arran Lake. The lattermost is over three miles in length. The area is traversed by the Sauble River which follows a very crooked course as it winds around the various drumlins. It has, however, hardly begun to cut a valley and is rather ineffective as an agent of drainage.

The Arran drumlins are higher and steeper than those of the Teeswater field to the south and the surface is more stony. Harkaway silt loam, the domi-

OGS 10 706

Photo 55. Vertical air photo of the Gould Lake area in Amabel Township, Bruce County. The oval peninsula is a drumlin; the striped pattern shows other drumlins. The small whitish dots in some fields, particularly those south of the right-hand arm of the lake, are stone piles. The Algonquin beach confines the lake on the north (top). Crescentic sand dunes are evident farther to the northwest. Photo courtesy of the Canadian Armed Forces.

nant soil of the Arran drumlins, is akin to the Otonabee loam of the Peterborough drumlins, not only because of topographic similarity, but also because of stoniness. The Arran till is highly calcareous and the surface deposit of silt, thin or absent. On this parent material the weathered soil profiles are shallow, ranging in thickness from 10 to 18 inches. Free carbonates are often present in the surface soil of cultivated fields. It is a good soil for grazing and general farming although somewhat limited in its moisture-holding capacity. The control of erosion is necessary while the rebuilding of soil on the spots already badly eroded is a major problem.

Land Use and Settlement

Travelling through the Arran area one does not get the same impression of agricultural well-being that is gained from observations in the Teeswater area. Here, again, the surveyors obeyed their compasses in defiance of the lay of the land, placing the roads diagonally across the drumlins. Farm layouts are apt to be very inconvenient with many odd corners and difficult slopes. One gets the impression that there is a reasonable amount of uncleared land, despite the 1981 census record of only 12% in wood and waste.

In Arran Township 97% of the land is reported to be occupied by farms which average about 241 acres. Most of them are 100 to 400 acres in size, but 12 are reported to be over 560 acres. About 81% of the farmland is improved with 41% in crop and 40% in improved pasture. Hay, mixed grains, and silage corn are the chief crops. Wheat and barley, formerly of some importance, are now little grown, but corn for ensilage seems to be increasing. Animal production is important, each 100 acres carrying about 48 animal units or an average of about 115 per farm. Less than one-fifth of the cattle are dairy cows, beef animals dominating the scene as they do in most of Bruce County. On numerous farms regular cropping has ceased and the land has been given over to range. On the whole the type of agriculture is conservational as befits sloping land; hay and pasture dominate and there is only a small area of intertilled crop. It is true that many farmers still plough up and down the slopes, but contour cultivation is hard to arrange because the line fences run diagonally across the slopes.

Being an isolated part of Ontario and dominated commercially by the port city of Owen Sound (19,624), it is not surprising that the Arran drumlin field contains no towns. One incorporated village, Tara (701) grew up at one of the few favourable mill sites on the Sauble River and, because of its central position, has maintained itself as the farm supply point of the southern part of the region. It is also a cultural centre and the home of one of the oldest agricultural societies in the Province. Another small village, Allenford, grew up at the point where the Owen Sound-Southampton road (now Highway 21) crossed the Sauble River. Here, also, there was opportunity for a mill site. Allenford later suffered from the fact that it was bypassed by the railway which established its station about one mile to the east, thus effectively preventing the consolidation of the village. The village of Shallow Lake is situated farther north where the dolomitic rock appears on the surface between the drumlins. This village achieved some prominence when the small lake for which it is named was drained in order to excavate the marl on its floor for making cement, but these workings have long been abandoned. The whole area is one of gradually declining population as farms are gradually being increased to a more economic size.

14 OXFORD TILL PLAIN

The Oxford till plain occupies a central position adjacent to the Stratford till plain in the peninsula of southwestern Ontario. It covers about 600 square miles, or 385,000 acres, mostly in Oxford County. An upland surface ranging from 1,000 to 1,200 feet a.s.l., it is crossed by three well-marked valleys cut by glacial meltwater streams. The surface is drumlinized, with good drumlins appearing south of Woodstock, where the glacier apparently overrode an older moraine, and faint drumlins and flutings farther north. Both drumlins and flutings have a northwesterly alignment. The till is a pale brown, calcareous loam in which Middle Devonian limestone is the dominant material, although grey or pale brown dolostone is also abundant. A group of kames around Lakeside in the northwest corner of Oxford County are included in mapping this region. The valleys that cut across this till plain are at present occupied by the headwaters of the Thames River. These are obviously misfit streams, too small for the valleys they occupy. They emanate from a little clay plain southeast of Tavistock where the drainage divide is poorly defined. Trout Creek, which leads to the north branch of the Thames at St. Marys, and the south branch of the Thames take rise in the same swamp about four miles west of Tavistock. The ancient rivers, by cutting away the overburden from the bedrock, have made quarrying possible, particularly at Beachville where a great deal of limestone is processed. Some parts of the old spillway system contain gravel which is very useful for road construction and as concrete aggregate in spite of a sprinkling of chert.

In much of the area, the dominant soil type is Guelph loam, a typical Grey Brown Luvisol, devel-

oped under a maple-beech forest. Because of the gentle slopes, good drainage, medium texture, neutral reaction, and lack of extreme stoniness, this is a good soil. Stoniness varies probably because of differences in the depth of the surficial deposit of silt which is found throughout the region. Large areas of very gently rolling land are classified as London loam, while there are occasional flat areas with poor drainage which have a Parkhill soil profile.

Land Use and Settlement

During an earlier period there were many small farms on the Oxford till plain but an unusual consolidation of holdings has taken place, bringing the average size of farm to more than 400 acres. Change to other uses than agriculture has been very small in Oxford County. Statistics show that 91% of the occupied land is improved and 81% is devoted to crop production, 6% to seeded pasture, 6% to woodland, and 9% is classed as other unimproved land. The crop pattern in terms of occupied farmland averages 15% in hay, 2% in oats, 8% in mixed grains, 45% in corn, 3% in wheat, and small areas of many other crops. In recent years the trends are toward decreases in oats and hay and increases in corn, especially grain corn.

Within the area there are notable variations: toward the south cornfields and silos have always been more numerous, with few farmers growing wheat; toward the north dairying seems to have been a later development, for many of the farms still have the wide German barns of the former beef-raising period, although they may be used to stable Holstein cows. It is toward the north also that one notices the modern tendency toward more beef feed lots and large hog barns. There has been a fairly rapid increase in the size of farms to an average of 452 acres. However this Oxford plain, and particularly the Woodstock area has earned its reputation as a foremost dairy farming area with purebred Holstein cattle. The number of cattle per farm according to the 1981 census is 157, 9 out of 10 being dairy breeds. This region is also one of the foremost hog- and poultry-producing areas in the Province, each farm on the average having 284 hogs and 1,344 poultry. This makes 228 livestock units per farm or, 50 per 100 acres. Fortunately the more gently rolling, loam soil is less susceptible to erosion as that in the more sandy Waterloo sandhills.

Although a few settlers were found in this area in the latter part of the 18th century, the great wave of settlement came after the Napoleonic wars when large numbers of Scots immigrants took up land in the bush. Scottish traditions and people of Scots descent are still dominant. Population increased rapidly, most of the townships reaching their population peak by 1871. The county of Oxford, in fact, reached a population peak in 1881, declining slowly thereafter until 1921. In 1951 it reached the same level as in 1881 and is still gaining. Farm population is still dropping although the average per farm has risen perceptibly in the last few years. There are no large cities in the area under study, nor in the whole of Oxford County; thus the growth of population in the future is likely to be slow in comparison to some other parts of Ontario.

The commercial and social focus of the area, in fact the seat of Oxford County, is the City of Woodstock (26,096) located on the southern bank of the Thames River. It has dairy plants, feed mills, and other services required by the surrounding agricultural region. Woodstock also has a few secondary industries, but its population, and therefore its market potential, is not increasing as fast as the productive capacity of the surrounding farmlands. Ingersoll (8,174) is located in the Thames Valley about nine miles downstream from Woodstock. It is the focus of a local trading area and a small manufacturing centre long noted for cheese and other dairy products. Half-way between the two larger centres is Beachville (876) near which there are large high-calcium limestone quarries in the floor of the valley. Thamesford (1,800) and Embro (733) are associated with the valley of the middle branch of the Thames. Innerkip, Hickson, and Bright are small centres in the northeastern part of the area.

The undulating or gently rolling landscape of the Oxford till plain is most pleasing. Roads and farm lanes are commonly lined with maple trees and it is unfortunate that modern improvement has made it necessary to severely prune them or remove them from the highways. There are many well-constructed houses and barns now around 100 years old, seeming almost to blend with the natural landscape. There are also many signs of modern progress—large new silos and circular cribs for the expanding corn crop and new metal-covered buildings to accommodate a greater wealth of livestock and new machinery.

15 MOUNT ELGIN RIDGES

Between the Thames Valley and the Norfolk sand plain lies a succession of ridges and vales which are called the Mount Elgin Ridges. Including the southeastern portion of Middlesex County, southern Oxford, and small adjoining parts of Elgin and Brant, the area consists of about 563 square miles or 360,000 acres. The general elevation of the lowlands is between 800 and 900 feet a.s.l., rising gradually toward the northeast. The crests of the ridges are at 950 to 1,000 feet giving a local relief of about 100

feet with few slopes greater than 10%. The ridges are moraines of pale brown calcareous clay or silty clay, while in the vales it is common to find alluvium of gravel, sand, or silt. The region is named after the little village of Mount Elgin which is built on the crest of a typical ridge, on Highway 19.

The divides between the Thames River system and several small streams that run south to Lake Erie are found within this region. There are numerous examples of basins with no visible drainage outlets, ranging from small kettles such as Mud Lake, Walker Pond, and Whittaker Lake to the wide swampy hollows of the old spillways, as for example near Dereham Centre.

The northern slope of the Ingersoll Moraine drains directly into the Thames. The Thames system also includes Reynolds and Dingman Creeks which provide drainage for two sections of the flat-floored trough south of the Ingersoll Moraine. Deep loams, sand, and gravels in that valley bear witness to the former much larger stream which occupied it during the melting of the last glacier.

South of the Westminster and St. Thomas Moraines the country drains to Lake Erie by means of tributaries of Kettle, Catfish, and Otter Creeks. The broad Belmont vale is occupied by the main branch of Kettle Creek which, working headward from Lake Erie, has entrenched itself about 50 feet into the till. This stream has been dammed to provide a reservoir for the City of St. Thomas. The St. Thomas Moraine divides the Kettle and Catfish drainage areas. The long narrow vales on either side of the Culloden strand of the Norwich Moraine are drained by tributaries of Catfish Creek. At Delmer, however, Stony Creek breaks through both the Brownsville and Culloden ridges into the central depression to capture a little drainage for Otter Creek. Farther east several other branches of Otter Creek cross the Norwich Moraine into the hollows south of Mount Elgin. Big Creek rises in the moraine near Oriel while farther north the ridges are drained by Kenny Creek and Horner Creek, both tributaries of the Grand.

The two major landform components of this region provide obviously contrasting soils. The ridges are well drained while imperfect and even poor drainage characterize the hollows. The ridges are formed from clay till similar to that of the Wyoming Moraine and the Stratford plain, and the soils naturally belong to the Huron catena. Huron clay loam is commonly found but in some places there has been enough surficial silt deposited to create the Huron silt loam. Silt deposits are more widespread and usually deeper in the lowlands, Perth silt loam being mapped over those areas. There are also considerable areas of sandy deposits with varying degrees of drainage as well as a number of undrained basin with peat and muck soils.

The advantage of well-drained, well-aerated soil is nicely illustrated in this region. Farms on the ridges are generally more prosperous than those in the vales, in spite of the erosion that has taken place on the hillsides. The tendency, even on the same farm, is to use the low-lying land for pasture and cultivate the rolling fields. Perhaps at some future date the status of the upland and lowland soils will be reversed, if progressive erosion accelerates deterioration on the slopes and tile drains are installed in the flats to improve the warmth and aeration of the lowland soils.

From all appearances this is one of the most prosperous dairy and livestock regions in Ontario. Farm premises are neatly kept and in good repair. Paint is used more liberally, perhaps, than in most parts of the Province. Cornfields and silos are almost universal and of larger capacity than in most other areas. Holstein cattle predominate in the lush pastures. There are also thousands of well-fed beef animals, but comparatively few beef cow herds. Buildings for the housing of pigs and poultry are numerous. Many of the farms still consist of the original 100-acre lots, but smaller farms are being eliminated and the average size (1981) is about 161 acres. In the last 20 years the percentage of improved occupied land has risen from 86% to about 91% with 83% in crop and 5% in seeded pasture. In terms of total farmland the various crops line up as follows: wheat 6%, oats 2%, mixed grains 3%, hay 11%, corn for grain 39%, corn for ensilage 7%; and other crops 7%. Unimproved land totals about 9%, about half of which is in woodlots. In comparison with a previous period the acreage of corn has increased greatly, while mixed grains, oats, and hay have decreased. Small acreages of soybeans and other minor crops are grown also. The average farm in this area carries about 57 animal units of livestock including 37 cattle, mostly dairy cattle, 91 pigs, and 205 poultry. The actual livestock pressure on the land appears to have risen by over 75% since 1931, thus maintaining the region as one of the better general farming areas of the Province.

Despite its physical uniformity and its agricultural excellence, the region has no social or commercial unity. Politically it is divided amongst three different counties. It has, of itself, no large town which might serve as a nucleus. Instead it is flanked by London (266,319), Ingersoll (8,174), Woodstock (26,096), Tillsonburg (10,332), Aylmer (5,127), and St. Thomas (27,482), each of which includes a portion of the area within its own umland. The construction of Highway 401 along its northern boundary has given it more rapid access to distant metropolitan markets and is bound to exert an influence on the

land-use pattern. The villages such as Glanworth, Belmont (825), Mount Elgin (350), Norwich (2,854), Burgessville, and New Durham, which originally were market, service, and supply points, now find their business influence on the decline, even though some of them are gaining in population.

At this point perhaps one might take a quick economic inventory of agriculture in Oxford County. In 1981 there were 2,724 farms with average capitalization of $541,500 per farm: land and buildings, $440,500; machinery and equipment, $56,000; livestock and poultry, $45,600. While Oxford is still the outstanding dairy area in Ontario, both in production and in number of dairy farms, there is now much more diversification than formerly.

16 CARADOC SAND PLAINS AND LONDON ANNEX

West and east of London there are small plains which differ from the adjacent moraines and clay plains in that they are covered with sand or other light-textured, water-laid deposits. Together they comprise about 300 square miles or 192,000 acres in which the soils are conducive to specialized agriculture.

Immediately surrounding the city and extending several miles eastward there is a basin lying between 850 and 900 feet a.s.l. Into this basin the earliest glacial spillways discharged muddy water, laying down beds of silt and fine sand. Later, when standing water had retired westward to lower levels, gravelly alluvium was spread over the lower parts of the basin. These gravels continue along the Thames to Komoka where high-level terraces now appear. Later, when the standing water had lowered to the level of Lake Whittlesey the early Thames River cut through the Komoka terraces and built a delta which covers most of Caradoc Township.

The sands of Caradoc thin out toward the west until eventually the underlying clay appears on the surface. The surface is nearly level except near Mount Brydges where some old fixed dunes and other sandy ridges appear. Another variation worth noting is the channel extending from Komoka toward Strathroy, one section of it being occupied by a bog. In an area west of Falconbridge a peculiar layer of clay several inches deep appears in the sand near enough to the surface to affect the soil.

The main part of the Caradoc sand plains in Caradoc Township has been characterized by three soil types on the Middlesex soil map (Appendix C). Fox fine sandy loam appears on the finer sands which are deep and well drained, while the main type in those areas with a shallow layer of sand over clay, and having wet subsoil, is classified as Berrien sandy loam. On the old fixed dunes and other sandhills, the less productive Oshtemo sand appears. The Burford gravelly loam of the terraces along the Thames is a well-drained productive soil. The shallow silts and fine sands of the London basin are not freely drained and the incompletely developed profile of London loam is found. When tile drained, this is an excellent soil.

In the early days the system of farming on the light soils was not very different from that on the clay soils around them. Poor drainage, of course, prevented some land from being taken into cultivation and as time went on a good deal of poor land was retired from cultivation and used for pasture. For many years the farmers of Caradoc had more land in pasture than in cultivated crop, but now over 70% is in crops. Corn (40%), soybeans (8%), tobacco (6%), and pasture are the most important. Caradoc was long known as a potato-growing area but in 1981 only 347 acres of potatoes were grown. There is a moderate concentration of apple orchards in the Mount Brydges area and there are also a number of market gardens. Tobacco farms have persisted, one reason being that they have been able to set up irrigation systems by digging ponds to below the water table a few feet below the ground surface. Livestock farming is gradually giving way to cash crops in this region.

The gravelly terraces along the Thames from Delaware to London were characterized by orchards and market gardens. In recent years much of this land has been taken over by suburban development.

The London basin, to the east of the city was at one time dominantly a dairy region, although fruits and garden products were grown. During the Second World War, the Royal Canadian Air Force, Crumlin, airport was established in the centre of the little plain, signalling the end of the agricultural period. The City of London (266,319) is expanding rapidly and most of the London basin will soon have been put to urban uses. Some of its deposits of sand and gravel have been excavated for use in building roads and streets, and in concrete. London is the market and commercial centre not only of the small region under discussion but of most of southwestern Ontario. Its situation is related to the physiographic surroundings in several ways. It was originally located at the forks of the Thames because the river was the early route of travel, and because the high alluvial terrace offered a good site on which to build. The underlying sands also offered a good water supply which has now proved to be limited for the large city which has grown up. Water is now secured by pipeline from Lake Huron.

17 EKFRID CLAY PLAIN

Below the Whittlesey delta, or west and south of the Caradoc sand plain, stratified clays appear in Ekfrid

and parts of nearby townships. The surface is nearly level except where it is cut by gullies near the Thames and Sydenham Rivers. Here and there, knolls or low smooth ridges of sand and gravel are superimposed on the clay. The clay beds are thinnest between the Thames River and St. Thomas where the boulder clay often comes to the surface. The area of silt around Fingal is included, making an area of 360 square miles in all.

The sediments in the central part of the Ekfrid plain no doubt were imported from higher up the Thames Valley. Those in the Fingal area likely came from farther east. They are all pale greyish brown in colour and strongly calcareous due largely to Middle Devonian limestone. In Ekfrid Township and the Caradoc Indian Reserve (IR 42) the clay is fine in texture. More silty beds appear near Kerwood and south of Alvinston.

The silty sediments give rise to particularly good soil, being fairly pervious and easy to till. Slow drainage is their main limitation. Some of the better-drained clay lands around Melbourne are used only for pasture. The common dark-surfaced clay loam is a good soil when tile drained, better than that on the bevelled till plain of Lambton County.

Livestock production is quite low on this little clay plain. More than half the land is in corn, soybeans, and wheat, indicating the importance of cash crops in the economy. The plain is highly cleared with only 7% of land taken up by woodlots.

18 BOTHWELL SAND PLAIN

The Bothwell sand plain is the delta of the Thames River in glacial Lake Warren and stands between 600 and 700 feet a.s.l. The sands were spread thinly over the clay floor, covering some 700 square miles. With only three or four feet of sand, more or less over clay, water invariably collects above the clay because the rain readily infiltrates the sandy surface but percolates slowly through the clay below. With a water table so close to the surface the depressions are swampy, or at least moist. Near Bothwell and Newbury the surface exhibits a series of knolls and swales, and the variation in the colour of the surface soil gives a mottled appearance to vertical air photos. Other sections of the sand plain have a fairly smooth surface and the air photos are correspondingly uniform. The contrast between the two may be seen in Photos 56 and 57.

This sand plain is cut in two by the Thames River. Between Aldborough and Mosa Townships the river has cut a valley 50 to 100 feet deep and meanders over a flood plain that is up to a mile wide. Farther downstream where the channel is shallower, it overflows periodically. Another departure from the generally level topography appears near the shore of Lake Erie where gullies dissect the promontory above the shorecliff.

This is a region of low-grade soil, in contrast to the fertile Chatham flats to the west or the clay plain of Ekfrid Township. In its wetter parts a high proportion of the land remains in woods. This is on the Watrin and Granby soils as named on the county soil maps (Appendix C). The Berrien sandy loam is soil that, when tile drained, would become valuable for truck crops or canning crops if the demand for them arose. Currently 75% of the farmland is cropped with 65% being used for corn and soybeans.

Within this area some natural gas is found, particularly in Mosa Township. A few oil wells have operated but on the whole with disappointing results. Some of the drinking water is tainted with sulphur.

19 ST. CLAIR CLAY PLAINS

Adjoining Lake St. Clair in Essex and Kent Counties and the St. Clair River in Lambton County are extensive clay plains covering 2,270 square miles. The region is one of little relief, lying between 575 and 700 feet a.s.l., except for the moraine at Ridgetown and Blenheim which rises 50 to 100 feet higher. However, there are minor variations in levelness that have had a great effect on the vegetation and soils which will be discussed separately. There is a deep cover of overburden on the bedrock except near Amherstburg where a dome of limestone comes to the surface. Wells are frequently drilled 100 to 200 feet, often through a fairly uniform bed of clay, before striking solid rock. Limestone underlies Essex County and the adjacent part of Kent, while the remainder of the region is underlain by a black shale. This shale is an important component of the clays but limestone flour is also abundant.

Glacial Lake Whittlesey, which deeply covered all of these lands, and Lake Warren which subsequently covered nearly the whole area, failed to leave deep stratified beds of sediment on the underlying clay till except around Chatham, between Blenheim and the Rondeau marshes, and in a few other smaller areas. Most of Lambton and Essex Counties, therefore, are essentially till plains smoothed by shallow deposits of lacustrine clay which settled in the depressions while the knolls were being lowered by wave action. In general the levelling is better done in Essex than in Lambton. The very flat tract of land east of Lake St. Clair was submerged after the disappearance of Lake Warren in a correlative of Early Lake Algonquin and received a deeper covering of stratified clay and silt.

Essex Clay Plain

Essex County and the southwestern part of Kent

OGS 10 707

Photo 56. Air photo of the sand plain west of Glencoe, Middlesex County. The light patches are sandy knolls. Photo courtesy of the Province of Ontario.

OGS 10 708

Photo 57. Air photo of the sand plain west of Glencoe, Middlesex County. Even though this is very close to the area shown in Photo 56, the uniform colour denotes the lack of sandy knolls. Photo courtesy of the Province of Ontario.

County have a fairly uniform environment and may be discussed together as a subregion. Standing between the basins of Lake Erie and Lake St. Clair, the surface is, essentially, a till plain overlying the Cincinnati Arch which, in this area, is a low swell in the bedrock. The surface drainage of the plain is nearly all northward to Lake St. Clair, but the gradient is extremely low and the drainage divide near Lake Erie is rather vague. Although it is almost level, the clay plain has a faint relief so that it is better drained than the very flat, low-lying area bordering Lake St. Clair. The prevailing soil type is Brookston clay loam, a dark-surfaced gleysolic soil developed under a swamp forest of elm, black and white ash, silver maple, and other moisture-loving trees. There are also numerous undrained areas where peat and muck have accumulated. Most of the Essex plain has such imperfect drainage that dredged ditches and tile underdrains have had to be installed in order to provide satisfactory conditions for crop growth and tillage. A better-drained strip of land through Charing Cross and along Middle Road originally supported a forest of oaks and hickories; here the surface is grey, leached, and acid. Because it is so hard to work, this soil has largely been used for pasture.

Lying between the July isotherms of 72°F and 74°F mean temperature, and having an average frost-free period of 160 to 170 days, the Essex plain has summer conditions similar to those of the northern fringe of the United States Corn Belt. Its situation also, between Lake Erie and Lake St. Clair tends to reduce the daily range of temperature and prolong the frost-free season.

The most important crops in this area are corn, which is mostly grown for grain, soybeans, hay, and soft winter wheat. Around Leamington and Harrow is also the area in which most of the earliest potatoes in Ontario are grown. White beans, black tobacco, green peas, tomatoes, cucumbers, melons, and many other vegetables and canning crops are also found.

While the 100-acre farm is commonly found over much of the Essex plain, larger farms are not uncommon, actually, nearly half of the operating units have more than 129 acres. This area is not noted for its livestock production, each 100 acres of farmland supporting about 4 livestock units, which is only one-sixth of the Ontario average and about one-tenth the strength of the best livestock areas. However, the presence of Windsor with its demand for milk makes it possible for more than 5% of all commercial farms to be dairy operations.

Essex and the southern part of Kent also have a number of areas which are somewhat atypical of the region. One of these is the Blenheim Moraine, a modest ridge of rolling clay land, rising 50 to 100 feet above the surrounding plain. It is fringed by gravel terraces, which meet at Blenheim and continue to the southwest through Cedar Springs to the shore of Lake Erie. The clay land on top of the ridge is used for general crop and livestock farming, with a considerable acreage in pasture. The gravelly soils of the terraces have lent themselves to specialization: peaches, cherries, small fruits, apples, and tobacco are the chief crops.

A particularly attractive horticultural area is based on the silt loams between the Blenheim ridge and Rondeau, while the Rondeau marshes themselves are devoted mainly to onion production. All in all, the southeastern corner of Kent County has gained a good reputation for its special crops.

The continuity of the clay plain is broken near Leamington by a small morainic hill, standing about 100 feet above the general level. Being composed of a good deal of sand and gravel in the first place, it was smoothed by the action of Lakes Whittlesey and Warren, and surrounded by a series of gravel beaches. Down the slope toward Lake Erie are broad aprons of fine sand and silt. Being in the warmest part of the Province these well-drained soils warm up early in the spring, and it is here that the earliest truck crops such as asparagus, tomatoes, strawberries, sweet corn, and cucumbers are grown. The long growing season makes it possible to grow melons and other southern crops. Tender fruits are also important, especially peaches.

In the lee of the long sand spit of Point Pelee there is marshland which has been drained and developed, like the Rondeau marsh, for the growing of onions.

A third area of sandy soil is found on a slight elevation around Harrow. At 625 feet a.s.l. it was not high enough to form an island in Lake Warren and may be regarded as a group of shallow-water sandbars. Harrow was once an important flue-cured tobacco centre, but it has now turned to the culture of asparagus, tomatoes, sweet corn, potatoes, and other truck and canning crops.

The flatness of the Essex clay plain is further broken by a low gravel ridge extending through Essex, Cottam, and Maidstone, while similar gravel strands are found at Pelton and shallow gravel deposits occur near Edgars, Gesto, and Comet.

Lambton Clay Plain

Lambton County also contains a large area which might be termed a bevelled till plain, often having a shallow veneer of lacustrine clay over the underlying till. Over extensive areas it has the faint knoll-and-sag relief, typical of ground moraine. Vegetation and soil development reflect a somewhat better natural drainage than was found in the Essex plain and,

as a consequence, municipal ditches and tile drains are not nearly so prevalent. In some areas near Courtright and Corunna, where the till comes to the surface in low crooked ridges, the cultivated soil contains many small pieces of chert or flint.

There are two main soils found on the Lambton clay plain, Brookston clay and Caistor clay; the former in the lower, wetter sites, and the latter on the higher sites.

Agriculture does not seem to be so intensively developed in Lambton as in Kent and Essex. While originally, and indeed up until 1930, every surveyed lot was occupied, the census farms of 1981 included only about 84% of total land area. Farm size has increased from about 105 acres to 369 acres. The total area of both improved land and cropland has increased. The average land-use pattern for the area has changed, since 1961, and is approximately as follows: hay 12 to 6%, wheat 11 to 14%, oats 10 to 1%, soybeans 7 to 38%, other cereals 2 to 4%; and corn has remained at 10%. Soybeans have increased by more than 30%. The total crop area is equal to about 77% of the farmland. About 8% of the land is in seeded pasture, 5% in natural pasture, and 7% in woods. The average 100 acres of farmland carries about 18 livestock units, including about 13 cattle, 18 hogs, 2 sheep, and 91 poultry. In this respect the area is about equal to the average for Ontario farmland. Most of the farms depend upon the sale of meat animals for the greater part of their incomes. A few are dairy farms, mainly shipping to Sarnia, a few depend exclusively upon the sale of field crops, and there is also a fair number of specialized poultry farms. Lambton County is the most important turkey-producing area in Ontario.

Chatham Flats

The flat land east of Lake St. Clair in Dover and Chatham Townships covers a 256-square mile area. In the north it extends into Sombra Township where it is sharply bounded by a low but distinct bluff just above the 600-foot contour. Beyond the bluff the clay plain has very little relief but it lacks the deep lacustrine clays and extreme flatness of the lower lands. In Chatham Township a shallow surface layer of sand on the clay is prevalent. Immediately south and east of the City of Chatham beds of silt appear. In Dover Township the stratified clay or loam comes right to the surface except where a few sand spots occur, or, in two good-sized tracts, where black muck has accumulated. The southern and eastern boundaries of the area are indefinite but roughly follow the 600-foot contour.

In flowing across this plain the Thames River has a fall of barely one foot to the mile. Its channel is not deep enough to contain the waters in times of freshet, and recurrent floods have spread clay on the land adjacent to the river. This alluvium has a reddish cast which is in contrast to the grey clay of the lake bottom.

In its virgin state this area supported a swamp forest of elm, black ash, white ash, and silver or red maple, except on the fringe of Lake St. Clair where there was meadow. Its development was delayed until artificial drainage was established by the municipalities; now, the big open ditches along the roadsides form an integral part of the landscape. The main canals end in pumping stations designed to elevate the water a few feet into Lake St. Clair, thus lowering the water in the ditches below the outlets of the tile drains. Most of the farms are systematically tiled.

The Chatham flats is a small region of highly fertile soils. Climatically it is favoured with a frost-free period of 155 to 165 days. The warm summers are indicated by a July normal of 72°F, while in winter the snow blanket seldom stays long on the ground. Perhaps its most serious climatic handicap is the frequent summer droughts. The main soil handicap is that spring floods often delay spring planting and impair the soil.

This area is given to the production of cash crops rather than livestock although beef cattle and hogs are of considerable importance. Hay, barley, and oats occupy only 1% of the cropland. The main emphasis is on corn, soybeans (Photo 58), winter wheat, white beans, black or burley tobacco, and tomatoes, peas, or other canning crops grown for sale. At Jeannettes Creek a little tract of deep, black sandy loam is noted for its onions.

The secondary place of livestock in the agriculture of the Chatham flats shows up in the small, often poor barns. In fact the houses and grounds all too frequently appear neglected, even on good farms. The high farm values which prevail in this area are not due to the buildings, but to the highly productive and durable soils. Clyde clay loam and silt loam, black meadow soils found near Lake St. Clair, have the highest fertility levels of any soil in Ontario.

From the foregoing it is evident that within a broad clay plain such as that around Lake St. Clair and east of the St. Clair River there are elements of similarity and of contrast. The plain illustrates in striking fashion the effect of small differences in drainage and parent materials on the character of the resulting soils. Some of the best soil in Dover Township sells for more than ten times the price per acre paid for land in parts of Lambton.

In describing other regions we have occasionally commented on the need of controlling soil erosion in order to ensure a permanent agricultural environ-

ment. The St. Clair clay plain has no erosion problem, instead, the problem to be met and solved is that of regularly renewing the organic content and maintaining the granular structure of the soil. The scarcity of livestock and the predominant place of corn and other row crops has already reduced the perviousness, workability, and fertility of the soil. The use of large tractors on these farms brings with it the danger of creating a compacted plowsole. These are exceptionally good soils which should not be allowed to deteriorate.

St. Clair Delta

The delta at the mouth of the St. Clair River is a splendid example of a bird's-foot delta; the several channels drawn on a map produce the fanciful resemblance to a bird's foot. Most of the delta lies on the Canadian side of the South Channel, 64 square miles of it in all. It consists of a series of islands; Walpole Island, the largest one, is flanked by Squirrel Island and St. Anne Island, while within it is a smaller island produced artificially by canals which is called Pottaminie Island. Most of the delta is marshy with the outer border being a meadow. However, several thousand acres are cropped, producing corn and soybeans. It is worth mentioning that the earliest varieties of Japanese rice have been grown experimentally on this delta. The climate is similar to that of Hokkaido Island, Japan, where rice is grown and the soil well suited. At present this crop is not economically feasible but the potential is there if the need arises.

The only settlement on the delta is in the north where the water table is lowest. The National Topographical System maps (NTS 40 J/9 and NTS 40 J/10) show roughly 400 buildings. The area is the location of the Walpole Island Indian Reserve (IR 46).

20 PELEE ISLAND

Pelee Island is a detached part of Essex County, the distance from Point Pelee to Lighthouse Point being eight and a quarter miles. To the west and south are several tiny islets north of the International Boundary. Middle or Boundary Island off to the south of Pelee is the southernmost land of Canada. It is a bit of limestone of less than 10 acres, shaped like a tadpole with its tail to the west where the tip comes within 100 yards of the International Boundary. A recreation club is its only tenant. The half dozen islets to the west are all smaller than Middle Island.

Pelee Island covers 15 square miles or 10,000 acres. Roughly rectangular in shape, it is five miles from north to south and three from east to west. The somewhat rectangular shape is due to limestone ledges which form the shore at the northwest and southeast corners of the island. Most of the shore consists of a sand beach backed by a thin line of low

OGS 10 709

Photo 58. Soybeans growing on the Chatham flats. Photo courtesy of M.D. Johnson.

dunes. Lighthouse Point has a series of protecting sand bars. The southwest section of the shore is a low bluff, part of which is protected from erosion by concrete groynes. From the southwestern corner a gravel spit juts into the lake for a mile or more, curving eastward at the tip. The foundation of Pelee Island is a low dome of limestone, rising at its highest only 38 feet above the mean level of Lake Erie. Bedrock comes to the surface in several parts of the island and forms certain parts of the shore. Thus, approximately 15% of the area has shallow drift with no more than a few inches of clay or stony loam on the limestone floor. The remainder is a level clay plain lying barely above lake level. The drainage canals and deep ditches that facilitate tile drainage, without which the soil would be of little use, are now an established part of the landscape. The lowest tracts are, in fact, below high water mark and would at times be inundated except for the dikes which are built along the shore. The canals are sealed at the ends and equipped with pumps to hoist the water into the lake. In this way the water level in the ditches is lowered below the outlets of the tile drains which are installed in the fields.

Over most of the island the clay is of moderate depth. The rock is exposed in the bottom of the main east-west drainage canal on the eastern side of the island. A similar covering of about ten feet is common in the south-central part of the island. The deepest drift is on the western side, 40 to 50 feet of boulder clay being recorded in several wells, although toward the northwestern corner one well is reputed to extend 96 feet in clay without hitting bedrock. Incidentally, a few dug wells derive their water from a gravelly layer just above the rock but most of them are drilled into the limestone.

The clay plain of Pelee Island, as in most of Essex County, is a bevelled till plain. A search for stratified sediments proved fruitless; although there must be some reworked material on the surface, it may not be readily apparent because the deposits are shallow and the stratifications are largely destroyed by plant roots or by weathering.

The till is of fairly constant composition, fine in texture and containing very few big boulders. Pebbles appear in variable numbers. Several counts of the various rock types showed about 70% of limestone, chert, and a little dolostone, 18% of brown to black shale or sandstone, and an estimated 12% of granite, etc. of Precambrian age. The grey and pale brown limestones give the till its dominant colour, while its content of shale and sandstone are responsible for its extreme susceptibility to rusty mottling of the subsoil.

The soils of Pelee Island were described and mapped as part of Essex County. The black-surfaced Clyde clay in the lowest sites is a type of exceptional fertility and durability. It was developed under a swamp forest of elm, ash, and soft maple, but this may have been preceded by meadow. The Brookston clay is a little less poorly drained but requires tile drains also before it can be used. Its surface layer is shallower and contains less humus. There is some shallow muck but it is not extensive and does not appear on the map. The remainder comprises the shallow soils where the limestone comes nearly to or to the surface.

With an average frost-free period of 180 days, Pelee Island boasts the longest growing season of any part of Ontario, longer in fact than that for most of Ohio extending 150 miles to the south. However, because it is isolated from the markets, truck crops are not grown commercially. The clay soil also limits the choice of crops to be grown. For these and other reasons the present-day agriculture of Pelee Island can be fairly well covered by one word—soybeans (Photo 59). Over 70% of the cropland is in soybeans, much of the remainder being sown to seed corn (9%), and winter wheat (11%). The tobacco barns once used for the black tobacco crop are no longer in use for this labour-intensive crop. Hybrid seed corn is a specialty crop that is grown because this is an isolated environment. Soybeans are favoured because they are a reliable crop, require no special fertilization, and above all, are easily handled. Moreover, they provide feed for the pheasants for which the island is noted.

The environment of the island must approach an optimum for pheasants, as the population in autumn in some years has exceeded 20,000 birds. Each fall, hunters flock to these 15 square miles during the special, restricted hunting season (Photo 60). For their hunting privileges they pay fees which amount to a considerable proportion of the munici-

OGS 10 710

Photo 59. Soybeans growing on the level clay loam of Pelee Island.

pal taxes. The mild climate with its limited snowfall, the abundance of food, and the cover provided by the waste land on the island, are no doubt the combined factors that make it a good place for pheasants.

21 ERIE SPITS

From Long Point westward the shore of Lake Erie takes the form of three big scallops with as many big sand spits at the apexes. The centre of the scallops are marked by high bluffs which are constantly shifting inland. Conversely the spits are gradually extending farther out into the lake using the sand made available by the erosion of the shore.

It is not surprising to find the longest of these spits built off the shore at Port Rowan opposite the great Norfolk sand plain; Long Point, as it is called, is built from the west at the eastern apex of the biggest scallop. A smaller spit built from the east is growing out to meet it, threatening to confine a section of the lake that even now is called Inner Bay. At the other apex of the big Port Stanley scallop is the Rondeau spit which terminates in Point aux Pins, and this one is built from the east. Here also, a smaller bar built from the opposite side virtually closes off Rondeau harbour.

OGS 10 711

Photo 60. A pheasant hunter on the blackish soil of Pelee Island.

The most westerly of the three great spits is Point Pelee. It juts straight out from the shore and both sides are built up, indicating that sand is being added from both east and west.

The conformation of Long Point is clearly apparent from a map and from air photos. It is fabricated loosely from a succession of sand bars which run at an angle to the long axis of the spit. Marsh or open water appears between the bars. Point Pelee also includes several small lakes or ponds.

Much of these spits is covered with meadow, except in the case of Rondeau Park. The surface is at lake level or a few inches below so that cattails and other water-loving plants grow rather than trees. The spits are favourite feeding grounds for wild ducks.

Apart from Pelee Island the Erie Spits have the most temperate climate of any part of Ontario. In this respect they are exceeded in Canada only by small areas on the west and east coasts. Trees, such as hackberry, which are scarce inland, grow in groves on Point Pelee and wafer ash is plentiful. Point Pelee National Park is internationally famous for its variety of migratory birds. That approximately 270 species may be seen during the spring migration has attracted bird watchers to Point Pelee since the early 1900s. An additional 50 to 60 species are so rare that they are sighted only every 10 to 15 years. Only duck hunting is permitted and during the 1983 season 1,245 ducks were taken by 1,003 hunters.

Just north of the park, the privately owned Jack Miner's Bird Sanctuary is renowned for the 50,000 Canada Geese that stop there enroute during their migration.

A limited area on Point Pelee is used for fruit and truck crops (Photo 61), but there is no farming on the other spits. Their major value is recreational, as the sandy beaches attract summer cottages. Here, at least, there is no encroachment of the bluffs on the shore properties as there is along most of Lake Erie.

22 NORFOLK SAND PLAIN

The Norfolk sand plain is wedge shaped with a broad, curved base along the shore of Lake Erie and tapers northward to a point at Brantford on the Grand River. It includes the western half of the Regional Municipality of Haldimand-Norfolk (previously Norfolk County), the eastern end of Elgin

County, southern Brant, and a small corner of Oxford, with an area of 1,210 square miles or 775,000 acres. The plain declines southward from about 850 feet to the level of Lake Erie (572 feet) or in the west to the top of the shorecliff 100 feet or more above the lake. In good-sized sections of the plain the slope is only a foot or two to the mile, while a noticeable break in the slope occurs five to ten miles from the shore of Lake Erie.

The sands and silts of this region were deposited as a delta in glacial Lakes Whittlesey and Warren. A great discharge of meltwater from the Grand River area entered the lakes between the ice front and the moraines to the northwest, building the delta from west to east as the glacier withdrew. Thus it covered most of the area west of the Galt Moraine. This and other moraines to the west are partly buried by sand; some sections are entirely covered whereas others still stand up 50 to 75 feet above the general level. Observations of exposures in river valleys and along the bluffs of Lake Erie record sand beds up to 75 feet, but usually silt or clay strata or beds of boulder clay occur within 30 feet of the surface.

The drainage is through small rivers flowing directly to Lake Erie, except in a small area in the north which is tributary to the Grand River. These streams, the largest of which are Otter Creek and Big Creek, have cut deep valleys across the sand plain, often being incised 75 to 100 feet. The valleys, since the earliest days of settlement, have been the cause of frequent gaps in the road net. Dissection of the sand plain is quite incomplete, however, and drainage conditions vary accordingly. Near the streams and their laterals the water table has been lowered so that good or even excessive vertical drainage operates. In the intermorainal sections in the north and other interfluves there are large tracts of bog or wet sands.

One of the favourable attributes of the Norfolk sand plain is that of abundant well water. Frequently, a good supply may be obtained by driving in a sand point. Infiltration is rapid into the sandy soil, while finer sediments below hold up the water table. It is also a fact that summer rainfall is greater in this area than in most of Southern Ontario.

Norfolk was the first county in Ontario to have a soil survey, the work being finished in 1928. It came at an opportune time to guide in the selection of soil for tobacco. The dominant type of the well-drained areas was identified as Plainfield sand, in which the coarseness of the material and free drainage has produced a rather featureless profile and a thin surface horizon lacking in organic matter. Once cleared and cultivated it is readily blown about by the wind. Elsewhere finer sand has permitted the development of normal Grey Brown Luvisols which were classified in the Fox series.

Settlement began early in the Norfolk sand plains. The land was taken up rapidly after the townships were opened in 1792 to 1812, except in the wet areas. The light-textured soils, however, could not

OGS 10 712

Photo 61. Onion field on muck at Point Pelee.

stand up to the regular cropping. As the original humus became exhausted, productivity declined and wind erosion increased so that farm abandonment became common. A program of reforestation was urged and a forest nursery was established at St. Williams to provide the young trees. Whereas wheat, rye, corn, and peas were important field crops in the 1890s, the tendency toward canning crops and orchards increased during the first quarter of this century. Then, tobacco-growing started and it has come to occupy the leading role, the glass starting houses and box-like curing kilns now being part of the landscape. Tobacco occupies most of the warm, well-drained sandy soils and is a good example of fitting a crop to specifically adapted soils. The Fox soils are valued more highly than the Plainfield sand because they contain more moisture and fertility, but the latter type is also used extensively. These are the soils which are starting to be used for peanut culture.

Total population of the sand plain reached its lowest ebb at the end of the First World War. Much land was lying idle while efforts were being made to have large areas put back into forest. The discovery that successful cultivation of flue-cured tobacco was possible, changed the pattern of land use very rapidly. By 1931, about 16,000 acres of tobacco (Photo 62) were being grown by more than 500 farmers in what was known as the "new tobacco belt" (the "old belt" being the areas in Essex and Kent Counties which had grown mainly Burley and dark tobaccos). By 1931, also, the total population on the sand plains had recovered to a level slightly higher than it was at the turn of the century and it has been rising ever since. Farm population has fallen slightly and occupied land has also decreased slightly; the size of farms has increased, but the average is still only about 136 acres per farm, much smaller than in most agricultural areas in the Province. In 1961 the Norfolk sand plain had more than 3,200 tobacco growers with a tobacco crop area of more than 103,000 acres, giving an average of about 32 acres of tobacco per farm. Between 1961 and 1981 the acreage has remained stable, but the number of farms decreased to 2,100. According to statistics issued by the Ontario Department of Agriculture, the average yield per acre increased from less than 900 pounds per acre in 1931 to more than 1,800 pounds per acre in 1963. In fact, in the early 1960s there was an overproduction of flue-cured tobacco and since then mandatory acreage reduction has been enforced. This caused a noticeable switch to other crops, the acreage in husking corn in Norfolk County for instance, increasing from 10,000 to 30,000 acres in three years. By 1981 the acreage in husking corn had risen to 48,000 acres. The other important field crops are rye, wheat, soybeans, silage corn, and hay. Rye is commonly grown for green manure in alternative

OGS 10 713

Photo 62. Tobacco farm at Cathcart, west of Brantford. Photo courtesy of the Ontario Ministry of Tourism and Recreation.

years on tobacco land. Between one-half and two-thirds of the commercial farms on the Norfolk sand plain are tobacco farms. The other specialties are dairy, fruits and vegetables, livestock, and poultry. Peanuts, blueberries, and ginseng should also be mentioned.

The urban centres of the region follow a peculiar distribution pattern. There is a string of small ports and fishing villages along the Erie shore including Port Dover, Port Rowan (405), Port Burwell (680), and Port Stanley (1,894), but they are not directly connected with each other by either railway or provincial highway. Both these facilities are forced inland a distance of 10 to 20 miles from the lake by reason of the entrenched river valleys. The major centres of population are found at the points where the major traffic arteries cross the larger streams. Thus St. Thomas (27,482) is on Kettle Creek, Aylmer (5,127) on Catfish Creek, Tillsonburg (10,332) on Otter Creek, Delhi (3,775) on Big Creek, Simcoe (14,084) on Lynn River, and Waterford (2,400) on Nanticoke Creek. Among the smaller centres which might be mentioned are Vittoria, Teeterville, Courtland, and Vienna. Brantford (73,264) dominates the northern part of the region, but certainly has had other reasons for existence and growth. There are a few villages, much closer to the soil, including Scotland, Oakland, Burford, and Princeton.

While other smaller areas in Ontario also grow tobacco, there is no doubt that the Norfolk sand plain presents the observer with one of the most distinctive landscapes in Southern Ontario. It is striking, for instance, where one breaks over the low moraine from the east to find the cattle, pastures, and hayfields of the Haldimand clay plain suddenly disappear, replaced by a new assemblage of tobacco, rye, groups of curing barns, glass-covered starting houses, and water tanks. The old farm barns remain; some tobacco farmers also feed cattle and hogs; corn remains, or, rather, has again come to be a significant crop.

Another outstanding feature of the plain is the present distribution of the population. In the old days of rural Ontario there were many mill sites and road corner settlements. With declining agriculture these reached a low ebb by the end of the First World War. Most of them have now revived to a point far beyond their previous peak, while in addition thousands of people now live in scattered rural houses along the concessions and sideroads.

Should one relate this density of population to the underlying physiography? Approximately 60 years ago when the total population of the county was only about 26,000, the towns had 8,000 people, and most of the remainder lived on farms. The lack of prosperity of the county was then freely attributed to the poverty of the sandy soil. Now under different technology, must its prosperity not also be attributed to its physiographic pattern and soil, which have permitted a new system of agriculture that, directly or indirectly, has given work to thousands of new people? The very nature of the land, the ease of excavation, the accessibility of water, and the porous soil which permits the operation of septic tanks, also are major factors in the settlement pattern. One must also mention the availability of road gravel in the old moraines and deltas, which enable the new tax dollars to be used effectively. Finally one might comment favourably upon the use of abandoned but water-filled gravel pits, such as those at Waterford, for recreational purposes.

23 HALDIMAND CLAY PLAIN

Lying between the Niagara Escarpment and Lake Erie, thus occupying all of the Niagara Peninsula except the fruit belt below the escarpment, the Haldimand clay plain has an area of about 1,350 square miles. Although it was all submerged in Lake Warren the till is not all buried by stratified clay; it comes to the surface generally on the low morainic ridges in the north. In fact, there is in that area a confused intermixture of stratified clay and till. The northern part has more relief than the southern part where the typically level lake plains occur.

The underlying rocks consist of a succession of Paleozoic beds dipping slightly southward under Lake Erie. The vertical cliffs along the brow of the escarpment are formed of dolostone of the Lockport Formation and this formation underlies a narrow strip of the plain to be succeeded southward by the dolostone of the Guelph Formation. Overlying these hard dolostones to the southwest is a series of softer rocks which includes shale members. They have been worn down to form a broad depression in front of the Onondaga Escarpment. The latter is a low north-facing scarp formed of hard limestone. Small areas of bare rock appear along its crest; otherwise the change in bedrock makes little difference in the clay plain.

The overburden on the rocks near the Niagara Escarpment is generally less than 50 feet deep, but increases in depth as one goes southward. In the wide vale north of the Onondaga Escarpment the depth of drift may reach 150 feet. As noted before, the brow of this escarpment is often bare, but the overburden increases southward again and is 10 to 50 feet in depth along the Lake Erie shore.

The Haldimand clay plain can be described as falling into a series of parallel belts. The first is the highest ground adjoining the Niagara Escarpment,

where recessional moraines were built by the ice lobe that occupied the basin of Lake Ontario. It varies in elevation from 600 feet to 750 feet a.s.l. except on the gravel hills at Fonthill which reach an altitude of about 850 feet a.s.l. These sand and gravel hills of the Fonthill vicinity are in strong contrast to the heavy boulder clay of the moraines and adjoining ground moraine. It is a shaly till derived in large measure from the red and grey beds below the Niagara Escarpment. As moraines, these ridges have a much subdued relief due to having been built under water. The intervening troughs are floored with lacustrine silt or clay.

The drainage of this belt is controlled by the modest ridges which directed it eastward in several parallel streams. In the north, some of them have been captured through deep notches in the escarpment. Twenty Mile Creek, Forty Mile Creek, and the Welland River are the most important of these streams. They have cut shallow channels but many undrained depressions remain on the higher ground. The clay plain is hampered by many wet sloughs which may be seen on the ground, and the pattern in which they occur is clearly visible on air photos.

In the central part of the plain, the Grand, being a larger river, has cut a deep valley in the clay and silt below Brantford. Consequently there has been much dissection by tributary drainage. Near Caledonia an odd variation is provided by a scattered group of drumlins partially buried in moderately dissected clay beds. The lower course of the Grand River is almost without gradient and apparently controlled by the Onondaga Escarpment, until a low saddle is reached east of Dunnville allowing the river to cross it and proceed southward to Lake Erie.

The southeastern part of the peninsula might almost be considered as a separate subregion, characterized by levelness and poor drainage. The main part of Welland County (now part of the Regional Municipality of Niagara) comprises heavy clay, while the lowest part of the plain lies in the southern portion of that county. Here the watershed is provided by the Onondaga cuesta which, though quite low and lying close to the shore of Lake Erie, nevertheless forces the drainage to the north and east. Large undrained areas remain, covering several square miles in which the Wainfleet and Humberstone peat bogs have formed.

Besides the outright bog, there is a large area of poorly drained sand, silt, and clay in the Town of Dunnville. These deposits undoubtedly represent a delta of the Grand River built into a former, higher Lake Erie. Remnants of its abandoned shoreline may be seen near Lowbanks.

A few other beaches of former lakes deserve mention. Beaches of Lake Warren are found upon the upper levels of the high ground at Fonthill. The ridge at Lundy's Lane is a beach formed upon a faint moraine. The gravelly streaks at Ridgeway and Ridgemount (both part of the Town of Fort Erie) are also lacustrine beaches. Another is followed by the road from Crystal Beach to Sherkston, while still more are found capping high ground near Crowland (part of the City of Welland). These gravel bars are seldom over six or eight feet deep, and since the upper four or five come within the weathered soil profile it is only the deepest of them that provide gravel for road metal.

South of the Onondaga Escarpment the drainage is directly to Lake Erie by way of Nanticoke Creek, Sandusky Creek, Hemlock Creek, and other shorter streams. East of Port Maitland, morainic hills appear to form the headlands on the Lake Erie shore called Lapp Point and Kinnard Point, and a more extensive area of till lies between Ridgeway and Fort Erie.

The shore of Lake Erie is low and appears to be controlled considerably by the surface of the limestone, resistant beds of which form headlands. Besides the morainic headlands east of Port Maitland there are several lines of active dunes and a wide sand beach at Crystal Beach.

The outstanding characteristics of the soils of this region, the heavy texture and poor drainage, have already been inferred. Unevenness in drainage must also be mentioned, areas of better-drained soils being dotted with wet depressions of irregular size and shape. The better-drained soils have thin surface horizons immediately underlain by shallow brownish grey horizons which have lost most of their lime and phosphorus. The greyish soil of the higher ground contrasts strongly with the darker soil of the depression and it presents a bold pattern on air photos.

The better-drained soils are represented by the Oneida clay loam which is found in the dissected area along the Grand River around Caledonia where the sediments are somewhat silty, and by Haldimand clay loam on the bevelled plain north and south of the Grand. Caistor clay loam, mapped in the Welland River drainage area, is an association of imperfectly drained soil and wet, often swampy, spots. Farther east of the City of Welland where the topography is more uniformly level there is the heavy intractable soil called Welland clay. These soils are all lacking in lime and phosphorus.

Of the light-textured soils which break the uniformity of the Haldimand clay plain the deep sands and gravels at Fonthill are most prized for fruit and truck crops and for residential sites. The other gravelly loams on the old beaches are also valuable for peaches, cherries, and vegetables. The wet sandy

loams of the Dunnville area are gradually being improved for canning crops and general agriculture.

Land Use and Settlement

The Niagara Peninsula has the function of a geographic corridor. Traffic between Canada and the United States flows to and from the gateways at Fort Erie, Niagara Falls, and Queenston. Much of it descends the Niagara Escarpment to traverse the fruit belt below, but the remainder crosses the Haldimand clay plain. Because of the falls over the escarpment the Niagara River does not provide an open corridor for shipping between Lake Erie and Lake Ontario; this has been artificially supplied beginning with William Merritt's first Welland Canal in 1829 and represented by the Welland Ship Canal of the present day, with its Twin Flight Locks on the face of the escarpment. While Niagara Falls (70,563) and Fort Erie (24,136) are the modern phases of the old gateways, the later development of the canal bridge points and terminals have given rise to St. Catharines (123,644), Thorold (15,480), Welland (45,417), and Port Colborne (19,011). Smaller centres include Chippawa, Fonthill, Welland Junction, Ridgeway, Ridgeville, Stevensville, and Crystal Beach. The lattermost is not strictly of the clay plain, but is a resort centre on Lake Erie. St. Catharines, of course, is not on the Haldimand clay plain, but in the area below the escarpment, yet, as the largest urban centre of the canal area, it has considerable influence on human affairs in the clay plain.

The power plants at Niagara Falls provide the key to much of the industrial activity in that vicinity, and the falls themselves are one of the foremost tourist attractions on the continent. Each year nearly 12 million tourists visit them on the Canadian side. Tourist establishments catering to these visitors dominate the scene in the city and along the highways in the outskirts. No doubt Niagara Falls has earned the title of "Honeymoon Capital".

While the eastern end, or Frontier Zone, of the clay plain is highly urbanized, the western and far larger area is almost strictly rural. This region has no large towns or cities, its largest centres being Dunnville (11,226), Caledonia, and Cayuga, on the Grand River, and Hagersville (2,402), and Jarvis, in the extreme southwest. Smaller rural service centres which might be mentioned include Fisherville, Smithville, St. Anns, Binbrook, Wainfleet, and Wellandport. The existence of the industrial City of Hamilton (308,102) on the northwest corner of the region overshadows the whole area.

In Ontario, clay plains of low relief are usually general farming regions with emphasis on livestock. While this is true of the Haldimand clay plain, the development is by no means uniform. East of the City of Welland, less than half of the area is occupied by farms, and only about half of the farms are regarded as commercial; this explains the observable fact that much of this land lies idle. Dairying prevails along the brow of the escarpment and along main roads leading to Hamilton. A second, somewhat less concentrated area of dairy farming is found on the better-drained soils of the eastern half of Haldimand-Norfolk County. The most important crops of the clay plain are hay, corn, oats, wheat (Photo 63), and barley. Husking corn now occupies 22% of the farmland but, even with the favourable climate, soybeans occupy only 3%.

OGS 10 714

Photo 63. A field of winter wheat on the Haldimand clay plain near Caistorville.

The fruit belt on the plain below the escarpment is well known as the most intensively developed horticultural area in Canada, and it is natural that some of this activity should spread onto the upland. Consequently, orchards and vineyards appear on the "mountain" especially on the slopes of the Vinemount Moraine. Generally, the poorly drained vale of Twenty Mile Creek forms an effective barrier to this development, but in the Binbrook area some areas of good silt loam are planted to grapes, pears, and apples.

The light soils around Fonthill form a horticultural "island" in the clay plain. Here, practically all the crops of the Niagara fruit belt may be grown, including peaches, sweet cherries, and vegetables for the early market. A smaller area with similar development is found at Ridgeway on the soils of the old beach ridges. The sands north and east of Dunnville are being drained and used for vegetable crops, as are some marginal areas of the bogs. Areas of truck farming are found near Niagara Falls and Welland, although in both cases they are being overwhelmed by urban expansion.

The heavy clay soils of the plain pose a number of problems. They are deficient in lime, phosphorus, and organic matter, and many areas have poor drainage as well. In some areas there are numerous wet "sloughs". Much of the land is very weedy. Wild carrot, chicory, and daisy have taken possession of many meadows and roadsides. The beauty of these weeds is, unfortunately, poor compensation for the lack of grass, the dense fibrous roots of which are needed to impart good tilth.

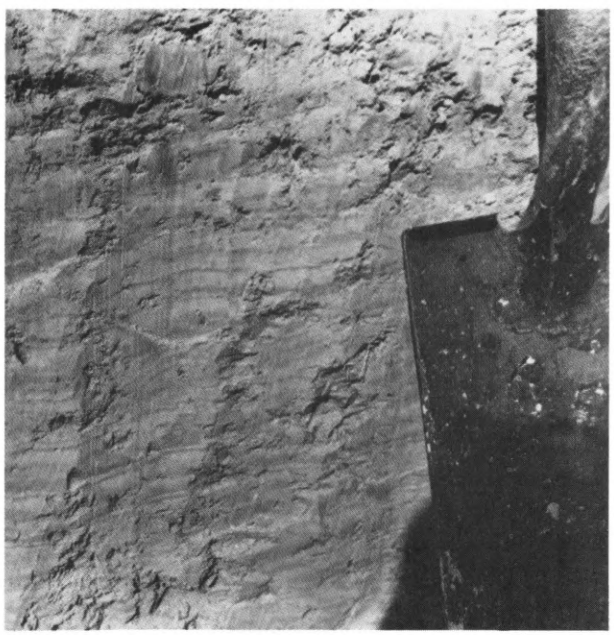
24 SAUGEEN CLAY PLAIN

This small clay plain is situated in the drainage basin of the Saugeen River, north of the Walkerton Moraine. It is underlain by deep stratified clay (Photo 64) deposited in a bay of Lake Warren and is thus distinguished from the more extensive plain of Lake Warren along the shore of Lake Huron, which has only a shallow surface layer of clay.

The clay is pale brown in colour and highly calcareous, being no doubt largely derived from the limestones and dolostones of the local bedrock. These sediments were brought into the basin by the ice-border drainage channels from the east, the forerunners of the present branches of the Saugeen system. The largest area of thick lacustrine clay lies between the Singhamton (Walkerton) and Gibraltar (Chesley) Moraines, below Lake Warren levels. The shoreline around the "Paisley Island" and the clay to the north of the Gibraltar indicate that Lake Warren persisted while the ice front withdrew northward. The next continuous low ridge of till, which occurs about five miles north of Chesley, makes a convenient boundary between the clay plain and the rolling landscape of the Arran drumlin field, even though the clay plain is also found farther north.

The original relief of this plain was flat to undulating, somewhat similar to that of the Schomberg clay plain, but the Saugeen River, Teeswater River, Deer Creek, and north branch have cut deep valleys in the clay beds. The main valley of the Saugeen near Paisley is 125 feet in depth. Consequently there has been considerable lateral gullying with the development of "river breaks" such as are found along the Grand River southeast of Brantford or along the Conestogo near Glen Allen.

The Teeswater and the Saugeen emptied into Lake Warren separately, but their deltas coalesced to form a sand plain between Eden Grove and the Ellengowan. A small part of this sand plain lies on the east flank of the Saugeen Valley while another small tract of sand is found just north of Vesta. The latter seems to be associated with a group of kames along the border of Elderslie Township. Another group of kames appears along the road between Gillies Hill and Salisbury. Although the dominant landscape of the area is that of a clay plain, there are thus a number of variant minor topographic elements. Drainage varies greatly, for while most of the southern part of the plain is well drained because of stream dissection, the northern area along Snake Creek has very poor drainage and was for decades known as the "Elderslie swamp".



OGS 10 715

Photo 64. Exposure of varved clay, 5 miles west of Chesley, Bruce County. Photo courtesy of M.B. McLeod.

The uplands of this area had an original forest cover consisting largely of sugar maple, beech, and hemlock, while the lowlands carried an association of elm, ash, soft maple, and cedar. The clay soils have been placed in the Saugeen catena by the Ontario Soil Survey. The well-drained profile is that of Saugeen siltly clay loam, that of the imperfectly drained areas, which are actually more widespread, is Elderslie silty clay loam, while Chesley silty clay loam is found in the poorly drained flats. These soils, developed on highly calcareous clays, are high in lime and humus. When drained they are very productive. They have relatively shallow profiles (12 to 18 inches) with either a very slight development of the A_e horizon or apparently none at all. Under conditions of poor drainage the brownish B horizon is replaced by a grey, massive, plastic gley. On the sand plain, the deeper beds near the river afford warm dry soil which is classified as Fox sandy loam while there are also areas of the more poorly drained Brady series. Much of the sand plain, however, is underlain at shallow depths by clay, and the internal drainage is imperfect, producing a Berrien profile.

Land Use and Settlement

First settlement in this area took place in the years 1851 to 1855, following the building of Highways 6 and 9 which opened up the area west of the Saugeen River. Later, the eastern and larger portion of the clay plain was also opened by main roads. Around 1870 both the eastern and western parts of the plain received rail service with the opening of the Toronto, Grey, and Bruce and the Wellington, Grey, and Bruce railways. During this period and for some years thereafter, lumbering was a dominant industry as the land was cleared for farming. The northern part of the plain, the "Elderslie swamp", required drainage in order to make it fit for agriculture and township ditches were dredged.

As in the rest of Bruce County, the agriculture of the first half-century of settlement was directed largely toward wheat production. Today, wheat is seldom grown, the emphasis being on pasture (29%), hay (24%), and corn for beef cattle; but the farmers still grow some mixed grain and barley for the grain, the straw, and as a nurse crop. Elderslie, according to the 1981 census, has the densest cattle population of any township in Ontario, 62 per 100 acres on the average. This surprising statistic is not due to the soil, as this township stands 25th from the top in terms of land values. Rather, it is due to the feedlots developed on these farms. There has been considerable consolidation and enlargement of farm holdings, the average farm since 1961 expanding from about 190 acres to 287 acres in 1981. The clay plains of Bruce County have seen the abandonment of many farm homes and a great reduction in total population.

The Saugeen clay plain contains no large towns. The trade of the southern portion is divided between Walkerton (4,511) and Hanover (6,199), the two larger towns of the upper Saugeen basin. Chesley (1,876), on the North Saugeen, is the centre for the northern part of the clay plain with Paisley (1,049) on the western margin. Smaller places such as Elmwood (400) on the eastern edge, and Cargill, Chepstow, and Pinkerton on the Teeswater River are grist mill and local supply points.

25 HURON SLOPE

Occupying an area of about 1,000 square miles along the eastern side of Lake Huron, the land between the Algonquin shorecliff and the Wyoming Moraine slopes gently upward from 600 feet to 850 or 900 feet a.s.l. It is essentially a clay plain modified by a narrow strip of sand, and by the twin beaches of glacial Lake Warren which flank the moraine. Below the Warren beach the surface has been smoothed, but the deposition of lacustrine clay seldom amounts to more than three or four feet, and the till often comes to the surface. Deeper clays of a silty nature are found between Point Clark and Ripley. Above the Warren levels, the surface is without the planing effect of the stratified clays, and is similar to that of the Stratford till plain. The till is formed from a brown calcareous clay, containing a minimum of pebbles and boulders. The sheet of till is generally only six to ten feet in depth and it rests on stratified clay of the same colour. There seems little doubt that the matrix of clay in the upper till sheet is mainly reworked lacustrine material similar to that of the beds below.

The sandy strip mentioned above runs parallel to the Warren beach, but is usually separated from it by a mile or so of clay or loam. It consists of a shallow deposit of sand spread over the clay, and under such conditions a perched water table occurs above the clay with the result that the sandy soil has a wet, cold subsoil. The surface of the sand is unevenly ribbed and swampy streaks occupy the depressions. Only a small amount of this poor soil has been tile drained and improved. There are two small deltas where the Bayfield and the Ausable emptied into Lake Warren thus creating other sandy areas. The Ausable delta around Sylvan is the larger of the two. In both cases the beds are deep enough to form well-drained soil.

Farmers on this slope generally emphasize the raising of livestock, grazing is featured, and grass farms with unoccupied houses are common. Corn,

hay, mixed grains, barley, oats, and wheat, in that order, are the usual crops. South of Goderich, beans and sunflowers appear. The sandy strip is rather poor for agriculture, even for grazing, as the cattle fail to thrive on it. Most of the cattle belong to the beef breeds, but some dairying is found near Goderich and Kincardine. Cheese is produced at Ripley. The summer rainfall in the lee of Lake Huron is fairly reliable, enabling consistently good crops of pasture, hay, corn, and mixed grains.

The Algonquin bluff at the lakeward border of this slope, or the shorecliff of Lake Huron where it has undercut the earlier cliff, have a drop of about 75 feet. With such a head the streams, large and small, have cut deep gullies, thus making a much-dissected fringe just above the bluff. It is this that forced the Bluewater Highway (Highway 21) away from the shore and, indeed, mostly out of sight of the blue water of Lake Huron. These gullies also present problems of control to the farmers whose land is being spoiled by their growth. Both Bruce and Huron Counties, in which the Huron slope lies and which comprise a very continuous body of agricultural land, are rural counties, yet the area contains a number of small towns and villages. Some of them, of course, have lakeside sites and are connected with the Huron fringe, but they draw much of their support from the general farming area and will be mentioned here. Goderich (7,297) at the mouth of the Maitland River, is the county seat of Huron County, an important port, a mill site, and a salt mining centre. Clinton (3,052), twelve miles inland from Goderich, is an old agricultural trading centre. Zurich (776) is centrally located in the southern part of the area. Bayfield (634) is a small lakeside centre some distance south of Goderich. Lucknow (1,091), actually in the spillway between the moraines, serves adjacent cattle raising country in both Huron and Bruce Counties. Kincardine (5,930) is the largest town on Lake Huron north of Goderich. The Village of Ripley (604) is centrally located in the best dairy section of the region under discussion. It is famous because, allegedly, the natural fluorine content of its water supply has given its inhabitants remarkable freedom from dental caries. Tiverton is a small village a few miles north of Kincardine.

26 HURON FRINGE

A narrow fringe of land along Lake Huron from Sarnia to Tobermory needs to be distinguished from the clay plain adjacent and above it, because it is so very different. It comprises the wave-cut terraces of glacial Lake Algonquin and Lake Nipissing with their boulders, gravel bars, and sand dunes. Although it is narrow, the strip is approximately 200 miles long and its total area amounts to about 435 square miles.

On the Bruce Peninsula this Huron fringe is a scoured belt of limestone just above the lake level, back of which are either a series of beaches, or sand dunes, sometimes interspersed with swamp. These are the work of either the extinct Lake Nipissing or the present lake. A few miles south of Wiarton, back of Sauble Beach, the boundary of this region swings inland around a sand plain. Sauble Beach itself is flanked by a range of sand dunes, and blowsand is common on the adjacent sand plain. A massive gravel beach skirts the northern border of the Arran drumlins, while along the western border bluffs cut in the sides of drumlins occupy most of the shoreline north of the Highway 21. Below the bluffs lie wide boulder pavements. The French Bay road (secondary Highway 21) follows a line of sand dunes, and about half way between this road and Lake Huron the Nipissing beach may be recognized. Beyond it are old beaches, one after another, to the shore of Lake Huron.

Across the mouth of the Saugeen Valley, Lake Algonquin built a massive beach of sand and gravel. Behind it was a lagoon in which fine sand and silt were deposited to a considerable depth. Delta sands were spread outside the beach, also, ending at a distinct bluff about half a mile from the present shore. The terrace below the bluff is ribbed with gravel bars built by Lake Nipissing and, as is the case along so much of the shoreline, the waves have washed most of the overburden off the bedrock on the lower or Nipissing terrace.

Between the big barrier beach at Port Elgin and the barrier of sand dunes south of Grand Bend the Huron fringe is bordered by a shorecliff, from 50 to over 100 feet high. From Point Clark to Grand Bend there is little or no terrace below this bluff. The few strips of sandy beach are eagerly sought by summer cottagers.

Grand Bend takes it name from the hairpin turn of the Ausable River as it doubles back to flow the length of the Ipperwash sand dunes to Port Franks before emptying into Lake Huron. This route has been used less since a channel was forced to the lake at Grand Bend, and a canal cut directly inland behind Port Franks to the Ausable, shortening the course of drainage by about 20 miles. The dunes here cover a belt about a mile and a half wide. Behind them is a lagoon with a marly floor, including a big marsh and Smith Lake. Some of the marsh nearest to Thedford has been drained and developed for the production of celery, onions, and other special crops.

The well-known Kettle Point is a shelf of bedrock which has not yet been worn away but stands uncovered so that big round concretions, called kettles, are exposed. These peculiar forms are like cannon balls of stone; the term "Kettle" seems to be something of a misnomer.

Adjoining the Kettle Point Indian Reserve (IR 44) is a small plain ending at Gustin Grove below the Algonquin bluffs. This protective wall to landward is 50 or 60 feet high and the little area also has some sandy soil suitable for fruit growing. Even peaches have been grown commercially.

The most southerly ten miles along Lake Huron from Brights Grove to Point Edward have sandy beaches along the shore protecting a marshy lagoon. There was once a shallow lake in this lagoon, but it was emptied by a drainage canal in a scheme to reclaim the marshland for the culture of sugar beets and truck crops. It might be well to record that the lowest of the marshlands are frequently inundated in the spring due to freshets, or plugging of the outlet at the lake, or both. As in the Thedford Marsh area, the Blackwell marsh and the flats around are underlain by marl or marly silt and clay.

The Huron fringe contains the resort areas of the Lake Huron shore. Such places as Port Franks, Grand Bend (642), Bayfield (634), Goderich (7,297), Bruce Beach, Kincardine (5,930), Inverhuron, Port Elgin (6,159), Southampton (2,732), and Sauble Beach are well known. Much of the clientele is drawn from London and other cities in southwestern Ontario, but there is a goodly number of American visitors as well.

Another use for relatively isolated shorelines is demonstrated by the location at Douglas Point, just north of Inverhuron, of the Ontario Hydro's first large-scale nuclear-powered generating station.

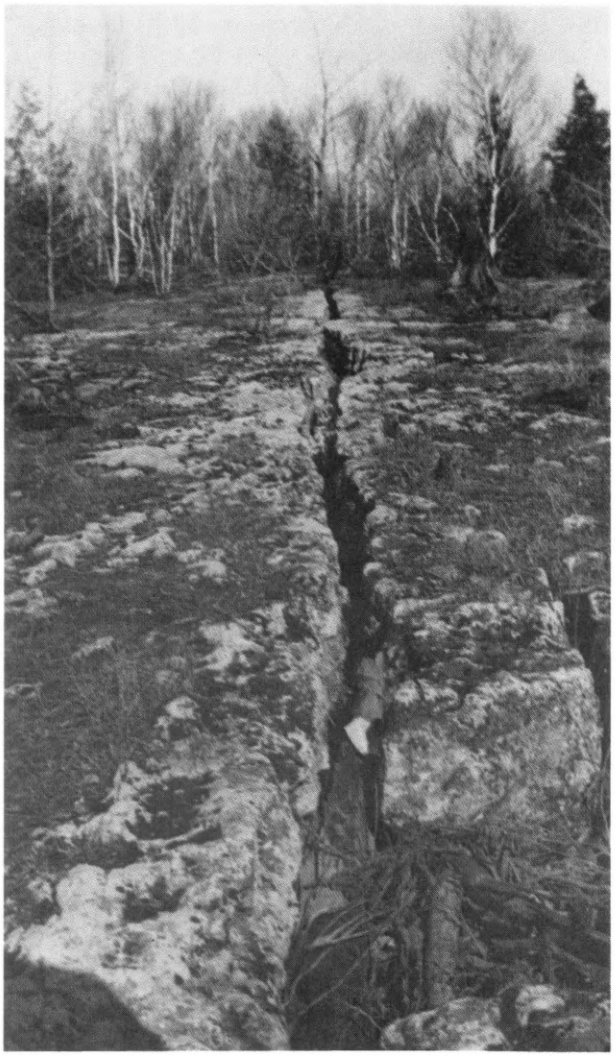
27 BRUCE PENINSULA

The Niagara cuesta near the escarpment is generally a zone of scour and the Bruce Peninsula section is no exception. Apart from the silt beds of Eastnor Township and a few drumlins, gravel bars, and sand dunes, the Bruce Peninsula has only a little overburden scattered on the grey dolostone. The surface of the rock is more irregular than that of the limestones and dolostones of central and eastern Ontario and many wet swampy basins and lakes appear. The dip of the rock strata is toward the west; the surface rises gradually from the water's edge on the Lake Huron side toward the escarpments on or near the Georgian Bay shore, the highest bluffs on Georgian Bay being well over 200 feet in height. Thus the latter shore is one of rugged beauty, while the opposite shore is low, with boulders, gravel, and sand bars, and intervening strips of wet ground extending some distance inland.

The greater part of the Bruce Peninsula has very shallow soils, with much bare rock exposed (Photo 65). Classified by the Ontario Soil Survey as the Breypen series, this land type covers an area of about 400 square miles. There is a small plain near Lion's Head in Eastnor Township which has deep but poorly drained lacustrine deposits. Ditches have been dug to improve the silt or clay loam soils and considerable land has been reclaimed by burning peat from the surface. This is the main farming area north of Wiarton, and at one time it enjoyed a good reputation for the production of peas. South of Wiarton, in Amabel and Keppel Townships, there is much rough, stony land with soils similar to those of the moraines and drumlins farther south.

Land Use and Settlement

The Bruce Peninsula was opened for settlement in 1850 and, for a period, lumbering was the chief activity. Most of the good stands of pine, spruce, and hardwoods have long since been removed, but limited cutting of second growth is still carried on. The



OGS 10 716

Photo 65. Fissure in dolostone, Bruce Peninsula.

farmer followed the lumberman but in the northern townships there was little land suitable for crops. In keeping with the characteristics of the land there are two land-use districts, north and south of Wiarton. In the northern townships only 45% of the land is occupied, and farms average over 305 acres, some indeed being very large. The scattered farms on the shallow soils are mainly beef cattle enterprises. In summer the cattle graze over wide areas. Toward the north, however, agriculture becomes less and less important. St. Edmunds Township, in 1981, had only 7 farms and only 1.5% of their land was improved. In Eastnor Township on the better soils, both the total land holding and the improved land have recently been slightly increased although there are fewer farms. The southern area, occupying the neck of the peninsula west of Owen Sound, is somewhat of a transition zone. About 70% of the land is occupied, the farms averaging just over 200 acres in extent, while only 27% of the farm area is in crop. Beef production is still the most important livestock enterprise but dairy cattle, hogs, and poultry are much more numerous than they are in the northern area.

The characteristics of population distribution deserve some notice. There are several Indian reserves on the peninsula with an almost static population of about 900. The population of the municipalities has decreased from about 15,800 in 1901 to about 11,200 in 1981. The City of Owen Sound, which is not here regarded as part of the peninsula, has grown in the same time from 8,800 to 19,624. It is a port of some consequence and is the commercial centre of wide areas in both Bruce and Grey Counties, as well as being county seat of Grey. Table 4 gives a population analysis of only the peninsular municipalities.

TABLE 4 POPULATION OF THE BRUCE PENINSULA, 1981

Total	8,659	100%
Urban (1 town, 2 villages)	2,064	23.8
Rural	6,595	76.2
farm	1,137	13.1
non-farm	5,458	63.1

area: 540 square miles
population density: 16.0

As one might expect, more than half of the scattered non-farm population is to be found in two townships, within a few miles of Owen Sound. All in all, the Bruce Peninsula is one of the less densely populated farming areas in Southern Ontario. However, permanent population reveals only one side of the character of the Bruce. Approximately 60 miles in length, its greatly indented shoreline provides 180 miles of water front, ranging from the superb sands of Sauble Beach to the commanding cliffs of Cape Dundas and Lion's Head. The trail from Dyer Bay to Cabot Head provides a particularly impressive array of cliff formations and cobble and boulder storm beaches. The peninsula is fringed by many offshore islands, including the famous Georgian Bay Islands National Park and the under water Fathom Five Provincial Park. There are, also, at least 30 inland lakes of varying size, occupying depressions in the bedrock created by glacial erosion. Summer brings a great, even if uncounted, influx of temporary population. In addition, many people use Highway 6 to or from Tobermory, because of the ferry service to Manitoulin Island. Many small settlements are busy in the tourist season. Large cottage colonies are found at Sauble Beach, Oliphant, Red Bay, Howdenvale, Pike Bay, and Stokes Bay on the western side of the peninsula. In addition to its transportation function, Tobermory is the home port of a small lake fishing fleet and a yachting centre of some importance. Motels, resorts, and private cottages are numerous. Cottage colonies are found on the eastern side of the peninsula at Dyer Bay, Lion's Head, Barrow Bay, Hope Bay, and Colpoys Bay. Physiography may not have been very favourable to agricultural development in the Bruce Peninsula, but it offers some compensation in the attraction of cottagers and other summer visitors.

28 MANITOULIN ISLAND

Because of its geographic individuality, Manitoulin Island (Figure 24) may be taken as a unit in this series of physiographic regions. It lies in the northern part of Lake Huron in line with the Bruce Peninsula, and Cockburn, Drummond, and St. Joseph Islands. It is 80 miles long, from 3 to 30 miles wide, covers 1,588 square miles, and is said to be the largest "fresh-water" island in the world. It contains more than 100 lakes, the 3 largest of which, Kagawong, Mindemoya, and Manitou together cover more than 65 square miles. Consisting mainly of limestone tablelands tilted toward the southwest or south, Manitoulin is basically similar to the Bruce Peninsula or Prince Edward County.

The island is part of the Niagara cuesta, the rim of the great dolomitic saucer that underlies the Lake Michigan basin. If it were not for a few low spots this rim would separate Lake Huron from Georgian Bay and a long land arc would extend around from the Bruce Peninsula to northern Michigan.

Dolostone of the Amabel Formation covers the southern two-thirds of the island. Along the south shore the rocky floor dips gradually under the water,

but the northern edge of this formation is seen in perpendicular cliffs. The headland projecting into Bayfield Sound, and High Hill between Manitou Lake and West Bay are outstanding examples. The latter stands over 500 feet above the level of Lake Huron or more than 1,100 feet a.s.l. and is one of the two highest points on the island. In both places the dip of the cap rock is clearly evident.

Below and north of the Amabel Formation, the Manitoulin Formation forms widespread rock plains. In places it too terminates on the north in steep cliffs which in turn overlook Ordovician shales and limestones, probably to be correlated with the Georgian Bay and Blue Mountain Formations, and Simcoe Group in south-central Ontario. Between the two dolostone formations lie the reddish shales of the Cabot Head Formation, but its outcrops are very limited. In this part of the Niagara Escarpment one misses the red shales of the Queenston Formation which form the lower slopes of the escarpment farther south.

Only a small proportion of the island is covered with deep drift; on the contrary the bedrock over large areas was washed clean of a scanty overburden by the waves of glacial Lake Algonquin. These rock outcrops bear strong evidence of erosion by the Pleistocene glaciers, often exhibiting gouges or flutings running 20° to 40° west of south (200° to 220° azimuth) (Photo 66). Striae are often well preserved when covered with a few inches of soil. South of Gore Bay, where dense strata of dolostone of the Manitoulin Formation appear on the surface, the rock is smooth and polished. From one site, striated slabs are cut from the upper stratum for use in hearths and mantels.

For the most part the striae point about 40° west of south (220° azimuth), agreeing with those on the Bruce Peninsula. Toward the west end of the island, however, the direction is 15° to 20° west of south (195° to 205° azimuth). They have the same alignment as the elongated ridges of dolostone and the drumlins. Traces of another earlier set of striae trending about 60° east of south (120° azimuth) were seen on Barrie Island.

OGS 10 717

Photo 66. Flutings in bedrock, Grimsthorpe, Manitoulin Island.

Just north of Sheguiandah there appears a ridge of white quartzite, of Precambrian age, protruding up through the Paleozoic strata.

Manitoulin Island has nothing to compare with the big drumlin fields of Southern Ontario, but there are several groups of these hills. They are mostly of the long thin type, some being actually cigar-shaped;

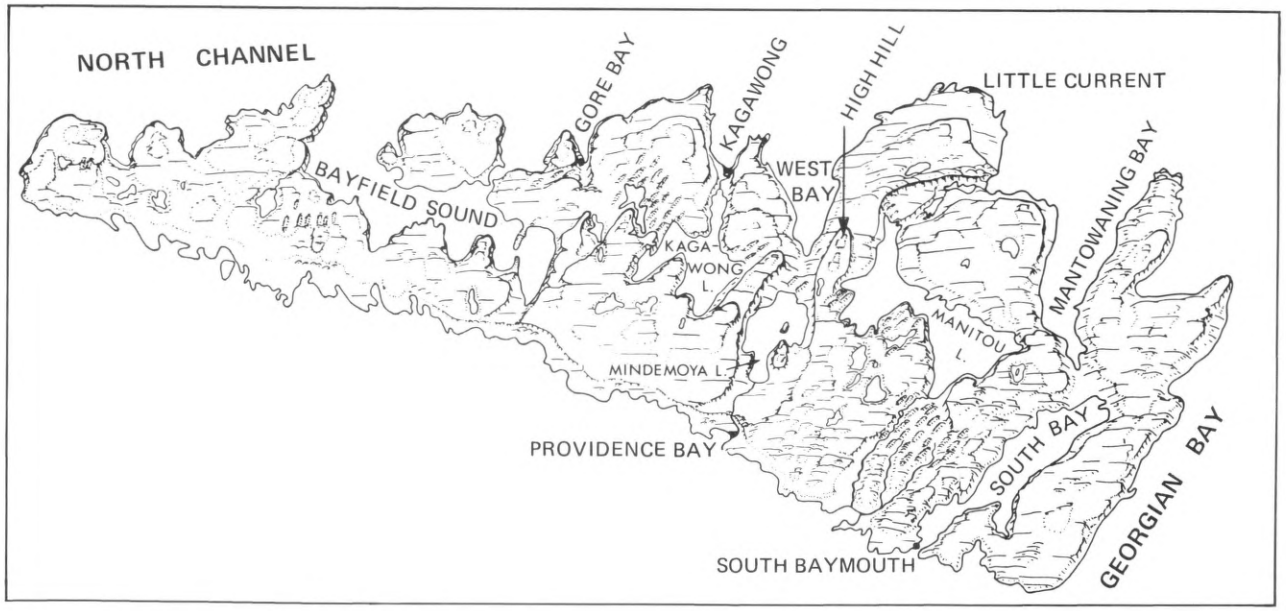


Figure 24. Physiographic sketch of Manitoulin Island.

and their crests are often bouldery from wave action at the time of Lake Algonquin. The drumlins around Tehkummah contain a good deal of acidic Precambrian rock, those near Ice Lake contain red shale which is not evident elsewhere on the island, and the several drumlins near Silver Water consist almost entirely of dolostone and limestone. As in drumlins generally, the till is medium in texture.

In the Tehkummah vicinity and in the valleys of Manitou River and Blue Jay Creek varved clay occupies the hollows and encroaches on the sides of the drumlins. Clay flats are also associated with the little group of drumlins in Billings Township, south of Kagawong.

With the possible exception of the crest of High Hill, all of Manitoulin Island was submerged by glacial Lake Algonquin. Gravel bars are common on the island since Lake Algonquin had several stages at as many levels. The waves also washed the surface of the rock, gathering the sediment that finally settled into the depressions. The larger stones and boulders which resisted the waves are strewn over the limestone floor in varying numbers throughout the island. The best tracts of stratified fine sand, silt, or clay, are in the valleys of Black Creek and the Manitou River, in the lowlands both north and south of Mindemoya Lake, the Spring Bay area south of Kagawong Lake, and the Burpee and Evansville flats near Lake Wolsey.

The effects of Lake Nipissing are also evident, not so much along the precipitous north shore where in places there are gravel beaches from 30 to 50 feet above the water level, but along the south shore where a belt one to three miles wide was under Lake Nipissing. The old shoreline is marked by low bluffs, sand dunes, or sand and gravel beaches. Much of this shoreline belt is a barren rock plain from which the forest has been cut or burned. In the Providence Bay and Poplar vicinities it is apparent that silt and clay beds left by Lake Algonquin were washed off the rock by the waves of Lake Nipissing.

Pedologically, Manitoulin Island is very much of a transition area. Typical Podzols and typical Grey Brown Luvisolic soils occur, but in many cases the profiles are weakly developed. Many profiles have characteristics similar to those of the Grey Luvisols of western Canada. Others found on highly calcareous parent material resemble the soils of the Peterborough drumlin field of central Ontario while some, on somewhat less calcareous materials, resemble the Luvisolic soils of the Parry Sound region. It is also fairly common to find a weakly developed Podzol superimposed upon what was a Grey Brown Luvisolic soil. Many areas on Manitoulin Island are imperfectly or poorly drained and have varying development of a gley horizon at the base of the profile. Fair-sized areas, also, have a covering of peat or muck. However, by far the most obvious and most important characteristic of the soil cover is its shallowness. Almost two-thirds of the island, most of it classed as Farmington, is too shallow for cultivation and is suitable only for woods or rough pasture.

Land Use and Settlement

White settlement on Manitoulin dates from 1862 when a treaty was concluded with the Indians of the western and central parts of the island, setting aside certain reserves and throwing the remainder open. The Indians of the eastern end of the island, however, refused to sign and their territory remains on some maps as "Manitoulin unceded". By 1900 the island had over 11,000 people of whom about 2,000 were Indians. The total population in 1981 was 10,555 of whom 3,140 were Indians. Manitoulin is still a rural area, its one small town, Little Current, having about 1,500 people. Gore Bay has a population of 779. There are also some small unincorporated villages and about ten rural hamlets. About one-third of the white population lives on approximately 400 farms having a total area of 189,000 acres. Table 5 shows population values for the Island.

TABLE 5 POPULATION OF MANITOULIN ISLAND, 1981

Total	10,555	
Indian reserves	3,140	
Other areas	7,415	100%
Urban (1 town)	1,498	20.2
Rural	5,917	79.8
farm (399 farms)	1,243	16.8
non-farm (includes 1 town)	4,674	63.0
area: 623 square miles		
population density: 11.9		

There is a common saying in Manitoulin that the island is made up of one-third good land, one-third rock, and one-third water. Actually about 40% of the island is occupied by farms, but the area annually cropped is less than 36,000 acres. The average size of farm is about 511 acres, which is more than twice the provincial average. Each farm has about 94 acres in crops, the most important being pasture, hay, oats, and mixed grains. A small amount of corn is grown for ensilage. The agriculture of Manitoulin consists mainly of extensive grazing, the latest statistics (1981) disclosing 23,200 cattle and 2,700 sheep on the island.

Many farmers have achieved a practical organization which utilizes to advantage both the good deep soils and the shallow rocky land. They live on small lowland farms on which they grow their crops and keep their herds of breeding stock. In addition they have several hundred acres of "range" on which

they pasture growing animals during the summer. There are at least 140 farms of 500 to 1,500 acres on the island.

Most of the island cattle are of the beef breeds, Herefords being dominant because they adapt best to range conditions. Due to the tuberculosis testing program the island has for years been free of bovine tuberculosis, and the range animals are in good demand in Southern Ontario where they are finished for market. Livestock sales are held annually at Little Current.

Dairying is of minor importance, less than 10% of the commercial farms being classified as dairy enterprises. There is a creamery at Mindemoya but cheesemaking never became established here as it did on the shallow soils of eastern Ontario. Manitoulin gained some fame in the production of turkeys. At one time about 50,000 birds were marketed annually, but there has been some decline in the face of competition from other areas. There are also a few large fur farms.

A great deal of Manitoulin still remains in forest. At one time it was an important source of lumber. Later it produced quantities of spruce and poplar pulpwood. At present this activity is much reduced but some reforestation has been carried out.

Apart from agriculture, summer recreation is the most important activity. Lodges, cottages, camps, and private cottages are widespread but they are especially attracted to the shores of the large inland lakes. The south shore, facing the wide open expanse of Lake Huron, is almost uninhabited except for a few spots such as South Baymouth and Providence Bay. Little Current, the nearest approach to the mainland, is a popular yachting centre. Deer hunting in the fall should also be mentioned.

In many ways, land use and human activity on Manitoulin Island resembles that of the Bruce Peninsula, with which it also shares so many physiographic characteristics.

29 ST. JOSEPH AND COCKBURN ISLANDS

In line with the Bruce Peninsula and Manitoulin Island on the Niagara cuesta are the three islands of Cockburn, Drummond, and St. Joseph. Drummond Island is part of the State of Michigan and therefore beyond our Province, but to some extent it resembles Manitoulin. St. Joseph and Cockburn Islands bear little similarity to Manitoulin and are distinctly reminiscent of the Penetang Peninsula. In particular, they are almost all covered with deep drift derived mainly from Precambrian rocks with a minor component of limestone and dolostone, whereas Manitoulin Island consists largely of limestone and dolostone rock plains. With an area of 150 square miles and a population of 1,042 people, St. Joseph is much the more important of the two islands. Cockburn Island is about 67 square miles in extent and there are only four permanent residents.

The landform pattern on the two islands is fairly similar. It consists of morainic hills near the centres which stood as islands in glacial Lake Algonquin and which are given prominence by high bluffs which encircle them. They stand about 500 feet above Lake Huron. Below these bluffs there are broad bouldery terraces, gravel beaches, and plains of deeper sands. A group of drumlins with bouldery surfaces add variety to both islands. Glacial moraines which are prominent in the northern part of St. Joseph have smaller counterparts north of the big hill on Cockburn Island. On St. Joseph Island a good-sized area of Algonquin and Nipissing clay occurs in the northwestern section, while only a very small clay area occurs on Cockburn Island. Limestone comes to the surface along the north shores of both islands, but there are no large areas of shallow soil.

On Cockburn Island farming is no longer carried on. The northern part of St. Joseph is a general farming area. In addition, strawberries, sweet corn, raspberries, and other vegetables grown on the island are noted for quality in the Sault Ste. Marie market. Even a few apples are grown.

The forests on these two islands contain mostly hardwoods with sugar maple the dominant species. Yellow birch, white birch, and beech are fairly abundant, along with some white and red pine, white spruce, balsam, white cedar, and aspen. Limited stands of black spruce are seen in the valleys of St. Joseph. There is some regeneration taking place on abandoned farmland, chiefly of hardwoods. On Cockburn Island some spruce has recently been planted, pointing the way for better future care of the forests which occupy over 90% of the area.

30 OAK RIDGES MORAINE

The Oak Ridges Moraine (*see* Figure 13) stands out as one of the most distinctive physiographic units of Southern Ontario. Its general altitude is about 1,000 feet a.s.l. and it extends from the Niagara Escarpment to the Trent River, forming the height of land dividing the streams of the Lake Ontario drainage basin from those flowing into Georgian Bay and the Trent River. Over 100 miles in length, its width varying up to eight miles, the total area is approximately 500 square miles. In three places it narrows almost to the point of extinction and, whether by accident or design, these saddles are crossed by the three north-trending highways, Highways 27, 7, and 28. It is also crossed by Highways 50, 11, 48, 47, and 35, where it is higher and wider.

The surface is hilly (Photo 67) with a knob-and-basin relief typical of end moraine. The highest parts are at the western end where, along the brow of the escarpment, the sandy hills have an elevation of about 1,400 feet near Mono Mills and Sleswick. A few miles east, Wolfe Mountain rises to 1,200 feet a.s.l. The triangulation station north of Lake Marie in King Township is above the 1,175-foot contour, while the Uxbridge triangulation station is above 1,325. The highest point in Clarke Township (now part of the Town of Newcastle) is over 1,300 feet while several nearby hills are nearly as high. The Haldimand triangulation station, situated on the highest point south of Rice Lake, has an altitude of over 1,175 feet.

While, for the most part, these hills are composed of sandy or gravelly materials, this is not always the case. Some, including the highest ridges around the Uxbridge and Clarke triangulation stations, are formed of till which protrudes above the sands. The depth of this sandy material is not completely known over the whole area but in King Township, where grading was done for Highway 400 from Toronto to Barrie, deep cuts often exposed till within 30 feet of the surface. On the other hand there are areas where stratified deposits are known to be 100 feet or more in depth. The northern border of the morainic area is deeply indented by swamp-floored valleys, along which many outwash terraces are found.

In general this upland is to be regarded as the source area for many streams which drain the till plains on either side of it. However, as Carman (1940) pointed out some years ago, there is in much of the moraine, itself, a virtual lack of streams. The water drains vertically through the sand and gravel, moving laterally only when it reaches less pervious beds and reappearing as springs along the slopes of the moraine. An important exception is to be noted in the case of the Humber River which cuts deeply into the sandhills northwest of Bolton. In that case the source of the water is not so much in the sandhills themselves as in the Niagara Escarpment which adjoins them to the west. This lack of streams puts the area at great disadvantage for recreational purposes and also limits its usefulness as pasture land.

The original vegetation of the area was a mixed forest of pine and hardwoods. The valuable white pine was early sought out and very few trees of any size are left in the present wood lots. Among the hardwoods, hard maple, beech, and red and white oak were most important and a few good stands may still be seen.

On the Oak Ridges Moraine there is much hilly sandy soil which is subject to blowing. Blowouts are frequent and it is common to find the original surface horizon of the soil in quite level areas buried under a few inches of calcareous sand. Some nearly level topography is provided by sandy outwash, or occasionally fine sandy loam.

The characteristic soil of the kames is droughty and unstable under cultivation or even pasture. Attempts have been made to fix the blowsand by

OGS 10 718

Photo 67. Oak Ridges Moraine showing the sand hills in the Ballycroy section of the moraine. Photo courtesy of M.B. McLeod.

reforestation here and there on the ridges, as for instance in the Vivian forest in the Town of Whitchurch-Stouffville, the Durham forest east of Pontypool, the Northumberland forest south of Fenella, and many smaller private plantations. They provide splendid demonstrations of the effectiveness of pine plantations on such soil. Furthermore, this land serves as the headwater area of the streams which take rise in springs on the shoulder of the moraine, and forest is needed to maintain these springs (Carman 1940).

On the gentler hillsides and the sandy outwash aprons the soils are more useful. They may be pastured or cropped, depending on the slope, and the texture of the sand. Cattle seem to thrive on the sparse pastures, perhaps because of the lime and phosphorus which the soil inherits from the local limestones. The livestock economy is supplemented by potatoes and considerable rye is grown. A few tobacco farms were established near Pontypool, but these are no longer operating.

The Pontypool series is found upon the hilly topography and the surface soil may be sandy loam, sand, or gravelly sand. The Brighton series is developed upon the almost flat or gently undulating outwash aprons which are here and there associated with the moraine. While the coarser textured materials predominate, there are still many areas in which the soils are classified as sandy loams, and may be expected to be more retentive of water and are, therefore, more useful soils.

Following the exploitation of the timber, practically the entire area was occupied as farmland and, despite the abandonment of the poorer hillier farms, much of it is still farmed. Only one township can be said to be entirely within the area, namely Uxbridge, and for various reasons it cannot be considered strictly representative. From the 1981 census for Uxbridge Township, however, the following information was obtained. Fifty-seven percent of the township is occupied by farms, the average size of which is 134 acres. Of the farm area, 75% is improved land, 58% is under crops, 13% improved pasture, 11% woodland, and 14% in natural pasture and waste land. The outstanding fact here is not so much a changed pattern in the use of land on farms during the last two decades, but that a considerable amount of land has been taken over for residential estates.

The Ganaraska River which has a large part of its area in the Oak Ridges Moraine was the subject of the pioneer study of conservation and river development in Ontario (Richardson 1944). It recorded the land use for a contiguous area of over 22,000 acres, showing 39% cropland, 35.5% pasture land (both improved and unimproved), 18.9% woodland, and 6.4% idle land. Problems of land use on the Oak Ridges Moraine were discussed in some detail. The primary problem was to decide what land should be reforested and to make plans for a program of tree planting. For much of the remainder, good sod culture was seen to be the key to management of this light land. It is of interest to note that some of the sandy soil was used for tobacco culture, despite the short frost-free season of these uplands, but much of this has been discontinued.

Declining agricultural land use and the extension of forest area usually means a declining rural population. This is not the case throughout most of the Oak Ridges Moraine, and particularly in the western portion which has become increasingly accessible to the people of the Metropolitan Toronto area through the building of improved highways. Between 1930 and 1960 farm acreage declined by 20% and farm population by 26%, but in recent decades this has become stabilized. However, since 1930 rural non-farm population has increased more than sixfold. Much of this is located on scattered roadside lots, but there have also been efforts to create scenic, rural or woodland subdivisions.

Although sand predominantes over gravel on this moraine there are deposits of fairly good gravel here and there and quite a few pits. In recent years the operation of these pits has been strongly opposed by the owners of the rural residences, especially those within commuting distance of Toronto. Gravel is a necessity and pits unavoidable, and with the strict regulations on operating and rehabilitation now in force, coexistance is not impossible.

Much of the land which has been taken out of agriculture has been put to recreational uses. There are a number of kettle lakes, such as Wilcox Lake and Musselman's Lake which have attracted summer resorts and cottage settlements. Ski resorts have been built in some of the hilly areas. There are some excellent golf courses. The Metropolitan Toronto Regional Conservation Authority has developed a number of areas for a comprehensive, year-round program of activities, including the Albion Hills Conservation Area's Field Centre. Thus the varied characteristics of the land which were unfavourable to agricultural development have been used to advantage.

Agriculture itself has some special characteristics. Many of the occupied farms are in actuality rural residences where only a nominal amount of farming is carried on by people whose livelihood is earned elsewhere. There are also many hobby farms owned by persons whose wealth is derived from industry or other business in the city. Increasingly, the Oak Ridges will come to be considered a non-agricultural area. It should be regarded as a reserve of open space for country residences which might

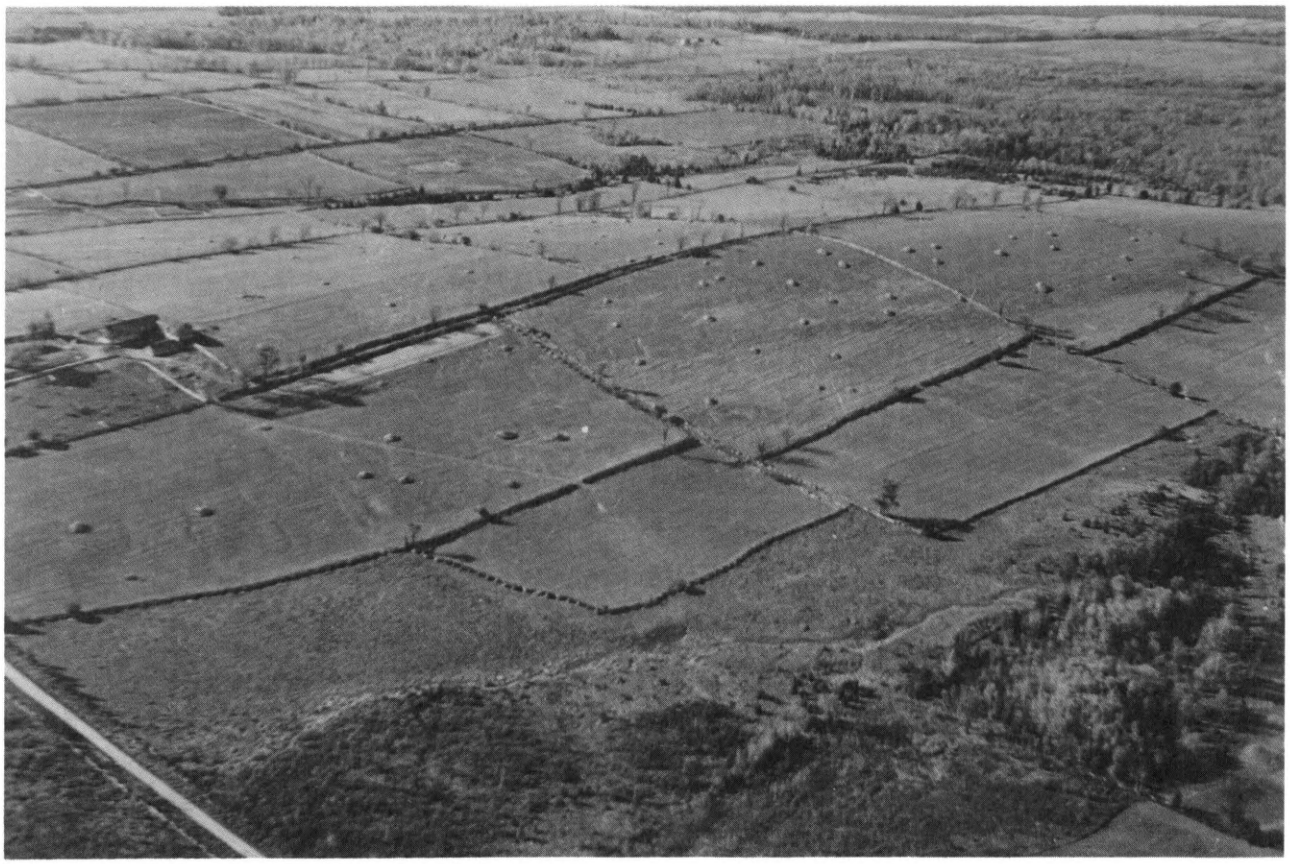
well be encouraged here in order to conserve good agricultural land in other areas.

31 PETERBOROUGH DRUMLIN FIELD

Lying between the Oak Ridges Moraine and the area of shallow overburden on the limestones of the Gull River Formation there is a rolling till plain with an area of about 1,750 square miles. Extending from Hastings County in the east to Simcoe County in the west, and including the drumlins south of the moraine in Northumberland County, this belt contains approximately 3,000 good drumlins in addition to many other drumlinoid hills and surface flutings of the till sheet (Photo 68). The name of Peterborough has been used to designate the whole group because the city occupies its geographical centre and because the drumlins are most typical in form and most densely distributed in Peterborough County. The Peterborough map sheet (NTS 31 D/8), depicts the contours of at least 1,000 drumlins. Because it was built upon drumlins, Peterborough was once dubbed "City of Seven Hills", but it has since spread its development upon several more. Ashburnham Memorial Park, the City Hall, the Hospital, the golf course, and Trent University all make use of drumlin sites.

For the most part the rock underlying this region is limestone of the Lindsay and Verulam Formations which are somewhat softer and less massive formations than the Gull River Formation. They are also highly fossiliferous and disintegrate easily. The beds slope slightly toward the southwest and the edges of overlapping strata face the north, thus providing the advancing glacier with good loading conditions. The general level of the bedrock plain in the east is around 600 feet a.s.l. but it rises to about 800 feet in the west. The drift varies considerably in depth, being rather thin on the borders of the limestone plains to the north and thicker toward the moraines on the south.

While the general orientation of the drumlin axes in this field is from northeast to southwest, there are local variations worth noting. In Hastings County the direction of the ice movement seems to have been 20° to 30° west of south (200 ° to 210° azimuth). Around Campbellford in Northumberland County, it was only 10° west of south (190°); west of Rice Lake drumlins are found pointing 40° west of



OGS 10 719

Photo 68. Oblique aerial photograph of a drumlin near Lake Scugog with stone piles dotting the surface.

south (220°), and in the Lake Simcoe area as much as 60° west of south (240°).

The drumlins throughout are composed of highly calcareous till but there are local differences. In Victoria County, particularly in Mariposa Township, the bedrock is seldom far from the surface and the till contains great quantities of angular limestone rubble. Here, also, the drumlins are more scattered and not so well formed as in other areas. Farther east in Peterborough, Northumberland, and Hastings Counties, the till contains much less small rubble. Instead, there is a much greater occurrence of boulders of Precambrian origin, many of them being two to three feet in diameter. These are often noticed to be more numerous on or near the surface than in deeper excavations.

Toward the south, along the border of the Oak Ridges Moraine, and in the western part of the field, the till is somewhat more sandy. Many drumlins near the moraine have shallow coverings of nearly stone-free silt and fine sand which is probably wind-blown material. Its depth, on the average, is less than two feet and hence it is all within the weathered soil profile; but in extreme cases a depth of six or seven feet of this material has been noted.

The Peterborough drumlin field is notable for its eskers as well as its drumlins. These gravel ridges afford poor soils but they are valuable as sources of road metal since other gravels of good quality are rather scarce. Good examples may be seen near Cannington, Cameron Lake, Omemee, Norwood, Stirling, Tweed, and Marlbank.

The Cannington Esker is a rather narrow and extremely crooked gravel ridge which crosses the highway just west of the village, ending in a large kame from which much gravel is removed. Across concession XII of Brock Township its crest is followed by a farm lane. In concession XIII the Beaverton River has cut away a short section. For the most part it is a single ridge about 25 feet in height. Between Cannington and Manilla the county line crosses a much larger esker which in places is over 60 feet in height. It is much segmented, its sections ranging from one-tenth to two miles in length. It can be followed definitely from Blackwater to a point about two miles north of Manilla, a distance of eight miles. Southwest of Blackwater the deep swampy valley of the Beaverton River extends for ten miles, almost to Uxbridge. Rising from the floor of this valley in various places are unmistakable esker segments. The esker near Cameron Lake follows the valley of Martin Creek and is more or less in line with it. The distance from Blackwater to Cameron Lake is 35 miles, but it is not definitely proven that these ridges all belong to the same esker train.

The Omemee Esker is crossed by Highway 7 about one mile west of the village. Known as the "Hogsback", it is from 50 to 75 feet in height. It is cut through by the Pigeon River, and for a short distance south of this a road has been built along its crest. A massive gravel ridge, it can be identified without difficulty from a point in the valley of Fleetwood Creek near Bethany to the shore of Pigeon Lake north of Fee's Landing, a distance of twelve miles. A mile or so northwest of Omemee, it is joined by another esker which can be followed northward through Downeyville for about six miles. Both northern branches are broken into many segments.

The Norwood Esker is also a very massive ridge, some parts of it being over 75 feet in height and the angle of slopes about 26°. In places the esker is compound, two or three ridges lying side by side. This esker can be followed for about twelve miles.

Between Stirling and West Huntington the Ridge Road follows a medium-sized esker for several miles. Another large esker can be followed for about twelve miles in the vicinity of Thomasburg and Tweed.

The longest of these gravel ridges is the one which can be seen near Marlbank, Frankford, and Codrington. It trends roughly southwest and can be followed, with some interruptions for nearly 50 miles. In the vicinity of Marlbank its crest is followed by a highway for several miles. For the most part its course seems to be controlled by preglacial limestone valleys, or, at least, it follows them very closely. Beaver Lake, four miles northeast of Marlbank, is almost divided into two by this narrow gravel ridge. To the northeast it was traced across the boundary between the Precambrian and Paleozoic rocks. On the Canadian Shield the stones in the esker are all of Precambrian origin, but about five miles to the southwest they are about 90% Paleozoic rock.

While the eskers are perhaps the most striking features of the plain, apart from the drumlins themselves, they are not as important in respect to soils as the deposits of clay which lie between the drumlins in some areas. This "drumlin and clay flat" landscape is particularly noticeable near Stirling, Bailieboro, Lindsay, Bradford, Schomberg, and other places flooded by the old glacial lakes. More clays are found in the Trent River region where Lake Iroquois covered all the lowland as far upstream as Peterborough. In other places such as to the south of Lake Simcoe we find drumlins or drumlin uplands rising from sand plains. In the flooded areas also many of the drumlins have been wave-washed sufficiently to leave a bouldery surface, while in some cases the hillsides have been undercut and oversteepened as well.

Another important landscape variation is due to the size and shape of the drumlins themselves, and these characteristics are fairly strongly correlated with the depth and abundance of the drift. Along the northern edge of this belt where the drift is thin, drumlins are small, scattered, and often imperfectly formed. On the other hand, along the southern edge of this group there are many very large drumlins. In the townships of Percy and Alnwick some outstanding specimens exceed 200 feet in height and 25% slopes are common. The typical drumlins of the central region around Peterborough are less than a mile in length, one-quarter mile or less in width, and 75 feet in height. They are closely spaced, averaging four or five to the square mile which leaves very little intervening space. Here also some of the drumlins are compound, with double crests, double tails or distinct secondary ridges, and flutings along the sides. In places where the hills are more widely spaced, swamps may intervene but there are not many lakes. On the upland just west of Peterborough, the drumlins are of a wide oval shape, sometimes almost round; but around Lindsay, particularly in Mariposa Township, they are poorly developed, low, elongated swells in the till plain. Farther west, near Lake Simcoe, they are of somewhat more typical shape with many swampy areas intervening.

A description of the area is not complete without mention of the series of deep valleys leading northward which break the continuity of this till plain. They contain such streams as Black River, Pefferlaw Creek, Uxbridge Brook, Beaverton River, Nonquon River, Eastcross Creek, Pigeon River, and Fleetwood Creek. Occupying a pair of similar valleys, Lake Scugog is held to its present level by the damming of the Scugog River. All of these valleys have wide swampy bottoms traversed by sluggish streams which have not been able to keep pace with the northward upwarping of the earth's crust since the ice age. The valleys, themselves, are deep enough to provide excellent drainage to the adjacent uplands.

The forest on the higher, well-drained sites consists largely of maple and beech with a fair admixture of white pine and hemlock. Precipitation is around 33 inches annually with summer droughts a regular occurrence. The zonal soils belong to the Grey Brown Luvisolic group. Owing to the high limestone content of the till, however, the profiles are often shallow, the soils near neutral to alkaline in reaction; carbonates are often found on the surface.

Otonabee loam, recognized extensively in Hastings, Peterborough, and Victoria Counties, lacks the distinct brownish grey, leached layer of the Luvisolic soils of the area. Instead, a dark brown, clayey, nutstructured horizon appears under the surface and the whole profile is seldom more than 15 inches deep.

In uncultivated areas uprooted trees and rodents have mixed much calcareous material with the surface soil. In cultivated areas the plough turns up the calcareous lower horizons so that the surface soil almost invariably gives a positive test for carbonates. Many stones have been gathered from the surface and dumped into piles or built into stone fences. No doubt the stoniness of this soil has helped to retard erosion, but considerable topsoil has been lost from the steeper slopes. Frequent patches of greyish subsoil show that the soil has been removed. Fortunately the uniform slopes of most drumlins are amenable to contour cultivation and strip cropping. To a certain extent some farmers have long followed such practices, keeping bands of steep land along the drumlin sides in sod or in forest. These precautions and working the gentler slopes on the contour will increase, and the sooner the better, because the continued productivity of this soil depends in the first instance upon the control of erosion.

Bondhead loam, a zonal Grey Brown Luvisolic soil, occurs in the western and southern parts of the area where the drumlins generally have a more moderate relief. In comparison with the Otonabee, the Bondhead has a deeper profile and has a light-coloured A_e horizon below a lighter, less stony surface layer in which free carbonates are seldom found. It is thus a more desirable soil for agricultural purposes. Bondhead fine sandy loam also occurs in many places. Another soil of some importance is the Dundonald series: it occurs where the basal till is overlain by deposits of fine sand to depths of two to four feet

Land Use and Settlement

The utilization of intensely drumlinized areas is under the triple handicap of stoniness, steep slopes, and wet swampy hollows. Throughout most of this area a second series of difficulties is imposed upon the farmer by reason of the cadastral survey. In common with the rest of Ontario the land was surveyed into townships, concessions, and lots with base lines parallel to the shores of the Great Lakes. This means that in the Peterborough drumlin field the roads and farm lines make angles of about 45° with general trend of the drumlin axes. Consequently there are a great number of triangular and diamond-shaped fields and many areas of wasteland just too small or too awkward to be worked successfully.

The average size of farm, on the basis of 6 representative townships, is about 189 acres— considerably larger than the average for Ontario. In the last 50 years the area has lost one-third of its

farmers, while the average farm has increased in size by more than 50%. The percentage of improved land varies somewhat around an average of 68; about 11% remains in woods leaving 20% for natural pasture and wasteland. About 45% of the farmland is cropped each year and about 20% is in improved pasture. Altogether, about 40% of the farmland is used for grazing. Of the cropland a little less than half is used for hay. The most important cereal crop is corn which takes up more acreage than mixed grain, oats, and barley altogether. Corn for silage averages 4%. Winter wheat which used to be more important, occupied not much over 2% of the cropland in 1981.

On the average the farms of the drumlin belt support about 25 animal units per 100 acres, or 48 per farm. That this is lower than in many other regions is not surprising in view of the high proportion of unimproved land. The composition of the livestock population varies somewhat: in Hastings County dairy cattle and pigs are important, Victoria County specializes in beef cattle, and in Peterborough there is a mixture of beef cattle, dairy cattle, and pigs, with poultry becoming important in some areas.

A widespread area such as this must necessarily have market points. Peterborough (61,595) is the largest and most centrally located. Its meat packing, dairy, and milling plants provide local markets. Peterborough, however, has outgrown the local phase of development, becoming an independent manufacturing centre of some consequence, using materials from many sources and selling them a national market. Its initial impetus was physiographic, its advantage being the power developed from the rapids of the Otonabee River upstream from the city. Now, however, power is also brought in from other sources by Ontario Hydro. Other centres of importance are Lindsay (14,094), Campbellford (3,364), Lakefield (2,256), Frankford (1,892), Norwood (1,240), Hastings (959), and Stirling (1,658). There are numerous interesting smaller villages such as Sunderland, Oakwood, Little Britain, and Omemee, as well as many road corner hamlets. We are unable to match the population census with the estimated area of the Peterborough drumlin field, but we can derive some information from the same four townships which we used for land use analysis. Here we see that only 18% of the rural population are farm families while 82% lives in rural hamlets and in scattered rural residences. Again there is a certain physiographic influence. A residential site overlooking a drumlin landscape has an aesthetic appeal. Odd corners on many sloping farms have much more value as building lots than they could ever have as agricultural land and rural homes on such lots are fairly frequent, particularly in the environs of Peterborough and less so in more remote areas. Even the smaller towns, however, show some development of the rural-urban fringe.

32 SOUTH SLOPE

Between Lake Ontario and the Oak Ridges Moraine the area has been divided into three regions. The Iroquois lake plain occupies the lowest land, under 400 feet a.s.l. in the west and 600 feet a.s.l. in the east. The Peel plain occupies a central position in the expanded western portion and is separated from the Iroquois shoreline by the Trafalgar Moraine and a strip of fluted till plain. The South slope is the southern slope of the Oak Ridges Moraine but it includes the strip south of the Peel plain. It rises to the line of contact with the moraine at 800 to 1,000 feet a.s.l. In other words it rises 300 to 400 feet in an average width of 6 or 7 miles. Extending from the Niagara Escarpment to the Trent River it covers approximately 940 square miles.

The central portion, in the Regional Municipality of Durham, is drumlinized, although drumlins are scattered and are of the long thin type pointing directly up the slope. The streams flow directly down the slope; being rapid they have cut sharp valleys in the till. In addition, numerous gullies have been cut by intermittent drainage so that the east-west sideroads cross a succession of valleys. Bare grey slopes where soil is actively eroding are common in this area (Photo 69), and the extension of gullies into otherwise unbroken fields is a critical problem. It is a particularly important problem because the land affected is otherwise of high quality.

In Hope Township (Northumberland County) between Kendal and Rossmount there are several large hills standing 200 or 300 feet above surrounding lowlands. They have steep sides but their crowns are moulded into drumlins. The south face of the moraine in this section appears farther north and is rather abrupt. Because of the gap in the moraine opposite the southwestern tip of Rice Lake there is also a gap in the South slope.

The eastern portion of the slope in Northumberland County is thickly covered by big drumlins pointing to the southwest, which have diverted the streams diagonally down the slope. The side of the Murray Hills, which constitute the eastern extremity of the South slope, is an abrupt slope over 200 feet in height, steepened near the base by the shorecliff of Lake Iroquois. On a clear day this imposing formation may be seen by looking north from Highways 401 or 2, west of Trenton.

The western portion of the South slope of the Oak Ridges Moraine lies north of the Peel plain, but the Trafalgar Moraine and adjacent till plain to the

south of the Peel plain is also included. East of Maple the slope is smoothed, faintly drumlinized, and scored at intervals by valleys tributary to the Rouge, Don, and Humber river systems. West of Maple the surface is morainic, most of it a ground moraine of limited relief. South of the Peel plain in the City of Scarborough there is a gently rolling till plain exhibiting bold flutings running about 30° west of north (330° azimuth), and low drumlins. Toward the west in the Cities of York, Etobicoke, and Mississauga this type of surface fades out in favour of ground moraine with its irregular knolls and hollows. West of the Credit River the Trafalgar Moraine provides subdued morainic topography, while a narrow belt above the Iroquois shorecliff is planed and fluted. In the Sheridan area (southern corner of the City of Mississauga) the flutings appear to be worn in the shale bedrock. All the rivers in this area have cut through the boulder clay and into the shale, the valley walls in the shale often being almost perpendicular.

The South slope lies across the limestones of the Verulam and Lindsay Formations, the grey shales of the Georgian Bay Formation, and the reddish shales of the Queenston Formation. The material in the drift is related to the underlying rock, allowing for some importation by the glacier. East of Oshawa the till is highly calcareous and the cultivated soils often contain free lime carbonates on the surface. Although shale appears in the till west of Oshawa, it is not until the City of Scarborough is reached that acid soil is found and it is only slightly acid. The shale content increases west of Toronto until a till consisting nearly all of red and grey shale is reached west of the Credit River.

Reference should be made to the calcareous clay till in the Regional Municipality of Durham. Containing few stones, it probably consists of lacustrine clay and silt reworked by the glacier.

In Northumberland County fine sand and silt is found on the surface of the till up to a depth of six or eight feet. This wind-blown deposit is generally less than two feet thick in the Regional Municipality of Durham and is unimportant west of Toronto.

The South slope contains a variety of soils, some of which have proved to be excellent through more than a century of agricultural use. They are developed upon tills which are more sandy in the east and clayey in the west while the slopes are often steeper in the east than in the west. They are highly calcareous east of Pickering; west of Oshawa a sprinkling of shale appears in all the tills and the shale content increases westward. Black and grey shales are found east of Brampton, while red shale characterizes the area west of there, particularly beyond the Credit River. Mostly, this slope is drumlinized, the main exception being the Trafalgar Moraine between Streetsville and Nelson with its moderate knob-and-kettle relief. The soils on the sandier tills

OGS 10 720

Photo 69. Gullied till plain north of Bowmanville, Regional Municipality of Durham, showing bare, eroded slopes.

of Northumberland have been classified in the Dundonald series. The Bondhead, Darlington, and Woburn soils are loams in texture, the latter two containing some shale along with the limestone. The King clay loam also contains a blend of shale and limestone while the main soils on the more shaly tills west of Toronto are called Chinguacousy clay loam and Oneida clay loam. The Oneida soil was developed on the reddish tills of the Trafalgar Moraine under a forest dominated by oak, hickory, and white pine.

Of all these soils, the Woburn loam on the gently rolling plain of the City of Scarborough appears to be the best, although the fine farmlands of this township are now largely urbanized. The Bondhead and Darlington loams are also very desirable soils. The Oneida and Chinguacousy clay loams are acid, harder to work, and more limited in their adaptation to various crops, but they cannot be regarded as poor soils. Lime and available phosphorus contents in these latter shaly soils are lower than in the soils east of Toronto, but potash content is higher. Thus the physical and chemical properties and productivity of the soils of this slope illustrate nicely the effect of different bedrock and landforms.

Land Use and Settlement

Lying behind the lakeshore areas of first settlement in Upper Canada, the South slope was colonized by the "second wave" composed largely of British immigrants after the close of the Napoleonic wars. Toronto (York) was founded in 1793, and Markham, Whitby, and Bowmanville in 1794, but the interiors of the Regional Municipalities of Peel and Halton were not laid out for settlement until 1819. The interior of the Regional Municipality of Durham was also settled later; names like Enniskillen, Kendal, Kirby, Tyrone, and Raglan undoubtedly give some clues concerning the origin of the settlers.

A mixed, subsistence agriculture was undoubtedly the rule in the early settlements but grain soon began to be exported from the little lake ports. This was increased by the repeal of the Corn Laws in Britain and by reciprocity with the United States; several of the main haulage roads were improved, and some were made into plank roads. In the mid-1850s the railways appeared. The period of grain growing was a period of prosperity, as the stony soils were cleared to make them suitable for the use of horse-drawn machinery. Ready cash and handy building material resulted in many fine fieldstone houses throughout the region.

Wheat growing declined, to be replaced by commercial mixed farming in which beef cattle, hogs, and dairy butter were the chief sources of income. The erosional scars of continuous grain growing can still be seen on some slopes but for the most part they have come under the control of the sod cover of long-term pasture. The expansion of the Toronto milk shed (the area from which fluid milk is trucked to Toronto) displaced the beef cattle and hogs over a large part of the region. Finally, of course, large areas, west, north, and east of Toronto have come under the "urban shadow" and are rapidly becoming part of the built-up metropolis. The eastern part of the South slope has preserved its rural character to a greater extent than the western part. Population values are shown in Table 6.

TABLE 6 POPULATION OF THE SOUTH SLOPE, EASTERN PART, 1981

Total	44,476	100%
Urban (3 towns)	18,043	40.6
Rural	26,433	59.4
farm	3,726	8.4
non-farm	22,707	51.0
area: 427 square miles		
population density: 104		

It is well to point out that the physical differences between the South slope and the Iroquois plain in this area are not sufficient to promote much contrast in agricultural practices. Orchards and canning crops are grown both near the lake and on the slopes, although canning crops seem to be of less importance than formerly, while a general livestock and crop pattern seems widespread. The whole slope between the lakeshore and the Oak Ridges Moraine may be considered as one geographic unit served by a series of strategically placed lakeshore towns.

The combined counties of Northumberland and Durham reached a population peak in 1880 declining to a stagnant level which changed little between the two World Wars. Since then, although farm population has continued to decline, total population continues to increase. The incorporated towns, now well served by land transportation, have had a new season of growth and rural non-farm population is of considerable importance.

33 PEEL PLAIN

The Peel plain is a level-to-undulating tract of clay soils (Photo 70) covering 300 square miles across the central portions of the Regional Municipalities of York, Peel, and Halton. The general elevation is from 500 to 750 feet a.s.l. and there is a gradual and fairly uniform slope toward Lake Ontario. Across this plain the Credit, Humber, Don, and Rouge Rivers have cut deep valleys, as have other streams such as the Bronte, Oakville, and Etobicoke Creeks.

There is, therefore, no large undrained depression, swamp, or bog in the whole area, although in many of the inter-stream areas, drainage is still imperfect.

The underlying geological material of the plain is a till containing large amounts of shale and limestone. In much of the Peel plain this has been modified by a veneer of clay which, occasionally, when deep enough, is clearly seen to be varved. When tile drains were laid during the building of the original Malton (now Lester B. Pearson International) Airport, deep beds of varved clay were seen. More recently during the widening of the Seventh Line road in Oakville, deposits of varved clay ten feet in depth were found near Drumquin. The clay is heavy in texture and more calcareous than the underlying shaley till, having, presumably, been brought by meltwater from the limestone regions to the east and north, and deposited in a temporary lake impounded between the higher land and the ice lobe in the Ontario basin. The plain extends across the contact of the grey and red shales of the Georgian Bay and Queenston Formations, respectively. Consequently the clay to the southwest of the Credit River is reddish in colour and somewhat lower in lime than the clay in the eastern end of the plain.

There are exceptions to be noted to the general heavy texture of the soil. In various places the stream valleys are bordered by trains of sandy alluvium. This is true of the Credit below Norval and of the Humber near Nashville and Thistletown (north of Weston). A small isolated sandy tract lies in concessions VIII and IX of Trafalgar Township (now part of the Town of Oakville) in Halton County. Near Unionville there is a flat sandy strip, which, like the others, is occupied by market gardeners. North of Brampton, there is a partly buried esker which has served as a local source of road metal.

The water supply of the plain is somewhat of a problem. Except in the central part of the Regional Municipality of York, the overburden is not deep, the till is dense, and there are few thick beds of sand to serve as aquifers. The high degree of evaporation from the deforested clay surface also militates against adequate recharge of underground water supplies. Further difficulties arise from the fact that the underlying shales are not good aquifers; even when water is obtained by deep boring it is often found to contain salt. Brampton's water supply is drawn from Lake Ontario.

Although now almost completely deforested there is evidence that this plain carried a hardwood forest of high quality and great wealth of species. In the better-drained parts grew sugar maple, beech, white oak, hickory, basswood, and some white pine. The depressional areas carried elm, white ash, and white cedar. Although there is some well-drained soil associated, the dominant soil is the imperfectly drained Peel clay. It is distinguished by: a very dark brown, crumb-structured, stone-free, surface horizon 5 to 6 inches thick; and a sub-surface layer of brownish grey, clay loam 4 to 5 inches thick; underlain by 9 to 12 inches of dull brown, blocky clay. This is in turn underlain either by dull brownish grey, calcareous, clay till or stone-free clay. The weathered profile is usually about 20 inches thick. It is a productive soil when surface drainage is established.

Land Use and Settlement

Settled during the early part of the 19th century, the

OGS 10 721

Photo 70. Faintly undulating to level clay plain on the Peel plain near Malton, on the present site of Humber College.

fertile clay soils were cleared rapidly. Once the pioneer stage was passed the plain became a noted wheat growing area which, besides supplying the growing city of Toronto, produced quantities of grain for export to the United States through various lake ports such as Oakville, Port Credit, and Whitby. Later a mixed type of crop and livestock farming developed with its chief market in Toronto. When alfalfa was introduced into Ontario it was found that this area not only produced abundant crops of hay but it was also ideal for the production of seed and, for a time, this crop was the source of a fleeting prosperity. Since 1926, however, the alfalfa seed crop has generally been a failure. Being within easy trucking distance of Toronto, and having a good mileage of improved highways the Peel plain rapidly became a well-developed portion of the Toronto milk shed. Nearness to Toronto also resulted in the development of a number of racehorse farms and in the establishment of some orchard, small fruit, vegetable, and poultry farms.

Until 1940 practically all of the land was used for agriculture. Farms averaged about 100 acres in size, slightly larger in the western part, and slightly smaller just north of Toronto. About 87% of the land was improved, 66 to 70% was under field crop, 10 to 20% in pasture, and only 6 to 7% remained as woodlots. Now, a good deal of this land has been bought for urban development and either lies neglected or is rented and used for cash crops.

Being close to Toronto the villages and towns, which for many years were mainly farmer's supply points, have grown rapidly in the last 25 years. The main ones are Milton (29,591), Streetsville, Woodbridge (15,100), Richmond Hill (38,488), and Markham (81,932). Brampton, which was the centre of a large greenhouse industry, particularly rose growing, has expanded to a city of 154,981 people. The expansion of Metropolitan Toronto has taken over the original townships of Scarborough, North York, and Etobicoke. The same is true of Toronto Township as well as Trafalgar and Nelson, now included in the cities of Mississauga and Oakville respectively.

Since 1940, Toronto, has rapidly expanded and now the built-up area occupies nearly all the Peel plain lying north of the city. To the west, the cities of Mississauga and Brampton have overrun all but a few farms in the Peel County part of the plain. Some of this land is still vacant and may be rented and sown to cash crops. Farther west the plain is still grenerally rural but even there urbanization has started along the southern border. A recent study directed by R.G. Putnam (personal communication, Principal, Parkdale Collegiate Institute, Toronto) found that south of Highway 403, between Highway 401 and Oakville, all but 2 farmers were tenants keeping the land in operation for other owner speculators. In total it appears that about two-thirds of this region is no longer farmed. Otherwise stated about 127,000 acres of good farmland have been taken out of production, and a similar fate is ahead for the remaining one-third.

34 SCHOMBERG CLAY PLAINS

A number of topographic basins along the northern slopes of the Oak Ridges Moraine contain deep deposits of stratified clay and silt. Located near Schomberg, Newmarket, and to the north of Lake Scugog, the three larger areas, taken together, cover about 475 square miles, and are included under the name of the Schomberg clay plains. In the first two areas the surface under the clay is that of a drumlinized till plain. The smaller drumlins are completely covered, but many of the larger ones escaped complete burial although the clay may occur well up the slopes of the hills. The average depth of the clay deposit seems to be about 15 feet, but deep deposits are known. The construction of the highway near Holland Landing in 1935 resulted in the exposure of nearly 50 feet of varved clays. Since the rolling relief of the underlying till plain has not entirely been eliminated these areas are not so flat as many lake plains. The Scugog area on the other hand overlies a flat till plain and has a more normal appearance for a lake plain. Even here, however, a few drumlins occur. In the area along the Holland River between Newmarket and Holland Landing considerable dissection has taken place giving rise to rough topography. Elsewhere, the beginning of soil erosion is indicated by light-coloured surface patches on knolls and gentle slopes.

The Schomberg sediments are typically varved clays with annual layers of two, three, four, or more inches in thickness. The summer band makes up three-quarters to four-fifths of the thickness, is more silty, and is grey in colour. The winter band is slightly denser and is brownish grey. Both portions of the varve are highly calcareous and small fossil shells are sometimes found in them. Chemical analysis shows the clay to contain about 50% calcium and magnesium carbonates. Mechanical analysis indicated about 50% clay and 40% silt, but its behaviour is more like that of silt than clay. It is very slippery when wet and inclined to be mealy when dry. It is probably composed of freshly ground rock flour rather than weathered clay minerals.

The soils of the Schomberg clay plains have been placed in the Schomberg catena by the Ontario Soil Survey. It contains the well-drained Schomberg silty clay loam, the imperfectly drained Smithfield silty clay loam, and the poorly drained Simcoe silty

clay and silt loams. In its natural state the well-drained member of this catena is one of the better clay loam soils of the Province. Furthermore, in the Schomberg and Newmarket districts, the well-drained soil predominates, occupying at least 75% of the area. Tile drains have been installed in most of the depressions so that whole fields may be cultivated at the same time, avoiding the patchiness seen in some clay plains.

The original vegetation was hardwood forest, the well-drained sites supporting sugar maple, black maple, beech, ironwood, and basswood; the areas of imperfect and poor drainage were dominated by elm, ash, soft maple, and white cedar.

Since almost no virgin forest remains, especially on well-drained sites, virgin soil profiles are hard to find. However, it is apparent that the dark brown surface horizon of this soil is deeper than usual for the region, and it possesses a good granular structure. The light yellowish brown leached (A_e) horizon is quite shallow; in fact it is sometimes not apparent at all. Free carbonates are commonly present on the surface in uncultivated areas, and are invariably present in the ploughed layer of the cultivated soil. From the standpoint of chemical nutrients the most serious limitation of all members of the Schomberg catena is a deficiency of available phosphorus. Phosphorus deficiency symptoms may often be seen in corn, especially if the soil is low in organic matter and in poor tilth.

Land Use and Settlement

Being associated with well-drained upland soils of drumlinized areas, such as the Bondhead series, and being fairly easily accessible to colonization routes from York, these clay plains were well settled and thoroughly cleared during the first half of the 19th century. Little forest cover remains except in the wettest places. Mixed farming was the rule with a dominance of grain in the cropping program. The suitability of the land for wheat was such that for many years the concentration of this crop was greater than in any other part of Ontario except the clay plains of Kent and Essex. Oats and barley were plentiful also, being largely used as feed for hogs. In the imperfectly drained Scugog area, wheat growing was not so successful, and alsike and red clovers were commonly used in the crop rotation and often matured for seed. In this latter area there was a great tendency to put cropland down to grass, while a good deal of land also remained in natural or unimproved pasture. All three areas have long been noted for the raising of good beef cattle while in an earlier period sheep were also fairly numerous. With the extension of paved roads these areas came within the range of the Toronto milk shed and some of the farms became fluid milk suppliers. Since these clay plains are small and are highly integrated with the adjoining till plains, and moreover since they are influenced differently by transportation and by other cultural factors, they can hardly be said to have developed a cultural pattern of their own. Yet some trends are apparent. Farms have decreased in number and increased in size, but considerable areas of land have been lost from agriculture to other uses. In the Newmarket area especially, but also in the Schomberg area, rural non-farm population and, consequently, rural subdivision of the land, have increased greatly.

On the farms the cropping pattern, in terms of area used, is made up of hay and pasture, grain corn, barley, mixed grain (oats and barley), winter wheat, silage corn, and oats, in that order. The major change in the last 30 years has been the increase in grain corn from almost none to an average of 22 acres per farm. Barley has also increased while oats have decreased from 13 acres per farm to almost none. Wheat acreage has dropped from 16 acres to 6 acres per farm since 1961. The number of dairy cattle in West Gwillimbury Township was listed as 2,322 in 1961 and 1,144 in 1981. Beef cattle were listed at 1,270 in both those years while the number of hogs dropped from 7,228 to 5,055, and poultry also decreased to only a few per farm. The Schomberg clay plain must, therefore, be rated as a good farming area.

These areas contain a number of towns and villages, such as Bradford (7,357), Schomberg and Lloydtown (1,126), and Newmarket (30,954), to which they must have contributed much in their early periods, but of course they serve wider areas as well. Most important, in the last 30 years, is the fact that they are directly connected with the Metropolitan Toronto area by four or five provincial highways.

35 SIMCOE LOWLANDS

The lowlands bordering Georgian Bay and Lake Simcoe may be termed the Simcoe lowlands (Figure 25). Together they cover an area of about 1,100 square miles. They fall naturally into two major divisions separated by the uplands of Simcoe County. To the west are the plains, lying between 580 feet and 750 feet a.s.l., draining into Nottawasaga Bay mostly by way of the Nottawasaga River. This area is, therefore, called the Nottawasaga basin. To the east is the lowland surrounding Lake Simcoe, lying mostly between 718 and 850 feet a.s.l., which will be referred to as the Lake Simcoe basin. These two basins are connected at Barrie by a flat-floored valley and by similar valleys among the upland plateaux farther north. Both the lowlands and transverse val-

leys were flooded by Lake Algonquin and are bordered by shorecliffs, beaches, and bouldery terraces. Thus they are floored by sand, silt, and clay. The lowest parts of the Nottawasaga basin were flooded in Lake Nipissing time and Lake Nipissing also covered a small area near Coldwater but did not enter the Lake Simcoe basin. The boundary of these lowlands is generally the upper Algonquin beach, although in the Penetang Peninsula, which was mostly within the Algonquin bed, the terrain resembles, and will be classed with, the Simcoe uplands.

Nottawasaga Basin

Named for the river which drains it, this basin is limited to the broad flats bordering the river and does not include the considerable areas of upland which help to swell the area drained by the river to about 1,145 square miles. For the most part, this restricted basin was at one time part of the floor of Lake Algonquin and its surface beds are therefore deposits of deltaic and lacustrine origin and not glacial outwash.

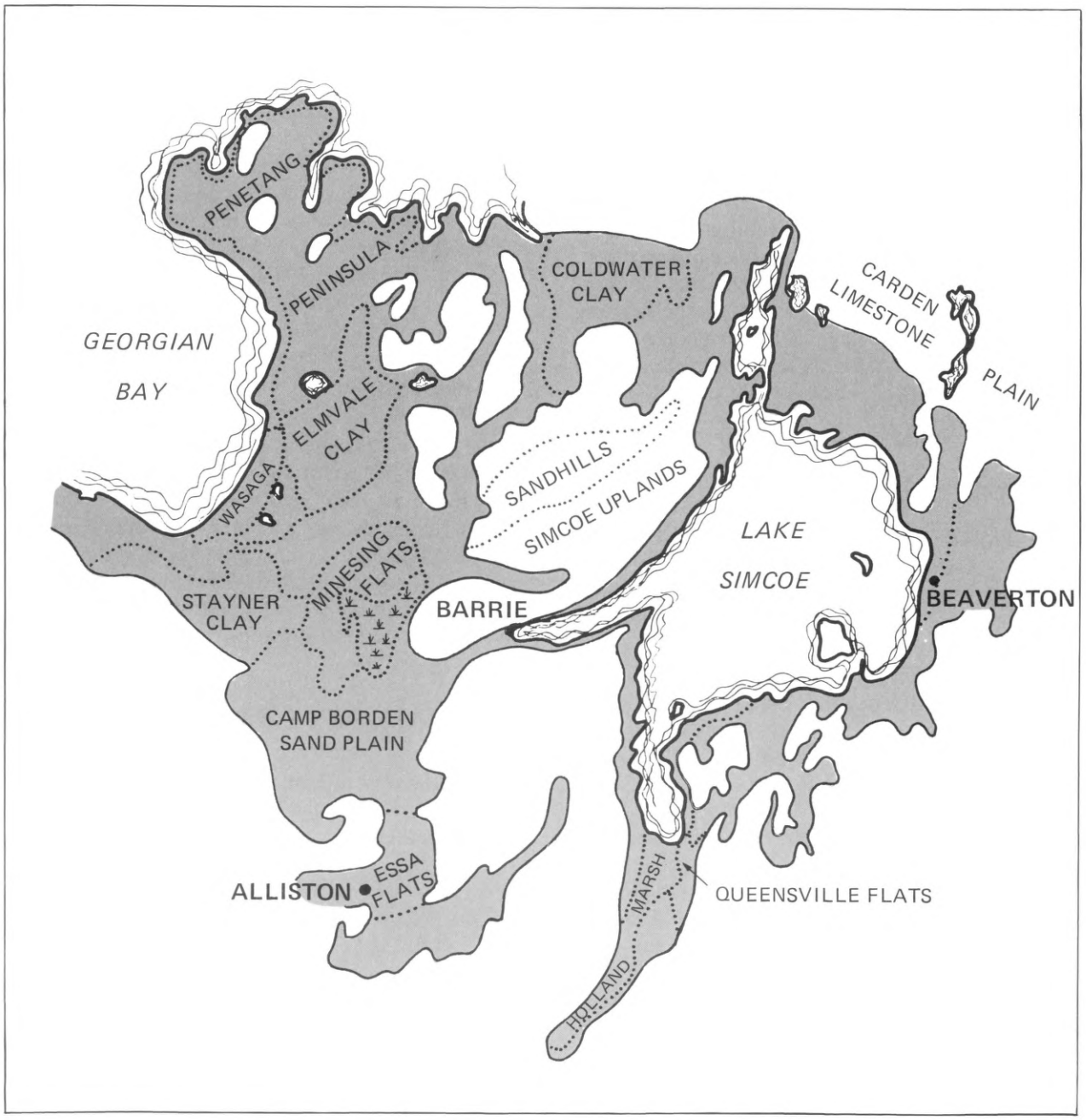


Figure 25. Map showing the several different parts of the Simcoe lowlands.

The southern portion of the basin, lying mainly in Tecumseth Township, represents a bay pretty well separated from the main basin by morainic uplands. Into this area, which we may call the Tecumseth flats, the upper Nottawasaga and its tributaries transported enormous quantities of sand and silt from the dissected outwash terraces of the Hockley Valley. Through these level plains, the present streams have cut only shallow channels and the drainage generally is poor. Near the head of Innisfil Creek in Innisfil Township there is a bog of some 2,000 acres, while another of 1,200 acres is found near Randall station farther down the stream. A third large bog of about 2,000 acres lies along Bailey Creek in Tecumseth and Adjala Townships. In addition to the bogs, this valley contains large areas of imperfectly drained and poorly drained soils which would be useful for special crops if properly drained. These areas have been mapped by the Ontario Soil Survey as Alliston sandy loam, Smithfield silt loam, and Simcoe silt loam (Appendix C).

The sands of Camp Borden (near Angus) and of the Lisle and Tioga areas were brought into the basin by the Pine and Mad Rivers. These loose, coarse-textured materials have been well drained by the entrenchment of the rivers of the area. Classified as Tioga sand or sandy loam, these soils are poor and droughty. They have never satisfactorily sustained an agricultural economy and should all be reforested.

The smaller area adjacent to the confluence of the Boyne and Nottawasaga which we have called the Essa flats, has sandy loam soils of better quality. Apart from a few wet areas the soils are mildly acid Grey Brown Luvisols with an abundance of lime in their parent materials and a fair moisture-holding capacity. These are the soils which gave the Alliston vicinity its reputation for potato growing and which today support the most important area of potato production in the Province. By 1961, 78 tobacco farms had made their appearance on the warm sandy loams of these Essa flats but now only 7 of them are still in production.

The Minesing flats represent an annex of the Nipissing lake plains, a small basin shut in by the Edenvale Moraine. Part of it, the Minesing Swamp, is still undrained and filled with deep peat. For the most part, the swamp is forested with elm, black ash, and soft maple, but in the centre there is an open bog several hundred acres in extent. The remainder of the basin is floored with calcareous clay, some marl (Photo 71) and, in the south, with the sandy delta of the early Nottawasaga. This low area is at times the scene of severe floods caused by the overflow of both the Mad and the Nottawasaga Riv-

OGS 10 722

Photo 71. Nottawasaga River flowing across the Minesing flats. Note the marl beds in the river bank.

ers. The wettest lands are used for pasture where better drainage has been established.

Within the basin there is one important hill upon which the hamlet of Minesing stands. Its soils are formed partly of calcareous clays and partly of overlying sands, both having good drainage conditions.

The Stayner clay plain, despite its low relief, is one of considerable complexity. In part it is a bevelled till plain with pebbly till appearing at or near the surface. Other parts of the area are floored with deeper beds of calcareous clay, while in other places the clay is covered with one to several feet of sand.

The morainic ridge north of Edenvale provides a strip of better-drained soil between poorly drained clay areas to the north and south. Its crest is smoothed by deposits of clay, sand, and gravel. The Nottawasaga River has cut a sharp valley nearly 100 feet deep through the ridge thus draining the lake which once occupied the Minesing basin. Toward the east, the lower Algonquin shorelines are marked by an area of sandy boulder pavement which has mostly been left in woods.

North of the Edenvale Moraine, and behind the Wasaga sand dunes lies the small, flat, Jack Lake basin, containing two small lakes with a normal water level of 589 feet a.s.l. This is well below the elevation of the Nipissing beaches and not far above the normal level of Georgian Bay. The lowlands adjacent to Jack Lake are subject to seasonal flooding by the Nottawasaga River. Like the Minesing basin, this depression contains marl and marly silt deposits.

Northeast of the Jack Lake basin lies the Elmvale clay plain which resembles the Stayner plain. Around Crossland and Allenwood boulder clay is found at the surface and the soil is pebbly. In places there are shallow surface layers of sand. East of Elmvale the stratified clay is deep and marly. Lying, as it does, between the Nottawasaga drainage and the streams flowing to the northeast the whole plain is either imperfectly or poorly drained. About three miles northwest of Elmvale there is a flat area about 2,000 acres in extent formerly occupied by the shallow Cranberry Lake which overflowed to the Wye River. It has been artificially drained but the depression is still subject to floods. East of Wyevale, the Wye River and its tributaries have cut deeply into the clay beds, providing better drainage for the adjoining lands. It is, perhaps, stretching a point to include the upper part of the Wye drainage area in the Nottawasaga basin, but in such a featureless plain there is no clear line of demarcation.

Along the slopes of Nottawasaga Bay to the north of Wyevale, the Algonquin shorelines are marked by considerable areas of sandy boulder pavement, while below the Nipissing bluff a wet bouldery strip has remained largely uncleared. The bluff itself gains prominence toward the north where it is more than 75 feet in height, thus serving as a clear-cut boundary between the lowlands and the uplands.

As an integral part of the Nottawasaga basin the beaches on Nottawasaga Bay must be mentioned, especially Wasaga Beach. The latter is a splendid sandy beach extending for six miles, backed by sand dunes. The dunes constituted a barrier in front of a lagoon in the Jack Lake area in Nipissing times, and they are still actively forming. Hundreds of summer cottages are built on the dunes behind this beach, and during July and August the summer colony amounts to a veritable city. On the east shore of Nottawasaga Bay, Woodland Beach, Wymbolwood Beach, and Balm Beach are also lined with summer cottages owned mostly by Toronto citizens.

The Nottawasaga basin exhibits some notable contrasts in agricultural patterns of land use which must in part be correlated with physiographical differences. In both the sand plains and the clay plains, numbers of farms, farm population, and occupied farmland have considerably decreased in the past 50 years. In both areas the average farm size has risen from 120 to 228 acres while the proportion of farmland in crops has risen from 50 to 70%. Both areas show a considerable decrease in cereal production, particularly in wheat and oats. The clay plains show a much greater increase in hay and pasture than do the sand plains. On the other hand, the Essa sand plains in particular show a great increase in cash crops, including corn (16%), potatoes (11%), tobacco, and asparagus. Livestock raising has changed considerably. There are about the same number of dairy cows but individual herds are larger and milk production is higher. The greatest change is in the number of beef cattle, the clay areas tending toward larger cow herds in keeping with their greater pasture areas while the sand areas specialize more in finishing cattle for market.

Actual farm population has fallen fairly uniformly by about 60% in 50 years throughout the basin. Total population declined slightly as well. Much of the total population has no connection with agriculture but is due to the presence of Camp Borden in the approximate centre of the basin. A smaller number have also been attracted by the development of summer recreational areas along Nottawasaga Bay. There are two towns: Alliston (4,648), the service centre for the local farmers, particularly potato producers, and Stayner (2,580), the farm centre for the northern part of the basin. The villages, Tottenham (3,017), Beeton (1,922), Cookstown (908), Elmvale (1,202), Angus (8,104),

Midhurst (1,938), and New Lowell (350), share in the farm service trade.

Wasaga Beach, with a permanent population of 4,566, is a summer recreation centre for thousands of people, drawn thither by the attraction of the sandy beach of Nottawasaga Bay. There are smaller summer colonies at Woodland Beach and Balm Beach farther north along the bay and they also have some permanent residents.

Lake Simcoe Basin

The eastern portion of the Simcoe lowland is termed the Lake Simcoe basin since about half its area is occupied by the waters of Lake Simcoe. Along the northern and western shores of the lake the lowland consists of a narrow bouldery terrace for the most part confined by a low bluff cut by the highest stage of Lake Algonquin. On the south and east there are broader plains which may be further described.

From the southern end of Lake Simcoe, known as Cook Bay, a broad valley extends southwestward for 15 miles between high morainic hills. Once a shallow extension of the lake, the floor of this valley is now a marsh of 20,000 acres through which the Holland River meanders sluggishly to Lake Simcoe. Near the upper end where it is crossed by Highway 400, from six to eight feet of peat was removed in order to base the highway foundation upon the sand and clay below. Towards Lake Simcoe the peat is considerably deeper. The central portion of the marsh supported a vegetation of sedges, cattails, and other reeds, while the margins had swamp forest consisting mainly of white cedars.

During the first century of settlement the marsh remained uncleared, being crossed by a single road now known as Highway 11. Since 1925 an area of 7,000 acres south of the highway has been diked and drained as garden land. In 1935 a number of natives of the Netherlands came to the eastern side of the marsh, building a new village known as Ansnorveldt. Since then practically the whole area within the drainage scheme has been put into such crops as onions, lettuce, celery, spinach, carrots, potatoes, and other vegetables (Photo 72). Development is proceeding in the area northeast of Highway 11 and about 1,800 acres has been reclaimed for farming. The marsh gardens have brought considerable prosperity to the Town of Bradford (7,357) which has become the location of vegetable storage and packing plants as well as the trading centre for the surrounding population. Although a great deal of the produce is sent directly to Toronto markets, a considerable amount is shipped in refrigerator cars to all parts of Canada and even to the United States.

East of the Holland Marsh the Algonquin lake plain consists of level plains based on deep deposits of sand and silt. Between the marsh and Holland Landing the soils are sandy and have cold wet subsoils. Though partially cleared they have not supported successful general farming; but since the development of the marsh, part of this sand plain has also been occupied by market gardeners. Farther north in what is sometimes called the Queensville flats, the soil is silty in texture and highly calcareous. Much of it has been cleared and occupied by general farmers, who operate under the double handicap of phosphorus deficiency and poor drainage.

Directly south of Lake Simcoe a low, swampy, sandy plain covers most of Georgina and part of adjoining townships. Black River and Pefferlaw Brook are the most important streams but they have failed to provide good drainage. Extending upstream for several miles along each of these streams and their tributaries, Zephyr Creek, Mount Albert Creek, and Uxbridge Creek are long swampy valleys, a mile or so wide, which may be considered as southern extensions of the lowland. It is to be noted that several areas of drumlinized till, which were islands in Lake Algonquin, break the continuity of this plain. On certain exposures the sides of these hills are marked by shorecliffs and barrier beaches, as for example at Little Hell Hill.

About half of this area is swamp or wet sand which has not been cleared of forest, and more of the poorly drained sandy soil has never been fully developed. On the other hand a few very good farms are found on the loamy soil near Virginia. There are no large towns in the vicinity to provide markets, Sutton, with 2,470 people according to the 1981 census, being the largest village. The summer resort population creates demand for dairy produce and fresh vegetables, yet most of this demand is supplied from outside sources.

A good deal of Thorah Township (now the northern part of the Township of Brock) is similar to the wet sand plain just described, modified by several tracts of nearly bare limestone. Fortunately, the better silt loams along the Beaverton River and north of Beaverton make up a higher proportion of the area than in Georgina Township.

Northeast of Lake Simcoe in Mara Township an interesting variation is met in the form of a clay plain dotted with drumlins. The clay is less calcareous than that occurring south and west of Lake Simcoe. The drumlins are elongated and consist of calcareous till and, though stony, the soil is good for general farming. The clay land between the hills is more difficult to handle. Another clay plain without the drumlins occupies the southern part of Orillia Township. The continuity of this flat plain is broken by outcrops

OGS 10 723

Photo 72. Aerial view of vegetable farms on the Holland Marsh, one of the most intensively cultivated areas of the Province. Photo courtesy of the Ontario Ministry of Tourism and Recreation.

of limestone, glacial hills, and patches of sand and gravel. In the north the clay extends to the Precambrian rocks or, more particularly, where they appear on the surface.

The western shore of Lake Simcoe has many sandy beaches which are almost completely occupied by the summer cottages of Toronto people. This littoral area is poor agriculturally, but it includes Barrie (44,111) at the head of Kempenfelt Bay and Orillia (23,854) at the narrows between Lakes Simcoe and Couchiching. Barrie and Orillia are both centres for manufacturing, local trade, and the tourist traffic. The eastern shore of the lake has fewer sandy beaches but summer colonies exist at Atherley, Brechin, Beaverton, and Port Bolster. On the south shore there are fine beaches at Jacksons Point, Roches Point, Keswick, and at several intermediate points.

On the whole, the Lake Simcoe basin is a poorer farming district than the Nottawasaga basin, its major handicap being the extensive areas of bogs and wet sand. However, these latter soils may become useful as population grows, since both could be drained and developed for vegetables.

36 SIMCOE UPLANDS

The Simcoe uplands comprise a series of broad, rolling, till plains (Photo 73) separated by steep-sided, flat-floored valleys. They are encircled by numerous shorelines, indicating that they were islands in Lake Algonquin. Included, also, is a portion of the broad upland south of Barrie, which has certain similarities, and the high ground north of Alliston. These till plains stand about 200 feet above the adjoining lake plains at an average altitude of about 1,000 feet a.s.l. In northern Oro and Medonte Township a range of sandhills stands up above the general level. On the Penetang Peninsula the uplands were submerged in glacial Lake Algonquin with the result that boulder pavement, sand, and silt appear on the surface. They are included here because they are elevated and have rolling topography. The total area of these uplands is estimated at 400 square miles.

The origin of the broad ridges and valleys of Simcoe County is still in doubt. We know that deep wells have been drilled in the valleys without striking bedrock, but have no evidence of rock cores in the uplands. In spite of this the best interpretation which can be suggested is that the surface form follows the bedrock topography; that is, the valleys reflect stream valleys in the bedrock. A second suggestion is that the ridges originated as moraines because of an ice lobe in the Georgian Bay depression. In any event their surfaces were finally planed by a glacier advancing toward the southwest.

The till in these uplands differs from the till found east of Lake Simcoe; it consists mainly of Precambrian rock rather than limestone. Its texture is a

gritty loam, becoming more sandy toward the north, and it is also bouldery. Some heavier, more calcareous till occurs near Lake Simcoe and near Midland. Several drumlins appear near Orillia.

The morainic sandhills of Oro are similar in structure to the Oak Ridges Moraine but consist of less calcareous material. At least half of this belt is still wooded and considerable reforestation is being carried out. It is not good pasture land, and only selected areas are good enough for potatoes and a rotation of crops. In several places the hillsides have been developed as ski runs.

The surface of the Innisfil uplands south of Barrie is smoothed by shallow sand and gravel deposits. North of Barrie also there are gravel streaks which appear to be shoreline deposits of water levels 200 feet or more above Lake Algonquin.

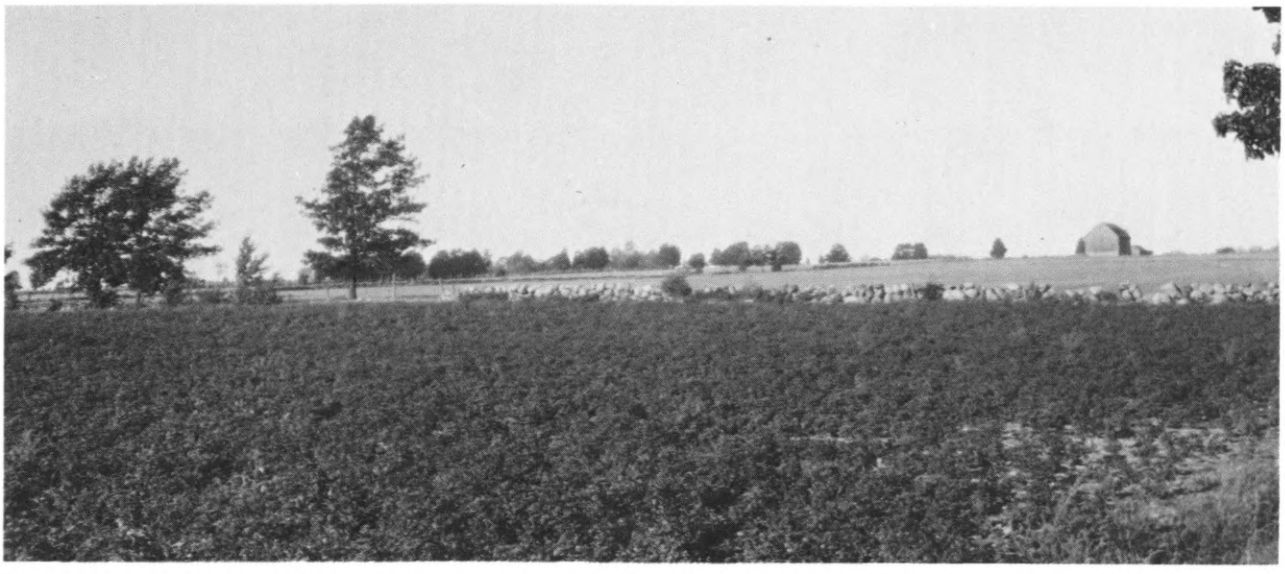
Between Orillia and Barrie and also south of Barrie certain areas are covered by the crooked ribs of loose sandy till and outwash which Deane (1950) called "ice-block ridges". Most of them are roughly parallel with a northerly alignment, while in some cases they encircle little depressions.

The original forest consisted of hardwoods, chiefly sugar maple and beech, together with white pine. Yellow birch, basswood, and hemlock were also common. The white pine groves have largely disappeared, having been cut out during the lumbering period. Beech are more plentiful here than anywhere else in the Province.

The dominant well-drained soil on the glacial till uplands north of Kempenfelt Bay has been placed in the Vasey series. It is a sandy loam which in some areas is rather steep and stony. Because there is often not much limestone in the till its profile differs considerably from the normal Grey Brown Luvisolic soil of the drumlin fields of the southern part of Southern Ontario and has certain relationships with those of the weakly podzolized soils on the Canadian Shield immediately to the north. The surface soil has a low organic matter content and is moderately acid. Weathering often extends to a depth of about three feet but the horizons may be weakly differentiated. The surface is undulating with only a few badly eroded slopes. Swamps are less numerous than in a drumlin field; indeed the sandy till allows downward percolation of water to such an extent that streams are rare on the crowns of the uplands. Springs issue from part way down the slopes, however, to feed the permanent streams in the lowlands.

The Simcoe uplands also include the sandy ridges of the Oro Moraine, the Hendrie forest, the heights overlooking Thunder Bay, as well as many smaller areas. These are also extremely pervious soil areas, sometimes with dry depressions many feet in depth. The loose sandy texture of the surface soil is conducive to wind erosion when the vegetation has been unwisely removed.

The agriculture of the Simcoe uplands may be classified as mixed farming based on a variety of products including milk, cream, beef, veal, hogs, eggs, and poultry. The Lafontaine area in the northern part of the peninsula has long been known for the excellence of its potato seed stock, in part because the slightly acid soils inhibit the development of the potato scab organism. Winter wheat, no longer an important crop, decreases from south to north, Orr Township having four times as much as



OGS 10 724

Photo 73. Rolling stony till plain of the Simcoe uplands, Medonte Township, with a stone fence.

Tay. The same trend is true with fodder corn and grain corn, mainly because of better soil in the south.

From several points of view agriculture seems to be receding; there has been great abandonment of land in recent years, the 1981 census showing that only 50% of the area of Oro and Medonte Townships is occupied by farms. The farms that remain, however, have increased in size to about 155 acres. Only about 75% of the farm area is improved, about half of the remainder being in woods; about 11% is in seeded pasture and about 60% in crop. The important crops, in order, are hay, corn, mixed grains, barley, oats, and wheat. Potatoes are not important, mainly because of the stones in the soil and because the soil texture is too heavy for this crop.

Each 100 acres of farmland carries approximately 30 livestock units which means about 47 per farm. The average farm has about 38 cattle, 20 hogs, 4 sheep, and 403 poultry. About 40% of the cattle are listed as milk cows. In comparison with the adjoining lowlands of the Nottawasaga basin the uplands exhibit considerably less crop specialization and the soils are not so variable as the lowlands.

The upland areas have not developed any market centres of their own, beyond a few crossroad hamlets. They are connected by good highways to both Barrie and Orillia, the growing urban centres of the Lake Simcoe basin. They are also in close proximity to the small ports and manufacturing towns of the Georgian Bay shore, including Midland (11,946) and Penetanguishene (5,282), and the villages of Port McNicoll (1,880), Victoria Harbour (1,094), Coldwater (963), and Waubaushene. These settlements also serve as centres for the Georgian Bay summer recreation region. For winter recreation several ski runs operate on selected hillsides.

37 CARDEN PLAIN

Between the Kawartha Lakes and Lake Couchiching there is an area of 225 square miles of limestone plain with very little overburden (Photo 74). It is named for Carden Township which occupies the central part of the area and where conditions are typical. While the physical conditions are much like those of the Napanee plain farther east, there are certain differences. This area was under Lake Algonquin and some beaches and offshore sand deposits are found. The original forest appears to have had some very good pine stands, but most of the present tree growth is of hardwoods.

There was considerable settlement during the lumbering era. The population peak was reached about 1881 when this limestone plain in Victoria County had about 3,300 people and 470 occupied farms. The latter averaged about 135 acres each with 32% improved land. In 1941 there were only about 1,700 people in the area and less than 280 farms. Farms averaged 315 acres in size with 13% improved land. By 1961 there were only 160 farms with an average size of over 420 acres, with 17% improved, 10% in crop, mainly hay, and 6% in seeded pasture. In the last 20 years the trend toward larger farms and

OGS 10 725

Photo 74. Shallow soil on limestone is typical of the Carden plain, north of Kirkfield, Carden Township.

even more extensive agriculture has continued. The 1981 census for Carden Township gives the average farm size as 493 acres. Improved land is 15%, of which 3% is in seeded pasture and 11% is in crops. There were only 8 head of cattle per 100 acres and very few hogs and chickens. More than 70% of the occupied land is accounted for by rough pasture, much of it being held in lots of 1,000 acres or more. Ten percent of all farmland is reported as woodland. It is probable that a large part of this region was cleared for its timber without any intention of making arable land. Following fire, of which burned stumps give ample evidence, the land gradually came into use for grazing. However, the dairy economy so noticeable on the Napanee and Smiths Falls rock plains never was established here, the land being used mainly as range for beef cattle. It would seem reasonable that some sections should be reforested.

While numbers of farms have continued to decline, and farm population has dropped to about 600, the total population of the area has remained fairly stable since the early 1940s. There are a number of small unincorporated but nucleated settlements including Coboconk (800), Burnt River (240), Kirkfield, and Victoria Road (125), as well as numerous isolated residences along highways and county roads. The presence of a number of lakes has attracted summer visitors and numerous waterside cottages have been built. Physiographic reasoning would indicate that this area should no longer be regarded as agricultural; it requires more than twelve acres to support one unit of livestock; obviously this is an area which in the long term should be returned to forest with full supplementary development of its recreation potential.

38 DUMMER MORAINES

The Dummer Moraines constitute an area of rough stony land bordering the Canadian Shield from the Kawartha Lakes eastward. The typical landscape is to be seen throughout much of Dummer Township and so the name is applied to the region. Other townships partly in the area are Belmont, Marmora, Madoc, Rawdon, Huntington, Hungerford, and Sheffield. The area is about 600 square miles.

The underlying bedrock is sedimentary limestones, mostly of the Bobcaygeon and Gull River Formations but also including some of the overlying Lindsay and Verulam Formations. They form a plain which declines gently southward from an elevation of 800 to 600 feet a.s.l. The limestone terminates on the north in an escarpment 25 to 75 feet in height. In some places there are several smaller north-facing escarpments, while in a few places the rock face is hidden beneath a morainic mantle. On the south there is an irregular boundary between the moraines and the drumlinized till plain.

Lying on the Canadian Shield, sometimes several miles north of the main escarpment, are a number of limestone outliers. In effect, they are detached pieces of this region and agricultural communities of several square miles exist surrounded by a wilderness of Precambrian rocks. The settlements of Oak Lake, Eldorado, and Cooper might be mentioned in particular. In this same area just north of the limestone bedrock, there is some shaley till which is mapped with this morainic area.

Crossing this morainic belt are several streams which are tributary to the Trent or Moira Rivers. Most of them follow preglacial valleys, entrenched up to 100 feet in the bedrock. A number of these valleys are blocked by glacial drift, thus creating long narrow lakes or swamps. The Kawartha Lakes and Moira and Stoco Lakes are prominent examples of this type.

The moraines of this area are characterized by angular fragments and blocks of limestone with many Precambrian rocks also present. The surface is extremely rough even though most of the morainic ridges are quite low. Bordering the escarpment, and here and there among the moraines are areas of shallow drift and even bare limestone. A few drumlins appear in Verulam Township and large eskers are found at Norwood, Tweed, Marlbank, and Tamworth.

In the present forests sugar maple predominates, with white cedar occupying the wetter areas. Basswood, oak, beech, and butternut are also common. There is evidence that white pine and hemlock were more abundant in the original forest than at present. In burned-over areas the second growth consists largely of poplars.

Land Use and Settlement

A surprisingly large proportion of this rough land was occupied and put to agricultural use. Small, odd-shaped fields were labouriously cleared of stones and boulders, and used to grow hay, oats, and corn. Apart from the presence of stones the chief drawback of the soil is its droughtiness and light crops are frequent. Actually, only one-half of the occupied land was ever made fit for the plough, about 27% is left in permanent woodland, and the rest, without being cleared of stumps or stones, is used as rough pasture. Also a large area of land, once cropped, was allowed to revert to permanent grass. The farm economy of this area is similar to that of the adjoining limestone plains, but now tends toward beef production rather than summer dairying for the

production of cheese. For some reason very few hogs are kept.

In this area agriculture has steadily declined since the beginning of the century. Between 1931 and 1961 the number of farms decreased by 42%. Between 1961 and 1981, in Dummer Township, the number of farms has continued to decrease from 173 to 144. Since very little is grown that is not marketed as livestock or livestock products, it interests us to note that in 1931 each 100 acres carried 15 livestock units (each farm therefore about 25), while in 1981 each 100 acres had about 19 and each farm 40. From an historical point of view, animal production has declined by more than 20% between 1931 and 1961, and then increased by almost 60% between 1961 and 1981.

There are no large towns or cities but, for an area of marginal or declining settlement, there is a surprising number of villages. Fenelon Falls (1,681), Bobcaygeon (1,644), Lakefield (2,256), Havelock (1,309), Marmora (1,325), Madoc (1,285), and Tweed (1,545) are all incorporated places. Most of them have a river or railway site which was important in lumbering days. Madoc and Marmora were once close to important mining development. However, all these settlements are now mainly farmer's towns and tourist supply centres. Only Fenelon Falls and Bobcaygeon have shown any growth in the past 20 years, and they about 25%. Besides these there are small unincorporated villages such as Tamworth, Marlbank, Thomasburg, Queensborough, and Warsaw. The rough bouldery land of this area, interspersed as it is with swamps and tracts of bare limestone presents a problem in land utilization. Most important are the pastures, which are in desperate need of renovation if the livestock industry is to continue. In many cases where pasture renovation is too costly, reforestation is in order. On the other hand, with large machines now available to handle the boulders and to level the surface, some more land clearing might be attempted on the better sites. Even though this should happen there is bound to be further withdrawal of agricultural activity from this physically difficult region.

39 NAPANEE PLAIN

The Napanee plain is a flat-to-undulating plain of limestone from which the glacier stripped most of the overburden (Photo 75). Based mainly on limestone of the Gull River and Bobcaygeon Formations, it is a counterpart of the smaller Carden plain, and the larger Smiths Falls plain which is underlain chiefly by sandstones and dolostones of the Beekmantown Group. Centring on the Town of Napanee it covers approximately 700 square miles. While the soil is only a few inches deep over much of the region, some deeper glacial till occurs in the stream valleys and toward the north where this region borders on the Dummer Moraines. There are also a few scattered drumlins of the long, thin type. In the south, particularly, the depressions often have shallow deposits of stratified clay which also provide better soil. This applies also to the Amherst and Wolfe Islands which are included in the Napanee plain.

Cutting the rock plain to a depth of 50 to 100 feet, the valleys of the Salmon and Napanee Rivers provide the greatest elements of relief. In these valleys are found a variety of deposits, mostly of alluvial origin.

OGS 10 726

Photo 75. Shallow soil on limestone, near Napanee, with a typical cover of cedar and spruce trees.

In the original forest sugar maple was probably the dominant tree, with white elm, silver and red maple, and white cedar occupying the low ground. Basswood, beech, and burr oak were also important trees, and there were some white pine, hemlock, balsam fir, and white spruce. White cedar now occurs in fairly pure stands on the dry shallow soil where it is invading old pastures. Hawthorne, hickory, burr oak, and black ash also withstand grazing. The characteristic plants of the pastures and roadsides are Canada blue grass, mullein, blueweed, and ground juniper.

Land Use and Settlement

The waterfront townships of the Napanee plain were among the earliest areas of Upper Canada to be laid out and settled. The pioneer occupants were United Empire Loyalists who made their homes here in the early 1780s. The traveller is reminded of them constantly by the many historical sites and commemorative parks. Particularly interesting are the old meeting house at Hay Bay and the park at Adolphustown. The occupation of the townships in the hinterland took place a few years later.

The geographical centre of the region, and the county seat of Lennox and Addington is the Town of Napanee which, in 1981, had a population of 4,669. It was located at the head of navigation where pioneer industry utilized the power possibilities of the Napanee River, which also served as a means of transportation for logs from the interior. As well as for saw milling, Napanee became a centre for grist milling and other farm service industries for a wide area. While there were boggy spots, the pioneer roads over the flat rock plains were generally passable at all seasons. Belleville (35,351) to the west, and Kingston (60,313) to the east exert a considerable influence over the extremities of this plain, but under the conditions of pioneer transportation they were unable to suppress the development of a local trading centre approximately halfway between them. At any rate, the earliest land route lay along the shore through Bath (990) and Adolphustown, to the ferry across the bay to Prince Edward County which was also an area of early settlement. Napanee was thus secure in its position of pioneer outpost. Scattered over the plain were many local supply points. Some of those still surviving are Cataraqui, Camden East, Newburgh (606), Odessa (950), Roblin (100), Sydenham (800), and Yarker. Amherst Island has the little village of Stella (100), while Wolfe Island has the somewhat larger village of Marysville, as local supply points. These are important, since all transportation to the mainland involves ferry services.

The land was early and completely occupied by farms. In 1931, 99% of the area in Lennox and Addington County was listed as agricultural land, while in 1961, it was still over 90% and among the highest degrees of farm spread in the Province. The number of farms has decreased while the size of farms has increased from about 125 acres (1931) to 195 acres (1961), and to 209 acres in 1981 with the largest holdings being more than 1,000 acres. In 1981, the average farm has about 10% of its area in woods and 18% in other unimproved land. About 60% is devoted to crops of which hay (23%) and corn (21%) are by far the most prevalent, while barley, wheat, oats, and mixed grains, taken together occupy less than 15% of the farmland. Cultivated and rough permanent pasture occupy 26%, thus grazing is on a very extensive scale. Roughly 47% of the commercial farms of the area are dairy farms while 53% depend mainly on beef cattle. It is noteworthy that beef cattle have increased in recent years while the population of dairy cows has declined, although the individual herd has increased to 12 cows in size and average production is 9,250 pounds per cow. By comparison, the average production in 1931 was only about 5,000 pounds per cow. Hogs, sheep, and poultry have notably decreased.

Averages unfortunately tend to obscure some basic realities. The census shows that three-quarters of the farms in this area can be classified as commercial, that is, in 1981 they had gross sales of more than $2,500. But only about half of these or about one-third of all census farms sold more than $10,000 per farm. The net farm income in 1980 was only $1,448. This is a much more realistic measure of the agricultural capabilities of the plain. Furthermore, approximately 90% of all farm operators appear to hold a job somewhere away from the farm, an adjustment forced in part at least by the shallow soils of the plain.

We do not have exact data for population distribution over the whole of what we have designated as the Napanee plain, but we can use a land area of 335 square miles, consisting of the townships of North and South Fredericksburgh, and Adolphustown, for which there is census data to represent the region (Table 7).

TABLE 7 POPULATION OF A REPRESENTATIVE AREA OF THE NAPANEE PLAIN, 1981

Total	10,968	100%
Urban (1 town)	4,795	43.7
Rural	6,173	56.3
farm (178 farms)	623	5.7
non-farm (includes 2 villages)	5,550	50.6

area: 335 square miles
population density: 32.7

It is only fair to say that the southern part of the plain, through which run the main corridors of traffic (Highways 2, 401, and 33), contains not only the incorporated places but also a much greater density of the scattered, non-farm rural residences. Total population density, in comparison with other Ontario areas, is sparse at 56 people per square mile. In the non-corridor township of Camden East, total density is only 27 per square mile, of whom 27% are farm residents. One can only conclude that the Napanee plain is a zone of difficulty and that a fair number of those who live on it do so for the sake of cheap space adjacent to a highway.

40 PRINCE EDWARD PENINSULA

Prince Edward County is a plain or low plateau of limestone projecting into the eastern part of Lake Ontario and almost separated from the mainland by the Bay of Quinte. The isthmus between the Bay of Quinte and Presqu'ile Bay at Carrying Place has been cut through by the Murray Canal, artificially creating an island. This isolation gives us our best chance in Southern Ontario to use a county as a natural region to which census data apply. Manitoulin Island is a closely related case, but there the administrative district includes a small section of mainland as well.

Prince Edward County has an area of 405 square miles, and is wholly underlain by the Lindsay Formation except for one small hill of Precambrian granite near Ameliasburgh. The highest point in the county lies between Picton and Glenora, reaching slightly more than 500 feet a.s.l. or more than 250 feet above the surface of Lake Ontario. Near this, the oddly located Lake-on-the-Mountain has an elevation of 415 feet a.s.l., while most of the area of limestone plain has an elevation of about 350 feet or about 100 feet above Lake Ontario. Two other upland lakes worth noting are Roblin Lake near Ameliasburgh and Fish Lake near Demorestville. The shoreline is irregular because a number of deep valleys dissect the limestone and thus form long bays or inlets. The surface of the plain has a slight gradient toward the southwest and the western and southern shores are very low. The inlets there are often closed by transverse bars, thus forming lagoons such as West Lake, East Lake, and other smaller bodies of water. On the other hand, the northern and eastern shorelines are often precipitous limestone bluffs rising 100 feet or more.

As a result of the irregular surface and the much indented coastline, the land survey of the county is also irregular. Shore roads were the natural original routes, and lots were laid out along them. Routes of rather irregular direction also follow the strips of deeper soil. Nevertheless the roads of the peninsula seem to be unnecessarily crooked although, as one resident wryly remarked, "they had to bend them or else they would have stuck out into the lake."

More than half of the county has shallow soils, that is, soils with less than 30 inches and mostly only a few inches of unconsolidated material over the bedrock. The profile development of these soils as well as their agricultural uses are conditioned by lack of depth and water holding capacity. A large area, approximately 55,000 acres according to the Ontario Soil Survey, must be classed in the Farmington series and regarded as similar to the soils of Manitoulin Island, the Napanee plain, Smiths Falls plain, and other mainland regions of shallow soils on limestone.

In the townships of Hillier and Hallowell, however, the surface strata of the Lindsay Formation are thinly bedded and have shale partings which have disintegrated to some depth (Photo 76). Consequently these soils provide better conditions for plant growth than those overlying more massive limestones. These soils are referred to as the Hillier series by the Ontario Soil Survey. Among the farmers of Prince Edward County, they are referred to as "clay gravel" or "limestone gravel" depending upon the relative proportions of these constituents. They cover about 25,000 acres. In other areas, notably in Ameliasburgh, about two feet of till overlie the

OGS 10 727

Photo 76. Nodular limestone of the Lindsay Formation exposed along a road cut in Prince Edward County.

limestone. There the soils have been classified as Ameliasburgh loam and clay loam, the areas covered by each type being about 25,000 acres.

In the low areas bordering Big Bay, Muscote Bay, South Bay, and Prince Edward Bay there are extensive areas of deeper clay deposits forming clay plains of about 34,000 acres in extent. Profile development varies greatly according to drainage conditions and a number of soil series have been identified. In certain areas, more notably in the townships of Sophiasburgh and Hallowell, there are a few areas of deeper drift with some low, but well-formed drumlins. The soils of these areas have been referred to the Darlington series. Notable, also, are the areas of sandy soils in the region southwest from Picton, between East Lake and West Lake. Sand dunes up to 75 feet in height are found on the barriers separating these lakes from Lake Ontario.

Prince Edward County contains over 10,000 ha of marsh and other organic soils (mostly hardwood swamp). Marshes border nearly every lake and lagoon in the county but are especially notable near Muscote Bay, East Lake, and West Lake. Many small areas of muck are found in the shallow depressions on the rock plains such as those near Ameliasburgh and Hillier, but the two largest areas are the Big and Little Swamps. The Big Swamp is about 10 km in length from east to west, 2.7 km in width, and has an area of 14 km^2. The Little Swamp, is 6 km long, 1.7 km wide, and has an area of 6 km^2. The average depth of organics is less than 2 m in Big Swamp and less than 1 m in Little Swamp. There has not, as yet, been any extensive vegetable growing on muck soil in the county. In all, 28 types have been described. They occur in a tightly packed mosaic of small areas and have had considerable effect upon the diversification of agriculture within the county.

From the climatic standpoint Prince Edward is favoured with warmer summer temperatures and a week longer frost-free season than the adjoining mainland. Its chief limitation is lack of enough rain in summer. Of course, droughts are particularly severe on the shallow soils. One of the greatest possibilities for development of this peninsula appears to be in supplemental irrigation.

Land Use and Settlement

Prince Edward County was early and almost fully occupied by farmers, most of them of United Empire Loyalist stock, and some very attractive old farmhouses still exist. After the pioneer stage, grain farming was tried by many and for a time a great deal of barley was shipped to the United States. Then the shallow lands of Prince Edward County, like those of the mainland limestone plains, went over to summer dairying for cheesemaking. The protection from frost afforded by the lake and the excellence of some pockets of deep loamy soils encouraged some famers to set out orchards of apples and some other fruits. For the same reasons, also, canning crops, mainly green peas, sweet corn, and tomatoes, became popular and a number of canning factories were set up. Peaches, however, are not grown.

Most of the commercial farms of Prince Edward County fall into four types, dairy farms, livestock other than dairy cows, fruit and vegetable farms, and mixed farming with livestock combinations. However, most (92%) of them are being worked part-time, the operators having jobs off the farm. In addition, it may be pointed out that some farms have been abandoned as operating units and are now devoted entirely to summer grazing of young cattle.

The area of agricultural land in the county is 177,000 acres, about 71% of the total area. During the Second World War some areas were taken for government purposes, and there has recently been some land taken for industrial use. The census of 1981 revealed 791 farms with an average area of 224 acres. For the most part they are 100 to 400 acres in size, although 63 are larger than 400 acres. About 58% is in crops and 10% in improved pasture. About 10% of the farm area is woodland and there is about 18% unimproved or natural pasture. The chief agricultural products may be listed as follows: dairy products, horticultural products, cattle, poultry and eggs, and hogs. It is unfortuanate that good agricultural land is so scarce in Prince Edward, otherwise its natural advantages of climate and position would make it one of the more productive areas in the Province.

Prince Edward County reached a population peak in 1881, declining about 20% during the next 50 years. Since 1945 it has exceeded its old level, and now stands at 22,336. The Town of Picton (4,253), and the villages of Wellington (1,077) and Bloomfield (728), are farm service and resort supply centres. Picton is the site of a cement factory and for one period was an iron ore port. Canneries have long operated at Wellington, Bloomfield, and West Lake and there are a number of cheese factories in the county. An analysis of the population is shown in Table 8.

Prince Edward's long shoreline, enclosed bays, sand beaches, and sand dunes (Photo 77) are natural resources that have been put to good use. Resorts, cottage colonies, and provincial parks draw many people to this delightful area where lake breezes modify the summer heat.

TABLE 8 POPULATION OF PRINCE EDWARD COUNTY, 1981

Total	22,336	100%
Urban (1 town, 1 village)	5,437	24.3
Rural	16,899	75.7
farm (791 farms)	2,628	11.8
non-farm (includes 1 village)	14,271	63.9

area: 405 square miles
population density: 55

41 IROQUOIS PLAIN

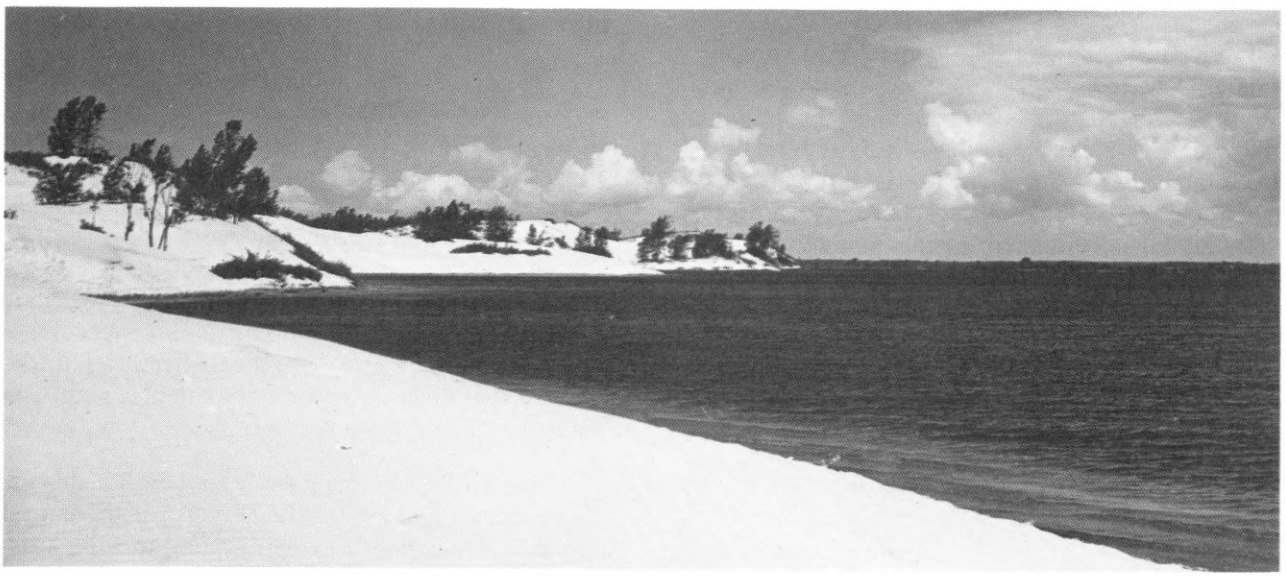
The lowland bordering Lake Ontario, when the last glacier was receding but still occupied the St. Lawrence Valley, was inundated by a body of water known as Lake Iroquois which emptied eastward at Rome, New York State. Its old shorelines, including cliffs, bars, beaches, and boulder pavements are easily identifiable features, while the undulating till plains above stand in strong contrast to the lake bottom which has been smoothed by wave action or lacustrine deposits. The latter area is the Iroquois plain which is discussed in this section, excluding the areas to the east which were flooded by Lake Iroquois but which, because of shallow soils, are treated elsewhere. The Iroquois plain extends around the western part of Lake Ontario, from the Niagara River to the Trent River, a distance of 190 miles, its width varying from a few hundred yards to about eight miles. Then it extends inland to include a large area in the Trent River valley. Conditions in the old lake plain vary greatly and it is convenient to divide it into a number of sub-sections for purposes of discussion.

Niagara Fruit Belt

The area commonly known as the Niagara fruit belt lies between Lake Ontario and the Niagara Escarpment and extends eastward from Hamilton to the Niagara River. For the most part this lowland lies within the Iroquois plain but it also includes higher terraces adjacent to the escarpment. The plain is cut by no large streams, but a number of smaller ones cross it to Lake Ontario, including Twelve Mile, Sixteen Mile, Twenty Mile, Stoney, and Redhill Creeks. All of these are drowned in their lower courses, producing lagoons or marshes cut off from Lake Ontario by a barrier beach.

From Grimsby eastward, the lake plain contains areas of sandy soils which have enabled the area to become an outstanding fruit-growing region. As the beds of sand are never very deep and often overlie clay at two to three feet; these soils have wet subsoils and are usually tile-drained. West of Grimsby the soil is largely developed upon red clay derived from the underlying Queenston Formation. This soil is heavy in texture and of low permeability, hence it sheds water easily and dries out rapidly. Acid in reaction, it has retained very little organic matter because of the lack of grass in the clean cultivated orchards and vineyards, and is a difficult soil to work. From Stoney Creek to Hamilton there are broad gravel ridges upon which well-drained loams have developed. Most of the farms are specialized to fruit and vegetables. The important crops are grapes and peaches but sweet and sour cherries, pears, and small fruits are also grown extensively.

It is estimated that there were originally about 35,000 acres of well-drained, light-textured soils in



OGS 10 728

Photo 77. Active sand dunes in Prince Edward County on the shore of Lake Ontario.

the Niagara Peninsula suitable for the growing of peaches (Krueger 1960). However, the advantages of the area are primarily climatic (Mercier and Chapman 1956) as there are considerable areas of soil elsewhere in Ontario which are just as suitable for fruit growing but are subject to greater climatic hazard. Unfortunately for fruit growing, the Iroquois plain in the Niagara Peninsula is in great demand as sites for housing and industry as well as for transportation and other facilities that go along with them. The City of Hamilton has spread eastward to engulf much former fruit land while St. Catharines has annexed part of Grantham Township thus effectively cutting the fruit belt in two. Nevertheless, fruit acreage in the Niagara area continued to increase at the expense of other crops until about 1956. Since then fruit growing has been losing ground to non-agricultural uses.

Ontario Lakehead

That portion of the Iroquois lake plain which lies at the head of Lake Ontario deserves attention as a special part of the Iroquois plain. Geographers mention many reasons why a lakehead location is likely to result in the building of a city. It is likely to be a port, a point at which transfer is made between water carriage and land carriage of persons and goods, a place of trade with a large hinterland, a place of processing goods brought thither by both land and water, and a place for the establishment of secondary manufacturing industries.

While it now has all of these characteristics, the City of Hamilton did not start out with them in mind. Dundas was at first much more the port and entrepôt, because of the building of the Desjardins Canal to that town to exploit as fully as possible the advantage of water carriage, and having the most direct access by road to southwestern Ontario and the settlements of the middle reaches of the Grand River. Burlington on the north side of the lake was also better suited to the area developing behind it. Thus Hamilton was not founded as a village until 1812.

Its advantage seems to have been as a focus of land routes. Later it grew downhill to the bay and developed its own port, quickly overcoming the lead of both Burlington and Dundas to become the most important lakehead community. Physiography, however, had denied it the supreme advantage, namely proximity to the natural connecting link between Lake Ontario and the upper lakes.

Lake Iroquois, however, had left it some advantages. The site, a narrow plain between the lake and the "mountain", afforded direct connections with Niagara by way of the old shoreline, the old bayhead bar provided a corridor to the north shore, and the old, higher terraces inside the bar lead to an easy grade up the escarpment to Ancaster, thus bypassing Dundas in two directions. When the railways came, they also had to come around the head of the lake and the Iroquois bar became the natural route even though it involved a tunnel through the bar itself in order to reach the centre of the city. The old bar also furnished high, dry ground for the cemetery and, later at the northern end, its slopes provided the site for the rock garden. Iroquois terraces in almost all locations have furnished favoured building sites, among the more notable, perhaps, being the location of McMaster University.

Hamilton to Toronto

The next section is that occupying the northeast-trending shore of Lake Ontario from Burlington to Toronto. Beginning with the great gravel bar which lies through Aldershot, the shoreline continues as a distinct bluff cut in red shale of the Queenston Formation for about 18 miles. In the vicinity of Clarkson and Cooksville the old shore is cut in grey shale of the Georgian Bay Formation, while in other places as in Toronto itself, along Davenport Road west of Yonge Street (*see* Figure 26), the Iroquois shoreline is cut in Pleistocene deposits.

Besides the Aldershot gravels the old lake built barrier beaches of varying sizes across Bronte Creek, Oakville Creek, the Credit River, Etobicoke Creek, and the Humber and Don Rivers in Toronto. Those at the Credit, Humber, and Don, especially, were noted sources of sand and gravel for many years but are now worked out.

The other boundary of the plain is the present shoreline where, as its water level has gradually risen, Lake Ontario has gradually cut back into the red shale from Burlington to Oakville, the grey shale at Clarkson, and the delta sands at Lorne Park. The mouths of the streams along this shore have all been drowned for some distance, but none of them has been cut off by a bar to form a lagoon like that of Jordan Harbour at the mouth of Twenty Mile Creek on the other side of the lake.

Between the two shorelines, ancient and modern, the surviving portion of the bed of Lake Iroquois is a slightly sloping plain with an average width of about two miles. In some areas it is covered with stratified sands of varying depth, in others, the soil is formed directly on the wave-eroded surface of the red shale and, in still others, a shallow cover of till remains over the bedrock as in the Niagara fruit belt. The sandy soils of Aldershot, Burlington, Bronte, Oakville, Clarkson, Lorne Park, and Humber Bay were preferred over the adjoining clay areas. This

narrow belt with its discontinuous areas of good soil, being protected to a considerable extent from frost damage by its proximity to the lake, and being quickly accessible to city markets by direct road and rail facilities, became an important horticultural area. Having just a little shorter season than the Niagara fruit belt very few of its farmers tried to specialize in peaches and grapes. Instead this area became famous for apples, pears, bush fruits, strawberries, and vegetables.

The Lakeshore fruit and vegetable district is, however, now almost a thing of the past. In 1941 there were about 1,000 fruit and vegetable farms in this area, with more than 15,000 acres of orchard, small fruits, and vegetables. There were also a number of general farms and rural estates. The small towns of Burlington, Oakville, Port Credit, Mimico, New Toronto, and Long Branch held a total population of 33,000 people. Now, in 1983, the whole of the Iroquois plain between Hamilton and Toronto has been built up. In a span of four decades, horticultural activity on the inter-urban portion of the Iroquois plain has been engulfed by a flood of more than 500,000 urban people.

The gravels of the old beaches have been excavated for use in construction. The sand plains make excellent housing sites, often without the necessity of providing sewers, while any flat lake plain with bedrock at shallow depths can be used for industrial sites. The lakeshore has two added advantages: large quantities of water may be pumped from the lake and new port facilities may be installed. These advantages have brought thermal-electric power plants to Cherry Beach (part of the City of Toronto) and Lakeview (part of the City of Mississauga); oil refineries to Clarkson and Bronte, and cement, gypsum, and clay products industries to Clarkson. Worthy of mention is the modern development of small-boat harbours in the drowned estuaries at Port Credit, Oakville, and Bronte.

Toronto

The growth and development of the City of Toronto may be assigned to the influence of many factors. Not the least of these, by any means, is the physiographic pattern of its site. Toronto was selected as a site for urban development because of its harbour. The harbour, in its natural state, is protected by Toronto Island: a bar composed of sands derived from undercutting of the Scarborough Bluffs, a product of the waves and currents of Lake Ontario. The land on which the first settlement was made and, in fact, the whole area in which the first century of growth took place was an inheritance from the realm of glacial Lake Iroquois. The Iroquois lake plain, cut in previously deposited clay and till, is partly floored with sand deposits as shown on the generalized surficial geology map (Figure 26). It is about three miles in width, sloping gently northward from the level of Lake Ontario at a rate of 50 to 60 feet per mile. Along its northern border are evidences of the old beach and a steep bluff or shorecliff which, at Casa Loma, is about 75 feet high. Both to the east and to the west of the shorecliff, the deep valleys of the Don and Humber Rivers were cut to early Iroquois base levels. Across these valleys Lake Iroquois built immense sand and gravel barriers, so that, in Iroquois times, Toronto had two harbours instead of one. The old bars furnished countless tons

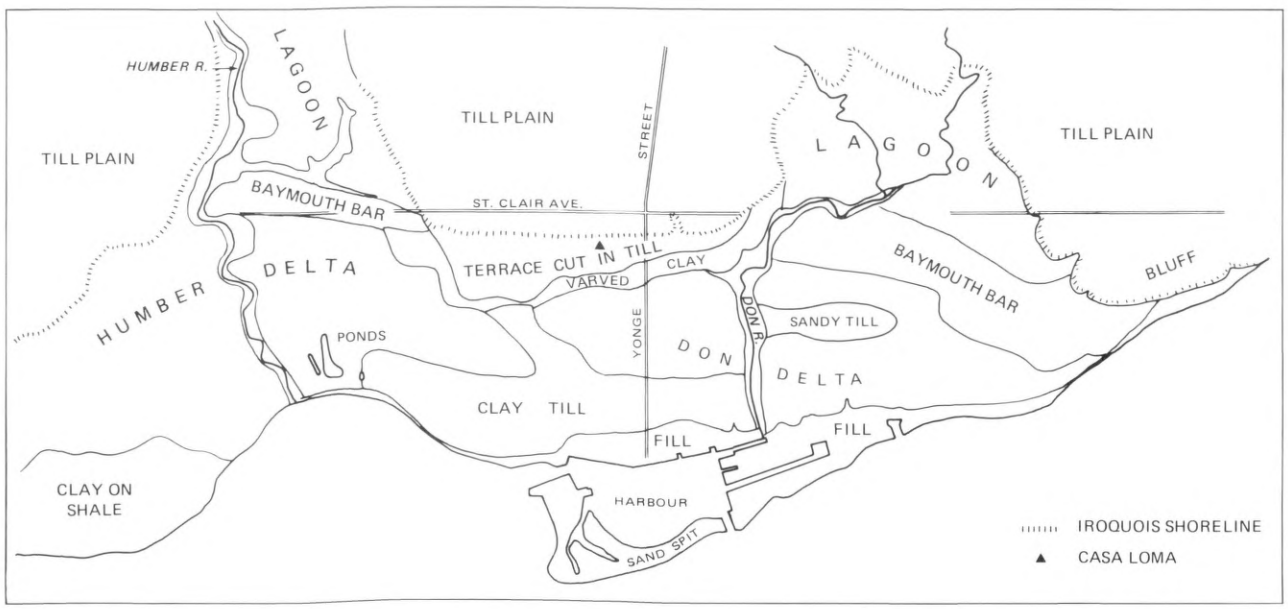


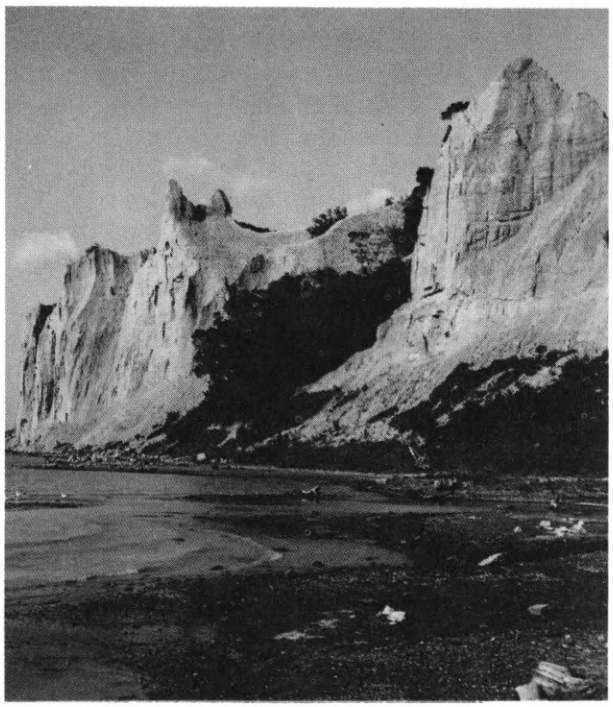
Figure 26. Generalized map of the surficial deposits of Toronto.

of sand and gravel, particularly in the Humber Valley, while in the Don Valley and some of the ravines deposits of clay were exposed which were suitable for the making of bricks. The sands and gravels were deposited by Lake Iroquois, but the clay for the most part was of pre-Iroquoian age.

Eventually Toronto grew large enough to fill the area bounded by the harbour, the bluff and the two river valleys. It has crossed both rivers to occupy further segments of the Iroquois plain and expanded northward into the Peel plain. However, the downtown area, the "central business district", and most of those institutions which are the essential constituents of "the city" are still to be found in a few hundred acres of the Iroquois plain adjacent to the harbour.

Scarborough

In the City of Scarborough the Iroquois shoreline lies very close to the present shoreline of Lake Ontario. Here are the famous Scarborough Bluffs (Photo 78), standing about 350 feet above the lake at their highest point. These cliffs are cut in Pleistocene deposits composed of till, varved clay, and interstadial and interglacial sands of various ages. Between the top of the cliff and the old shoreline is a wave-cut terrace floored by a few feet of sand laid down in Lake Iroquois. It is constantly being reduced in area, undercut by the waves of Lake Ontario, and is not important for agriculture. It is occupied by a golf course and other recreational facilities and, toward the east by residential subdivisions. As scenic attractions, the cliffs are unrivalled along Lake Ontario.



OGS 10 729

Photo 78. Scarborough Bluffs: progressive erosion produces constantly changing shapes. Photo courtesy of E.V. Sado.

Scarborough to Newcastle

The Iroquois plain on the north shore of Lake Ontario from Scarborough to Trenton is an area of considerable complexity but one not easily divisible into well-marked geographical units. To a certain extent, however, the meanderings of the old shoreline, the soil pattern of the old lake plain, and the mosaic of present land use, enable us to distinguish certain areas.

First and largest is the area extending from Scarborough to beyond Newcastle. Eastward from Scarborough Bluffs the plain widens rapidly until at Greenwood the old beach is six and one-half miles inland from the present shore of Lake Ontario. Highland Creek and the Rouge River debouched sand into the old lake to build the sand plain in the southeast corner of the City of Scarborough and the adjacent portion of Pickering. Across the Regional Municipality of Durham the Iroquois plain has a fairly constant pattern. The old shoreline is well marked by bluffs or gravel bars while immediately below it is a strip of boulder pavement and sandy offshore deposits which varies from one-half to three miles in width. Fairly level and often poorly drained, this coarse sandy soil is not very productive and much of it is covered by cedar thicket. An exception, however, is provided by the dry sandy terrace north of Oshawa. The rest of the plain is a mosaic of till plains, drumlins, and areas of silty lacustrine deposits. The two most important soils of this area are Darlington loam and Newcastle loam, the former developed on the upland areas of till, and the latter on the lacustrine sediments in the lower lying areas. Both of these are good, well-drained soils, but in some areas there are also imperfectly and poorly drained profiles developed on similar materials.

A study of trends in rural land use was made of this area by R.G. Putnam (1962) while a study of the process of urbanization in Pickering Township was made by Cramm (1962); both have been used to supplement our own observations. Previous to 1930, and for the most part until 1940, the Iroquois plain was a general farming area, differing little from the till slopes above it, except for a tendency toward horticulture and the growth of canning crops. The mellow, stone-free soils of the lacustrine deposits and the diminished frost hazard near the lake were contributing factors. The area near Newcastle is noted as one of the best apple-producing areas in

Ontario. The sand plain, however, was an area of poor general farms. Since 1940 the farms have become fewer, larger, and more specialized, while much land has been taken out of agriculture and put to urban uses. The specialties include those which were carried on before: orchards, other horticultural crops and canning crops, and tobacco which has come into the sandy soil in a minor way.

The area is no longer actually rural. Of its 125,000 acres, about 27,000 are included within the bounds of urban municipalities which now contain about 250,000 people. Largest of these is the City of Oshawa, but there are also Ajax, Pickering, Whitby, Bowmanville, and Newcastle, making an urban zone extending for 30 miles to the east of the limits of Metropolitan Toronto. In addition to those who are actually urban dwellers, there are many suburbanites, dwellers in rural subdivisions, and several thousands who live in scattered rural non-farm residences. The whole area may well be said to lie within the "urban shadow" (Putnam 1962).

Small urban nuclei had been there before, even from the earliest days of settlement, in order to serve the surrounding rural areas. Physiographic influence was strong in early settlement days. Physiography also provided the easy grades for the railways and highways that now link these settlements together and to the metropolitan centre to the west. Physiography alone cannot be credited with the location of General Motors at Oshawa, any more than that of Ford at Oakville; but for both of them the Iroquois lake plain provided reasonably flat building sites. Oshawa and neighbouring areas will undoubtedly go on attracting both industrial and residential land uses until full urbanization takes place. In this way, as in the area west of Toronto, waterside locations will attract certain types of large industries while water supplies and sewage disposal will be comparatively easy to install. It is not difficult to foresee a time when agricultural land uses have been banished forever as Toronto expands over all this area.

Newcastle to Trenton

East of Newcastle a group of drumlinized uplands formed islands in Lake Iroquois and now serve to interrupt the continuity of the lake plain. Beyond it there is a small natural basin drained by the Ganaraska River which has already been mentioned. The soils in this area are sandy and rather unproductive under a general farming program. However, since the early 1940s this area has become an outlier of the Ontario tobacco belt, with an annual crop of flue-cured cigarette tobacco from more than 1,000 acres.

To the north of Port Hope and Cobourg, the old shoreline is very much indented. It is a region of many large drumlins, some of which stood out as islands in the old lake while others formed jutting promontories. Against the exposed ends of the drumlins the waves maintained a constant and merciless attack, cutting steep shorecliffs and spreading the debris in the hollows to form a broad offshore terrace. For the most part it is a dry terrace, cut at intervals by deep stream valleys. Wet boulder pavements are rare exceptions. These islands, cliffs, and terraces are well in evidence along Highway 46 from Cobourg to Baltimore and along the county road from Baltimore westward to Dale. This is a picturesque, general farming section with numerous fieldstone houses. The steep hillsides are mostly used for pasture, while the dry part of the inter-drumlin valleys are used for field crops.

From Cobourg to a point a few miles east of Colborne, the Iroquois plain is about three and one-half miles in width and has a peculiar belted pattern. Through the centre, along Highway 2, numerous drumlins may be seen. They are large drumlins, some of them reaching a height of 150 feet or more, while some of the slopes have been over steepened by the waves of post-Iroquois waterplanes. They have a southwest alignment and the hollows between them are floored with silt. To the north along the route of Highway 401, the high shoreline of Lake Iroquois may be seen, the old waterplane rising steadily from 565 feet a.s.l. near Baltimore to 600 feet a.s.l. near Biddy Lake. The broad, slightly sloping sand terrace of the old shoreline provides an excellent base for a four-lane highway. Between Highway 2 and Lake Ontario, the land is almost flat, much of it having only a shallow covering of drift over the bedrock. An occasional, long, low, slender drumlin is seen, oriented almost west. There is a considerable area of cedar-forested swamp. The lacustrine deposits here are composed of sand, fine sand, and silt, and where drainage is good the soils are suitable for orchards.

North of Colborne, the Iroquois plain is narrowly constricted, but the old shoreline then swings abruptly northeastward along the base of the Murray Hills to leave a lake plain over six miles wide. The triple belts are still in evidence but they become wider and most semblances of drumlin forms are missing from the central belt. Instead, it is a rather hilly, sandy region at the base of which is a post-Iroquois shoreline.

This wider area of the old lake plain, extending from Brighton to Trenton is also one of the noted orchard areas along the north shore of Lake Ontario. Tomatoes and other canning crops are also extensively produced. Near Smithfield an important experimental station for orchard practices is maintained by the Government of Canada. Brighton is also the nearest point of access to Presqu'ile Park, a

low rock mass in Lake Ontario tied to the mainland by a long sand spit enclosing a lovely little bay.

Once the Oshawa urban-industrial complex is left behind the eastward traveller enters one of the oldest settled rural areas in Ontario. Not only was it settled early but it rapidly became and has remained a corridor between more densely settled areas. It also has some of the oldest towns in Ontario, none of which have grown very large. Among them may be mentioned Port Hope (10,274) and Cobourg (12,980), both of which in their time had hoped to be the lake port serving Rice Lake, Peterborough, and the whole upper Trent watershed. They have become small manufacturing centres as well as service centres for their rural umlands. Colborne (1,821), which used to advertise itself as "the oldest apple town in Ontario", and Brighton (3,232) are little more than rural service centres with some interest in the lakeshore recreational areas. Trenton (14,887) serves the lower Trent Valley, is a small port at the outlet of the Trent Canal, and has some manufacturing. A flat area just east of the town is also the site of one of Canada's most important airforce bases.

Trent Embayment

While Lake Iroquois extended far to the east of the Trent River, the inundated area has other characteristics which have led us to give names which do not emphasize the relationship to Lake Iroquois. Northward and eastward, however, there is a complex area embodying much of the lower Trent drainage, which bears many marks of the Iroquois inundation and to which we attach the name Trent embayment. It was, indeed, a great bay of Lake Iroquois, containing many islands. Large areas, of course, are made up of wave-washed hillsides or boulder pavements. There are numerous sand plains such as that near Morganston. Other areas in the Trent lowland have deposits of stratified silt such as those near Codrington, Norham, Campbellford, and elsewhere. Lacustrine deposits of various types are found in the Trent basin all the way upstream to Peterborough. Although in many places the old shorelines are vague, the general "drumlin and clay flat" pattern of the landscape is unmistakably characteristic. The Trent basin also includes the great marshes along Percy Reach as well as Rice Lake which is still an open body of water. Northeast of the Trent, near Stirling, a fairly extensive clay plain occurs. A wide area of lacustrine deposits occurs along the Ouse River. The whole area defies a rigid classification for it is, simultaneously, a part of both the Peterborough drumlin field and the Iroquois lake plain. In terms of land use it is still largely a general farming area, with more emphasis on meat products than on dairy products.

To some extent the Trent River itself provides a natural geographical focus to this region. Falling 368 feet from Rice Lake to the Bay of Quinte, the Trent and its major branches provided a number of power sites which attracted pioneer urbanization. Hastings (959), Campbellford (3,364), Stirling (1,658), and Frankford (1,892), are the largest urban centres upstream from Trenton. There are 45 locks on the Trent-Severn Waterway in a distance of about 368 km, with 125 dams built across the river to provide a water control and storage system that covers more than 18,600 km^2. The locks range in size from 84 to 154 feet in length, 23 to 33 feet in width, and a minimum draught of 6 feet, and are suitable for small craft only. In 1977 construction began on a marine railway at Big Chute which can accommodate vessels with a 100 t displacement, 1.83 m draught, 35 m length, and 7.3 m width. The railway was built instead of a lock in order to prevent the migration of sea lamprey into Lake Simcoe. The long stillwaters and widenings behind the dams provide excellent fishing areas and waterside cottage sites, so that the area with its boating and sport fishing resources attracts a great many summer visitors. The building of the dams also enabled the development of considerable hydroelectric power along the Trent River.

One cannot, of course, relate all the development to the fact that the Trent embayment was part of Lake Iroquois. For many things, particularly the course of the Trent River itself, other physiographical factors are much more important. The best agricultural lands, however, are found on lacustrine deposits; without them, settlement would probably have been less successful.

Geographical Significance of the Iroquois Plain

The Iroquois plain has been described at some length, not only because of its extent and complexity but, also, because its importance within the geographical framework of Ontario warrants full attention. About one-third of all the people in Ontario live within its borders, making it by far the most densely inhabited area. Many others live as close to it as they can get because of the opportunity for employment. By reason of its proximity to Lake Ontario and its facilities for transportation, it became the first settled area while, from the various lake ports, colonization roads were pushed into the interior. But few of the interior areas were as attractive to the new settlers as the old lake plain where the first settlements already had a head start. Here land transportation routes developed because of the easy grades, linking together the lakefront settlements and stimulating the growth of new centres depending entirely upon road and rail facilities. Its

desirability is most evident in its two largest cities, Toronto and Hamilton, both of which have been forced to spread beyond its borders.

The presence of large cities creates demands for special agricultural products. Since trucking adds to the cost, it is desirable to grow them as close to market as possible. The Iroquois plain thus became, and east of Toronto still remains, an area of specialized farming where not overwhelmed by suburban growth. Part of its special advantage accrues from the presence of Lake Ontario and its climatic influences but the favourable soil factor is a direct inheritance from glacial Lake Iroquois.

Other points might be mentioned. The old sandbars and offshore aprons of sand are good aquifers, supplying domestic water to farms, villages, and even some towns. The gravel bars have been good sources of road metal and building materials, while the clays of the old lake bed have been used for the manufacture of bricks. The interested observer will be able to note many phenomena which recall the former presence of the old lake.

42 LEEDS KNOBS AND FLATS

In the St. Lawrence River near Gananoque are the well-known "Thousand Islands" consisting of knobs of granite and other Precambrian rocks among which, by devious channels, the river finds its course. In Leeds (the western part of the United Counties of Leeds and Grenville) and Frontenac Counties to the north of the river there are another "thousand islands" of rocks, but the channels between are filled with clay left by a late stage of Lake Iroquois or subsequent lakes (Figure 27). This landscape of rock knobs and clay flats (Photo 79) occupies an area of about 385 square miles, a typical section of which is seen along Highway 2 between Kingston and Brockville. The rock knobs of the Frontenac Axis are relatively bare because the shallow covering of drift was removed by wave action, and the contrast between them and the deep clay beds is clear and sharp. The clay, itself, is grey to drab in colour and very weakly calcareous. Where drainage is good it gives rise to an acid soil similar to that found in Renfrew County. Poorly drained, near neutral soils are also found.

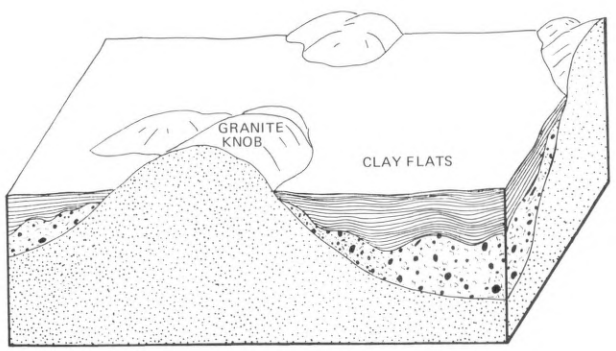


Figure 27. Block diagram illustrating the structure of the rock knobs and clay flats of Leeds County (part of the United Counties of Leeds and Grenville).

The largest block of clay land is probably that lying west of Lansdowne village. Another good block is found in the area between Taylor and South Lake and extending well to the west into Pittsburgh Township. Clay lands are also found on Wolfe and Howe Islands.

Land Use and Settlement

Dairy farming is the mainstay of this area as it is in most parts of eastern Ontario. The deep clay soils promote excellent yields of hay, silage corn, oats, and mixed grain, which are the chief crops. Grain corn is being given increased attention.

Lying between Kingston (60,313) and Brockville (20,169) and having adjoining it, also, Gananoque (4,848), "Gateway to the Thousand Isles", this section is fortunate in having nearby markets and service centres. It is also well provided with railway and highway facilities which give rapid access not only to local centres but to Ottawa, Montreal, and Toronto as well as to the United States by way of the International Bridge at Ivy Lea. The St. Lawrence waterfront is not the only attraction for summer recreation, for the interior of Leeds also contains a number of excellent lakes along which many cottages have been erected.

43 SMITHS FALLS LIMESTONE PLAIN

The largest and most continuous tract of shallow soil over limestone in Southern Ontario, covers nearly 1,400 square miles in the United Counties of Leeds and Grenville, the Regional Municipality of Ottawa-Carleton, and Lanark County. Between Brockville and Carleton Place, Highway 29 passes almost exclusively through this type of country. Smiths Falls lies almost in the centre of it and the Rideau River divides it into two nearly equal portions. The Mississippi is the only other large river.

The exposed rock strata belong to the Beekmantown Group and include grey limestone, magnesian limestone, blue-grey dolostone, and some calcareous sandstone. The surface has a slight slope toward the northeast, but over large areas is almost

level. Locally, a little relief is provided by low ledges and shallow valleys in the rock. North of Carleton Place there is greater irregularity of the surface due to faulting and clay has been deposited in the depressions, while its most northeasterly extension lies along an upraised fault block which overlooks the Carp Valley. To the west, against the Canadian Shield the dolostone does not present a strong scarp similar to that of the Gull River Formation in central Ontario, but the Rideau Lakes occupy depressions along the Beekmantown border which are comparable to those along the borders of the Gull River Formation in which the Kawartha Lakes are situated. The overall gradient on the dolostone around Smiths Falls is about five feet per mile, and many depressions are left undrained. The area abounds in bogs which are especially prevalent in the townships of Rideau, Montague, Beckwith, and Wolford. In the case of Cranberry Lake in the lattermost township, a small body of open water is left, while around lie hundreds of acres which have been filled with peat to the point where it supports a dense swamp forest.

On the higher parts of the plain a scattering of old marine beaches occur which are both interesting and valuable. For the most part they are composed of limestone shingle and sand, and contain marine shells. They often provide the only areas of soil deep enough for cultivation, and the gravels have also been used extensively for road construction.

In a region of shallow soil those areas having appreciable depth of soil material are highly important. West of Smiths Falls a few low drumlins appear, while elsewhere there are scattered small patches of till, three to five feet or more in depth. Fairly deep clay deposits occur along the Rideau River, allowing the development of small tracts of first class soil. Other tracts of clay, not quite so deep, are found near Athens, Perth, and Carleton Place.

For the most part, this plain supported a hardwood forest in which sugar maple was the dominant tree. Evidence seems to indicate that oak and pine were formerly more common than at present. In the poorly drained areas, elm, ash, soft maple, and white cedar are found. In some of the bogs there are larch and black spruce.

The physical characteristics of this region present the agriculturist with great difficulty. Disregarding for the moment, a few small areas of deep soil, there are hardly any good points to be mentioned. The shallow soils vary greatly in texture from clays to light loams, sands, and even gravels, although they are all classed within the Farmington series. Surface stoniness is common. Drainage is often impeded so that seeding is delayed even though later in the summer they become exceedingly droughty. Water for stock may also be scarce, although there is usually access to a swamp on most farms. In fact, very large areas of this limestone plain are covered with peat and muck deposits which, for the most part, remain under a forest cover. In a few marginal areas, however, the land has been cleared but is used only as rough pasture.

Land Use and Settlement

The "front" of this area was part of the original

OGS 10 730

Photo 79. Granite knobs and clay flats near Gananoque.

townships laid out to accommodate the United Empire Loyalists who took up land here in 1781 and following years. Military settlements in the interior included Perth in Lanark County (1815) and Richmond in Carleton County (1819). The real spread of settlement, however, came during and after the building of the Rideau Canal, begun by Colonel John By in 1827.

Early farm life was fraught with extreme hardship and the economy was of the most elementary subsistence type. Because of its harsh climate this area could not, even on its better soils, participate in the wheat enterprise which characterized central and western Ontario during the middle part of the 19th century. Some hay, oats, and perhaps potatoes, were produced for the lumbering areas which lay to the north. Agricultural stability of a sort was reached with the introduction of cheesemaking in the latter half of the century. The farm economy was based on summer dairying, the milk being marketed through small local cheese factories which operated during the warmer months only and were closed during the winter. The cows began lactation in the spring to take full advantage of the June flush of pasture on the shallow land. They were allowed to go dry in autumn, and were wintered over on forage produced on patches of deeper soil. Good hay, oats, and corn were produced on the gravelly soil of the old beach ridges which, on some farms were the only soils really deep enough for cultivation (Photo 80). A few hogs, a few sheep, and a small flock of poultry were also found on most farms. On some farms maple syrup provided an important supplementary source of income. This area still contains the greatest concentration of maple groves in the Province and the situation might be improved by the reforestation of a great deal of rocky land which is more suited to maple trees than to grass.

The landscape of this area is peculiar. In comparison with the landscape in southwestern Ontario, or with the Winchester clay plains, it presents a rather ragged and unfinished appearance. In fact it retains many elements of the pioneer stage of development. There is the previously mentioned high percentage (47%) of unploughed land, including rough pasture, woods, and swamp. Rail, stump, and stone fences are common. Log houses and barns are nearly as plentiful as those of frame construction. In addition there is much evidence of abandonment with many farmsteads falling into ruins, or having disappeared almost entirely, leaving perhaps a gaunt old fashioned chimney to mark the site.

Nearly all the stages of the agricultural development of Ontario may be discerned. One encounters the original settler's shanty, now housing chickens to be sure, but still, after 125 years preserving the components and design of its primitive construction. It is built of cedar logs, rather raggedly notched together at the corners. The eaves are low and there are very few windows. The roof is made of cedar "scoops"—hollow trunks, split and overlapped in the fashion of the classical clay tile. Within is a huge square fireplace built of flat limestone blocks quarried nearby, and beside it still hangs the old iron crane.

The second stage is represented by the house built of squared logs with carefully dovetailed corners, plastered chinks, and shingled roof. On many a farm the shallow soils have not provided the capital necessary for further improvement. The barns of this stage are built of logs also, but unhewn. They are numerous, there sometimes being 12 to 20, on an individual farm (Photo 81). They are small, the size varying according to the length of the logs available to the builder. Sometimes they are placed end to end in a long train, but often haphazardly scattered about a farmyard of two acres or more.

The third stage is reached with the construction of a frame or brick house and a frame barn; but only on the best and deepest of the soils of the limestone plain is this achieved. Combinations are often seen: a neat brick house accompanied by a dozen log

OGS 10 731

Photo 80. Marine beach deposits of limestone shingles provide small areas of soil on the Smiths Falls limestone plain.

barns; or the reverse, an old squared log house and a frame barn; or sometimes, even a modern steel barn. Basement or bank barns are rather rare in eastern Ontario, but in this region one sometimes sees barn foundations built of cedar blocks instead of stones.

The present agricultural situation may be understood by reference to the 1981 census statistics for a few townships in the neighbourhood of Smiths Falls. Slightly over 80% of the land is occupied by farms averaging 235 acres in size, almost twice as large as those of the good clay lands of eastern Ontario. As a rule only about half of the land is improved and about one-third is in crop, the latter consisting chiefly of hay, corn, oats, mixed grains, and barley. The lack of a cash crop combined with a large area of unimproved pastureland, is in accordance with the extensive type of dairy farming. The average farm has a herd of 8 milking cows, 8 beef cows, 3 sheep, 8 hogs, and a few poultry. The area is still a cheddar cheese district, but there are fewer and larger factories, and an attempt is being made toward year-round production. The presence of so many submarginal farms, however, brings the average farm income in these townships down to a very low level, and nearly all of the operators have jobs off the farm.

The limestone plains are shared by the umlands of Ottawa and Kingston but, rather surprisingly, they contain several sizable centres including: Brockville (20,169), Smiths Falls (8,904), Perth (5,734), Carleton Place (5,776), and Almonte (3,837). Merrickville (978), Athens (931), and Newboro (253), are incorporated villages. A complete census population analysis of the Smiths Falls plain such as that given for Prince Edward is not possible but the accompanying table (Table 9) deals with the central and most typical part of it. This area of some 620 square miles, immediately surrounding Smiths Falls, is comprised of eight townships and five incorporated towns and villages.

TABLE 9 POPULATION OF THE CENTRAL PART OF THE SMITHS FALLS PLAIN, 1981

Total	41,396	100%
Urban (4 towns, 1 village)	24,964	60.3
Rural	16,432	39.7
farm	2,407	5.8
non-farm	14,025	33.9
area: 620 square miles		
population density: 66.8		

The limestone plains for years constituted an area of declining rural populations. Many of the townships reached their population peak almost a century ago. Among such may be cited: Kitley with 2,870 people in 1871, 1,445 in 1941, and 1,870 in 1982; and Montague with 3,187 in 1871, 1,547 in 1941, and 3,679 in 1981. The farms have gradually increased in size as smaller and more marginally located farms have ceased to operate. Gradually the farmers are adjusting their operations to the quality of the land at their disposal while adopting new techniques to overcome the tremendous handicap under which they were placed when each settler was given his 100 acres regardless of where it was or of what it consisted. It is a slow process, however, and the adjustment is far from complete.

Something else is also happening. Total population declined until 1931, rural population continued to decline until 1941, while farm population is still

OGS 10 732

Photo 81. Farmsteads consisting of several log buildings are common on the limestone plains of eastern Ontario.

declining. On the other hand urban population has slowly and steadily increased and, especially since 1951, rural non-farm population has increased at a more rapid rate than urban population. Physical features—power sites—on the Rideau and Mississippi were responsible for the urban settlements in the first place even though they were also rural service centres. This function decreased as the farm population dropped. Now these places have become small manufacturing centres with job opportunities and people seek cheap building sites nearby.

44 EDWARDSBURG SAND PLAIN

In Edwardsburg and the surrounding townships, the bedrock and most of the boulder clay are covered by beds of sand. The surface of the sand plain is for the most part nearly level or only slightly undulating, although hummocks and ridges appear in places. The sand is undoubtedly glaciofluvial in origin. Although it has been well spread about by wave action, probably in the late stages of the Champlain Sea, a few undoubted morainic structures remain. As the land emerged from below sea level, a few beach ridges were formed on high ground, notably east of Kemptville. Finally the wind built some of the drier sand into dunes before it was covered with forest. The sand plains thus formed, though not continuous, characterize an area of about 280 square miles.

The Edwardsburg sands have an altitude of 300 to 400 feet a.s.l. and lie within the South Nation watershed. The overall relief is small and the water table generally stands near the surface, so much so that shallow muck and even peat bogs have frequently developed.

The common forest on this plain is an association of moisture-loving trees including elm, ash, soft maple, and white cedar. Tamarack and black spruce are seen in bogs and on the wetter sand. On the ridges white pine, hard maple, beech, and burr oak are found.

The soils are acid and deficient in all important nutrients. The parent sands contain some lime carbonate, but the bases have been largely leached from the surface horizons of the soils. Strongly acid Podzol and less acid Grey Brown Luvisolic profiles appear on higher sites and Humic Podzols on lower sites. Still wetter sites have dark, deep surface horizons underlain by grey and mottled subsoils. Granby sandy loam represents this wet soil on the Grenville County soil map (Appendix C). If drainage could be secured, this would be the best of the sandy types. The Bridgman sand of the former sand dunes is subject to blowing and should be kept in forest.

This area is part of the eastern Ontario dairy belt where small cheese factories used to dot the road corners to take in milk during summer and fall. It still produces milk which is hauled longer distances to larger plants. The region has long had the appearance of having seen better days. There are well-built stone houses along the concession lines, albeit some of them are now abandoned. The quality of buildings is about on a par with that of the adjoining limestone plains, but the farms are gradually becoming larger. The population of Edwardsburg Township fell steadily from the end of the 19th century until the Second World War, but since then it has risen considerably. However, farm population has continued to fall and in 1981 was only a quarter of what it was in 1931. There were also only one-third as many farms. Only 45% of the total area is now in census farms, and the average size has risen to 162 acres. There are fewer cows, but more of them (20) per farm, and they give more milk. A third of the improved land is used for pasture and an equal amount for corn.

The Towns of Prescott (4,595) and Kemptville (2,359), and Village of Cardinal (1,695) serve as the principal supply points for this and adjacent areas. Several unincorporated places have been built adjacent to mill sites. Spencerville (385) is the most important of these, being situated on Highway 16, where it crosses the South Nation River.

45 NORTH GOWER DRUMLIN FIELD

The North Gower drumlin field occupies an area of about 150 square miles lying in Rideau and Osgoode Townships, and the Cities of Nepean and Gloucester. The drumlins are scattered and some of them incompletely formed, the best group being those clustered about the village of North Gower. For the most part the land between the drumlins is covered with clay or silt deposited by the Champlain Sea. Other features adding to the complexity of the area are various gravel ridges such as those near Kars and Osgoode, a few small areas of partially drumlinized till plain in Osgoode Township, and some bare limestone plain in the same vicinity.

Although the area is traversed by the Rideau River and its tributaries, drainage is not well developed and the lowlands are occupied by Gleysolic soils. North Gower clay loam and Osgoode loam are both poorly drained, the latter having more sand in both surface and subsoil than the former. They suffer badly from delayed seeding in wet seasons.

The drumlins of this area have good drainage and the soils exhibit a normal Grey Brown Luvisolic

type of profile. The soil is adaptable and its chief limitation is stoniness. In the Carleton County soil report it is called Grenville loam.

The North Gower drumlin field is not quite so highly developed agriculturally as the Winchester clay plain, nevertheless its achievements are above average for eastern Ontario. Osgoode Township may be taken as representative of the whole area. It has an area of 91,330 acres (143 square miles), of which over 66% is occupied by farms. There are 388 farms averaging 155 acres in area. About 81% of the farmland is improved, 61% is under crop, and 17% is improved pasture. Only about 8% remains in woods. Hay and grain corn are the most important crops but silage corn, mixed grain, oats, and barley are grown. Having fairly easy communication with Ottawa, this area is an outlying part of the Ottawa milk shed. Each farm has, on the average, a herd of 28 milking cows plus a few pigs and poultry. The lighter soils near Osgoode constitute an extension of the Gloucester special crop belt and a few fruit and vegetable farms are found. Potatoes are important.

The population centres within the area are North Gower (1,000), Manotick (3,000), and Osgoode (1,500), which serve their own constituencies. These places also serve as residential areas for many who commute to work in Ottawa. In addition, almost 50% of the population lives in scattered non-farm residences. Less than 10% lives on farms.

46 GLENGARRY TILL PLAIN

The Glengarry till plain is a region of low relief forming the drainage divide between the international section of the St. Lawrence and the Ottawa basin, from Prescott to the Quebec Boundary. Its area is estimated to be about 935 square miles, including the eastern part of the United Counties of Stormont, Dundas and Glengarry, and tapers off westward to the St. Lawrence at Prescott. The surface is undulating to rolling, consisting of long morainic ridges and a few well-formed drumlins together with intervening clay flats and swamps.

A great many small streams arise within the area. Draining toward the north are a number of tributaries of the South Nation River, including the south branch, Black Creek, Payne River, and Scotch River. Draining to the St. Lawrence are Hoople Creek, Raisin River, Baudet River, Delisle River, and other shorter streams. To the east the Rigaud River drains to the Ottawa. The drainage pattern is peculiar in that the headwaters of most of these systems flow sluggishly for long distances between the ridges before finding outlets to the master streams.

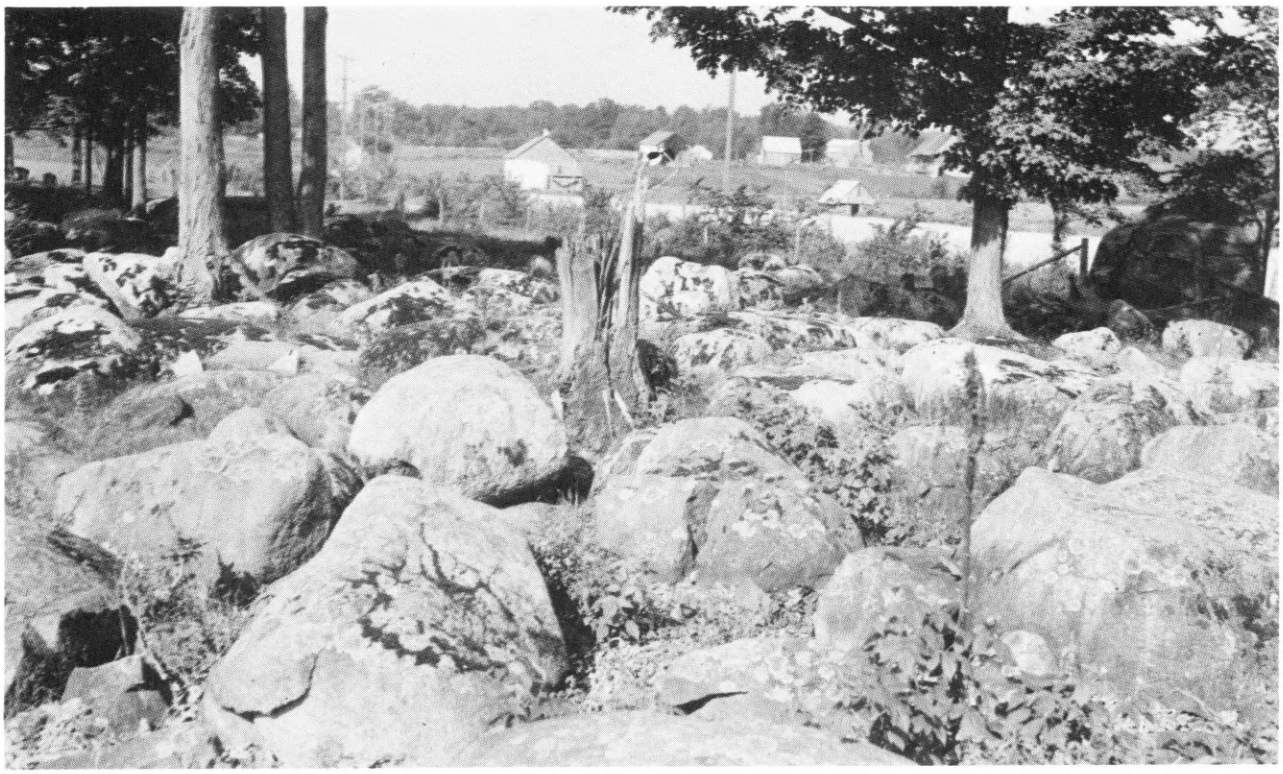
The till has a medium texture and contains a high proportion of limestone mixed with materials derived from the Precambrian rocks to the north and from the sandstone of the Nepean Formation at the base of Rigaud mountain in Quebec. The depth to bedrock is seldom over 100 feet, and over much of the area the till is less than 25 feet in depth.

The outstanding characteristic of the region is stoniness. The fields are either dotted with rock piles or bordered by stone fences. The till itself is very stony, and on the crests of the ridges and drumlins which suffered wave action in the Champlain Sea there are boulder pavements (Photo 82). The clearing of this sort of land required a prodigious amount of work, and high wheeled stone-wagons (Photo 83), with steel tongs for clasping the boulders and windlasses to lift them, are still in use. Nevertheless, many of the stoniest areas remain uncleared, either as woodlots or rough pasture. The action of the waves also built numerous bars of sand and gravel which are useful sources of building material. Other deposits of sand and gravel, considered to be of glaciofluvial origin but modified by wave action, are found near Newington, Finch, Avonmore, and Maxville.

In its natural state the St. Lawrence River bordering this area was marked by numerous rapids, most noted of which was the Long Sault. In order to make the river navigable a series of canals was constructed in the early days and subsequently improved, culminating with the building of the St. Lawrence International Seaway which was opened in 1959. This construction has also made it possible to install turbines producing 6,400,000,000 kW annually in the Robert Moses Power Dam-Robert H. Saunders Power Plant. The power is shared by New York State and Ontario.

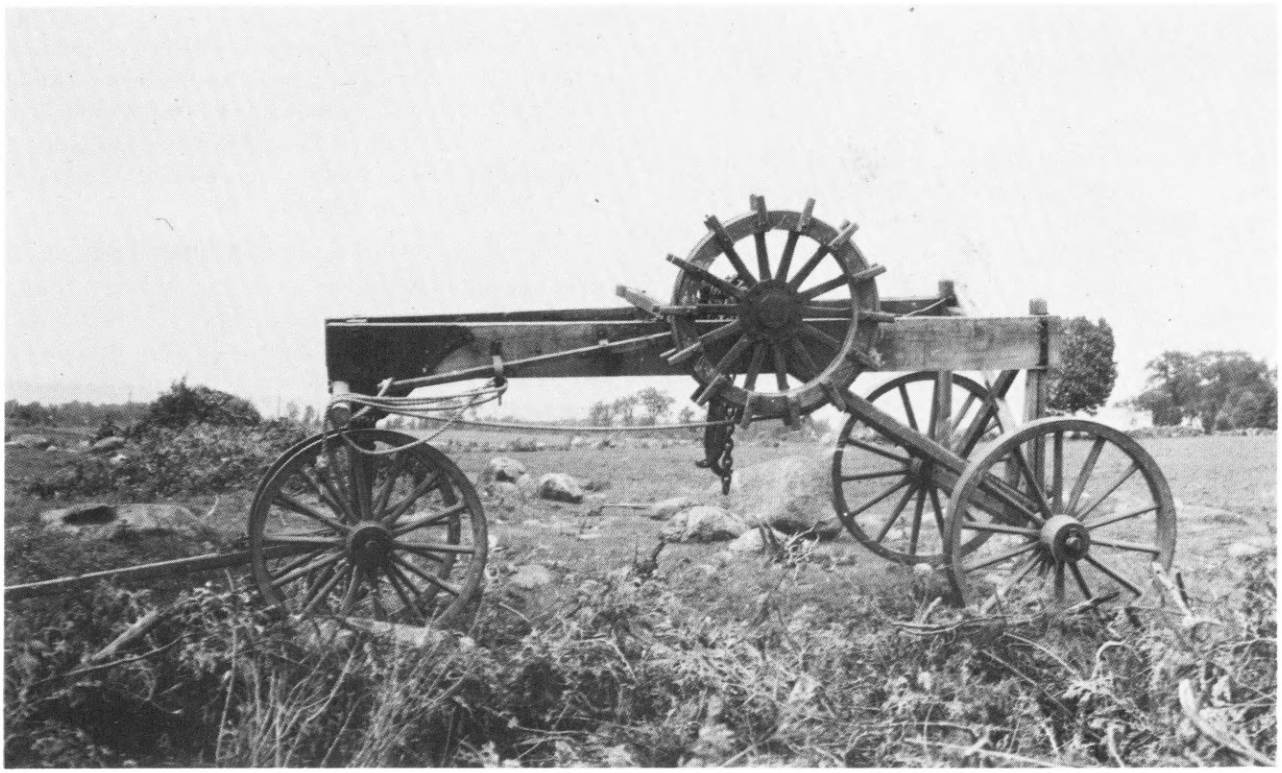
This construction has greatly altered the physical landscape of this area. By raising the water to the level of Lake Ontario much low-lying land was flooded and the shoreline placed squarely against the till ridges where, of course, a certain degree of shoreline erosion will take place. The flooding entailed moving some villages to new, higher sites. Some of the previous islands have been completely submerged, while new islands and peninsulas have been outlined at higher levels. Some of the present shoreline has been set aside as a small park.

The normal soil on this till plain resembles the Grey Brown Luvisols of southwestern Ontario but there is, actually, little mature soil. Even on the ridges, where drainage is good, the highly calcareous material has resisted weathering and the soil profile is shallow with an abundance of free carbonates within the ploughed layer. In this there is a resemblance to the Otonabee soils of the drumlins near



OGS 10 733

Photo 82. Boulder pavement near Maxville, Glengarry County.



OGS 10 734

Photo 83. Stone wagon, near Vankleek Hill, northern Glengarry County.

Peterborough. The most commonly encountered of these soils in much of the Glengarry till plain, and on the North Gower drumlins as well, is Grenville loam. There are many gently sloping or almost flat areas where imperfectly drained, and even poorly drained soils are developed. There are, also, large undrained depressions in which peat and muck are found.

Land Use and Settlement

These limestone till soils must be rated as fairly good land, in spite of some excessive stoniness and the inclusion of some wet land. Alfalfa, oats, barley, and corn are all well adapted. The porous nature of the soil and substrata usually predetermine a supply of well water, a utility that is sometimes lacking on a clay plain.

Dairy farming dominates in this region just as it does in the adjoining clay plains, but there are a number of contrasts to be noted. The farms are somewhat larger, averaging nearly 200 acres, although the most common size is still 100 acres. In some townships about 75% of the farmland is improved. There is approximately 16% in seeded pasture and nearly as much in permanent pasture on rough, stony, or wet land. About 15% of the area remains in woods and swamp. Crops occupy half of the farmland; hay and grain corn are the most important but there is still some oats and barley. On the average each 100 acres of farmland carries about 22 livestock units, 7 of which are milking cows; that is, more than 80% of the farms have dairy herds of 18 milking cows. There is much variation within the area, some farms being very well kept, but, in general, agriculture seems to be at a somewhat lower level than on the clay plains. The uncleared land provides a certain supplementary income. Most farmers have a woodlot from which fuel and lumber for their own needs are obtained. There are also a number of maple groves which have given the eastern third of the United Counties of Stormont, Dundas, and Glengarry a reputation for syrup and sugar.

The population pattern is dominated by the City of Cornwall (45,906) which draws most of its milk supply from the adjacent area and provides a market for small amounts of other farm produce. Cornwall also provides employment for many people in the surrounding unincorporated villages, including the "new towns", the hamlets, and even many of the farm residents. Smaller markets are found in the other towns and villages of the area including Alexandria (3,270), Iroquois (1,138), and Morrisburg (2,257). An analysis of the population is shown in Table 10. A score or more of unincorporated villages and small villages act as local supply centres. Most of the farm income, however, comes through the sale of milk to the cheese factory or other industrial dairy plants.

TABLE 10 POPULATION OF STORMONT AND GLENGARRY COUNTIES[1], 1981

Total	82,181	100%
Urban (1 city, 1 town, 3 villages)	50,556	61.5
Rural	31,625	38.5
farm (1,743 farms)	6,279	7.6
non-farm	25,346	30.9

area: 878 square miles
population density: 93.6

[1]Stormont and Glengarry comprise the eastern two-thirds of the United Counties of Stormont, Dundas, and Glengarry.

47 WINCHESTER CLAY PLAIN

The Winchester clay plain lies between the Glengarry till plain and the sand plains of the United Counties of Prescott and Russell, and is composed of an area of about 360 square miles. It is an area of low relief, lying almost entirely within the drainage basin of the South Nation River. The general flatness of the plain is exemplified in the gradient of the river which descends only 50 feet in 30 miles from South Mountain to Crysler.

Although the clay plains are dominant, the landscape has some complexity. In many places the underlying till protrudes and there are a number of low drumlins. In a few cases there are areas of shallow soil over bedrock and occasional bars, beaches, and boulder pavements are found as in the area to the south. There are also several thousand acres of bog.

The original vegetation of these low-lying plains was of the swamp-forest type, consisting chiefly of red maple, elm, white and black ash, but including many other trees such as burr oak, swamp white oak, yellow birch, white birch, basswood, black alder, and willows, depending upon degree of drainage.

The clays, themselves, fall into two main classes, with various intergrades. Toward the south and west they are grey in colour and fairly high in lime while toward the northeast are found deposits of alternately banded pink and grey clays, similar to those of the lower Ottawa Valley. They vary greatly in depth, 60 feet or so of clay underlying the sand in the canyon of the South Nation River below Casselman. The two types of clay result in the formation of two soil catenas.

The soils of the Winchester plain, or South Nation Valley, for the most part are poorly or, at least, imperfectly drained. The most commonly

identified soil types of the flat South Nation Valley in Dundas, Stormont, and Russell are the poorly drained North Gower clay and clay loam. The typical profile is shown in Table 11.

TABLE 11 SOIL PROFILE OF THE NORTH GOWER CLAY LOAM

A_h	6-8 inches, very dark grey, granular, friable clay loam; pH 7.0.
G_1	4-6 inches, grey and brown mottled, plastic clay loam; pH 7.0.
G_2	12-18 inches, grey and rust-brown mottled, extremely plastic, massive clay; pH 7.2.
C	grey, plastic, massive clay, alkaline but with no free carbonates.

These are the Gleysolic soils which are found throughout the area most often involved in the spring floods of the middle course of the South Nation River. On slightly better, but still imperfectly drained locations as, for instance, near Winchester the Carp clay loam profile is found, in which a shallow A_e horizon and a brown but mottled B horizon may be seen. Both Carp and North Gower are excellent soils when drainage has been established.

In the northern and eastern parts of the plain where the parent material is composed of massive, interlayered, pink and grey clay the Bearbrook is the dominant series. It is also poorly drained. Bearbrook and similar strongly leached soils are the ones which the French-speaking farmer calls "terre grise", the surface soil of the cultivated fields is grey, lower in humus than the North Gower type, and inclined to be very plastic when wet and very hard when dry.

Municipal ditches have been cut to provide drainage throughout the clay plain and very little uncleared land remains. Fuel is a problem since the forests are gone. At Cannamore the farmers used to cut and dry peat, succeeding in the use of this resource at a domestic level where commercial ventures had failed. A few areas of clay soil have been reclaimed by draining and burning off the overlying peat. It is a slow process in which timothy hay is used to advantage in the development of a friable surface soil.

In spite of the surplus surface water at certain times of the year, the provision of a reliable supply for stock watering and domestic purposes throughout the year poses a considerable problem. Wells often go dry because the tight clay soils are not good aquifers. Drilled wells are becoming common and it is often necessary to go more than 100 feet into the rock to find a satisfactory supply.

Land Use and Settlement

The Winchester clay plain is one of the better agricultural districts in Ontario. It also remains one of the most rural areas in the Province. Dundas County (part of the United Counties of Stormont, Dundas, and Glengarry), of which this plain provides three-fifths of the area, does not have a single town and has only four incorporated villages, the largest of which is Winchester (Table 12). Parts of the United Counties of Prescott and Russell have denser populations.

TABLE 12 POPULATION OF DUNDAS COUNTY[1], 1981

Total	18,946	100%
Urban (4 villages)	6,934	36.6
Rural	12,012	63.4
farm (949 farms)	3,487	18.4
non-farm	8,525	45.0

area: 393 square miles
population density: 48

[1]Dundas County, the western one-third of the United Counties of Stormont, Dundas, and Glengarry, is made up of the Townships of Mountain, Winchester, Matilda, and Williamsburg.

Winchester Township lies wholly within the clay plain and its agricultural statistics may be taken as representative of the larger area which includes parts of many other townships. The total area, outside of the incorporated villages is 57,962 acres or 90 square miles. In 1981, 311 farms occupied 53,672 acres or about 93% of its area. The average farm has an area of 173 acres, of which 160 acres (92%) are improved, and 125 acres (72%) are in crop. Seeded pasture occupies 17% or 29 acres. Wasteland amounts to 8%, some of which may be grazed, and only 5% remains in woods. The township contains three large bogs, totalling 7,500 acres, much of which has been cleared. In fact, outside of the bogs there is very little wooded or waste land. The important crops are hay, corn, oats, mixed grains, and barley. It may be worth noting that this township in eastern Ontario grows more silage corn (8%) than any township in the Toronto milk shed. In fact only two townships in Oxford County surpass it in this regard. It now also produces twice as much husking corn as silage corn. On the average each 100 acres supports a herd of 23 milk cows and enough other livestock to make a total of 34 livestock units. Forty years ago this township held the record for the Province but in recent years the livestock density in Winchester has been surpassed by several townships in the Regional Municipality of Waterloo, and Bruce, Perth, Huron, and Oxford Counties. In terms of milk production, however, Dundas County moves in the front rank, both in terms of yield per cow and in terms of yield

per acre. This, in no small measure, is due to the productivity of the Winchester clay plain.

One is struck, also, by the well-kept appearance of the majority of farms. In common with all of eastern Ontario, houses as well as barns are usually built of wood on rather simple lines, but they are neat and commodious. Paint is rather liberally used, white for the houses and red for the barns and outbuildings. It is noteworthy, too, that many Winchester farmers find time to mow the lawn and to grow a good garden. The observations noted above apply with equal force in the better parts of the adjoining townships of the clay plain, this whole area being one of the foremost agricultural districts in Ontario.

It is not without its problems, however. One of the greatest of these is drainage. The only outlet is by way of the South Nation River, the gradient of which is less than 20 inches per mile. Over a distance of several miles above Cass Bridge, near Winchester, the banks of the river are so low that it annually overflows, flooding an area of about ten square miles. The floods are usually in the early spring when little damage is done to crops. Sometimes the spring floods repeat, as in 1946 when some crops in the low sections near the river had to be reseeded three times.

Another problem, not peculiar, of course, to this clay plain, is the difficulty of maintaining passable roads in the absence of nearby gravel deposits. This is of importance when the chief product is fluid milk which must be taken out daily.

Market outlets for the milk are provided by large evaporating plants at Winchester and Chesterville, and by a number of large cheese factories. The Winchester clay plain, like most of eastern Ontario, once had numerous, small cheese factories but with modern truck transport in both summer and winter they have given way to a fewer number of more efficient, larger plants.

There are no large towns on the plain. The main centres include Winchester (1,999), Chesterville (1,397), both in Winchester Township, and Casselman (1,765), Maxville (824), Finch (366), Crysler, Moose Creek, and St. Isadore de Prescott. None of them detract much from a strictly rural landscape.

48 LANCASTER FLATS

In the southern part of Glengarry County (the eastern third of the United Counties of Stormont, Dundas, and Glengarry), for about eight miles back from the St. Lawrence, lies a lowland in which the till plain has been buried under water-laid deposits leaving exposed only the stony crests of a few drumlins and ridges. The water-laid materials range from clay to very fine sand in much the same way as they do on the margins of the Winchester clay plain. This area is but a small portion of a clay plain which extends into the Quebec counties of Vaudreuil and Soulanges. The portion within the Province of Ontario has an area of about 160 square miles.

Drainage is toward the St. Lawrence by way of the Raisin River, Baudet River, Sutherland Creek, and a number of other shorter streams. Nevertheless, the land is so flat that the area is poorly drained. The original vegetation was an association of moisture-loving species such as American elm, white ash, and red maple. Writers of the early history of the county present vivid accounts of clearing forests amid the mire of the "Lancaster flats".

The soils are generally poorly drained and have rather deep black surface soils underlain by rusty, mottled subsoils. In the eastern corner of Lancaster Township the material is mainly silt and fine sand, and the soils resemble those which in Carleton County (now the Regional Municipality of Ottawa-Carleton) are classified in the Castor series.

From the standpoint of agricultural development this is just another segment of the eastern Ontario cheese-producing region, although some fluid milk is shipped to Montreal. It has, however, a crop specialty worth mentioning. Fibre flax seems to find here the conditions of the soil and moisture supply which suit it and at one time it ws an important crop, but practically none is being grown at present.

49 OTTAWA VALLEY CLAY PLAINS

The Ottawa Valley between Pembroke and Hawkesbury consists of clay plains interrupted by ridges of rock or sand. It is naturally divisible into two parts, above and below Ottawa, each having its own distinctive traits.

In the upper section there is a broad valley with rocky Laurentian uplands rising on either side; on the Quebec side the rocks rise sharply 600 feet or more along a fault scarp, while on the Ontario side the slope is more gradual although it also presents some prominent scarps. Within the valley the bedrock is further faulted so that some of the uplifted blocks appear above the clay beds. The surface of the beds is level (Photo 84) in all but a few areas, but swamps are scarce. The sediments themselves are deep silty clays. Although grey in colour like the limestones that underlie them in part, they are only mildly calcareous and likely derived from the more acidic rocks of the Canadian Shield.

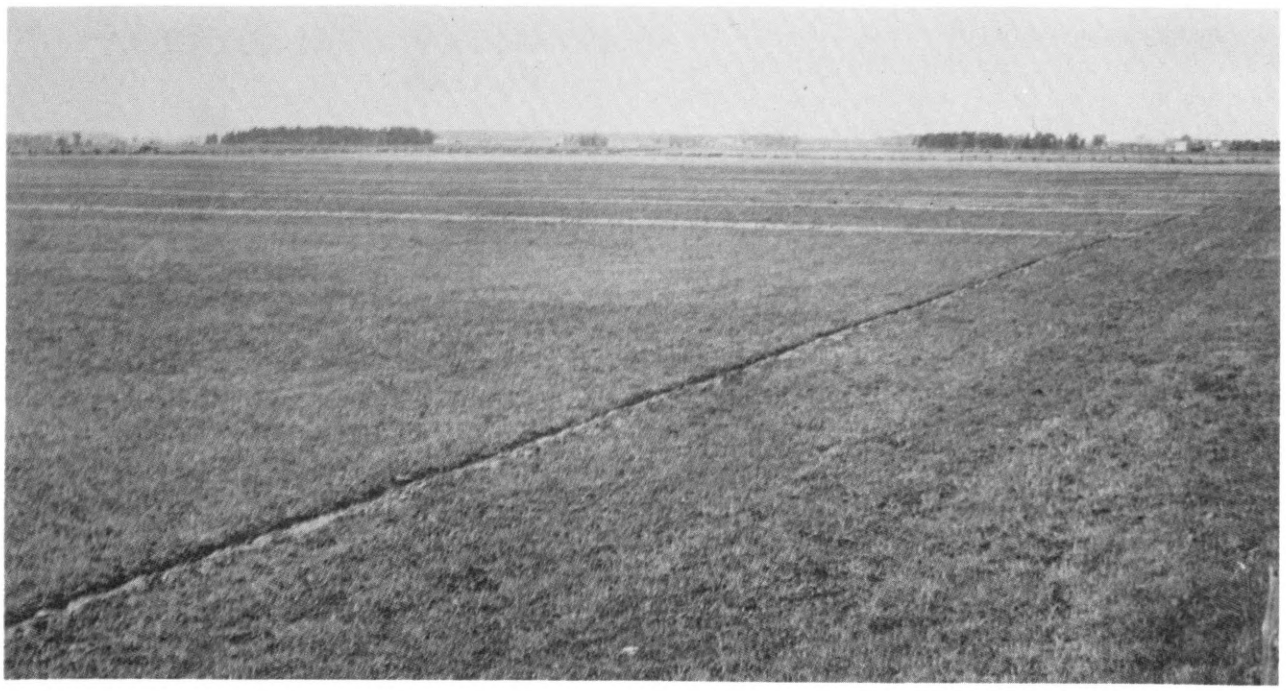
Nine miles south of Pembroke, Highway 17 crosses the Muskrat River and mounts a limestone outcrop. A companion outcrop lies to the west in Stafford Township. At this point the Muskrat River leaves Muskrat Lake, a narrow lake which extends to Cobden nine miles southward. This lake, together with Olmstead, and several smaller lakes in line with them, occupy sections of a preglacial river valley excavated along an old fault line. The western shore of Muskrat Lake is on clay while the opposite shore is formed by an escarpment in Precambrian rock nearly 200 feet high. The only overburden on the crest of this ridge is a little sand or gravel. Its eastern slope is gradual and the clay beds encroach upon it irregularly. This "Queen's Line" clay tract slopes toward the Ottawa River, giving good drainage, and it is cut at frequent intervals by gullies above the bluff that closely follows the concession road southeast from Foresters Falls. Another gullied area appears east of Beachburg. Toward the north in Westmeath Township the clay is shallow and the limestone is uncovered in places. A ridge of deep gravel and sand connects the villages of Beachburg and Westmeath.

At Haley Station, Highway 17 turns to cross another outcrop of Precambrian rock which extends to Osceola and Lake Doré. The Snake River finds a pass through it at Osceola and drains the clay plains on either side. The Bonnechère River drains the main part of the flats southwest of the ridge.

An area of stratified limestone rises above the clay northwest of Arnprior while to the south are several outcrops of ancient Precambrian crystalline limestone. Two more stratified limestone mesas appear west of Ottawa. Another mesa of sandstone around Fallowfield and a ridge of Precambrian rocks flank the Carp Valley on the north and east. Drainage is slow in the Carp Valley and in the clay plain north of Richmond village.

The Ottawa River is entrenched within an older channel which is bounded on either side by abrupt bluffs. The bluff southeast of Foresters Falls has already been mentioned. Its extension just south of the confluence of the Bonnechère and Ottawa Rivers appears as a bold bluff 50 or 60 feet high. Across the river in the vicinity of Shawville, Quebec, the bluff and gullied clay beds above it are especially well represented.

The Connaught Rifle Range, nearer Ottawa, is on the floor of the channel, while the low bluff which borders it may be seen near the Canadian National Railway at the same point. Toward Ottawa, bedrock is frequently exposed. The channel cuts across the northern corner of the Central Experimental Farm grounds and, just to the east, contains the Dow Lake section of the Rideau Canal. At Ottawa the old channel is split, passing on either side of an upraised block of limestone. The present river follows the northern channel east of Ottawa. The other channels, shown on Figure 12, are from two to six miles wide and, in places, 60 feet deep; they are floored with clay and silt and bordered by sand plains (Photo 85). An elevated clay plain is also found around Sarsfield. In South Plantagenet, Clarence, and



OGS 10 735

Photo 84. Level clay plain of the Champlain Sea floor, Barr Line, Renfrew County.

Cumberland Townships, the main valley is occupied by the South Nation River and its chief tributary Bear Brook. In the City of Gloucester it is drained by the headwaters of Green's Creek. These underfit streams have failed to establish complete drainage of the valley and consequently it is occupied by the Mer Bleue bog.

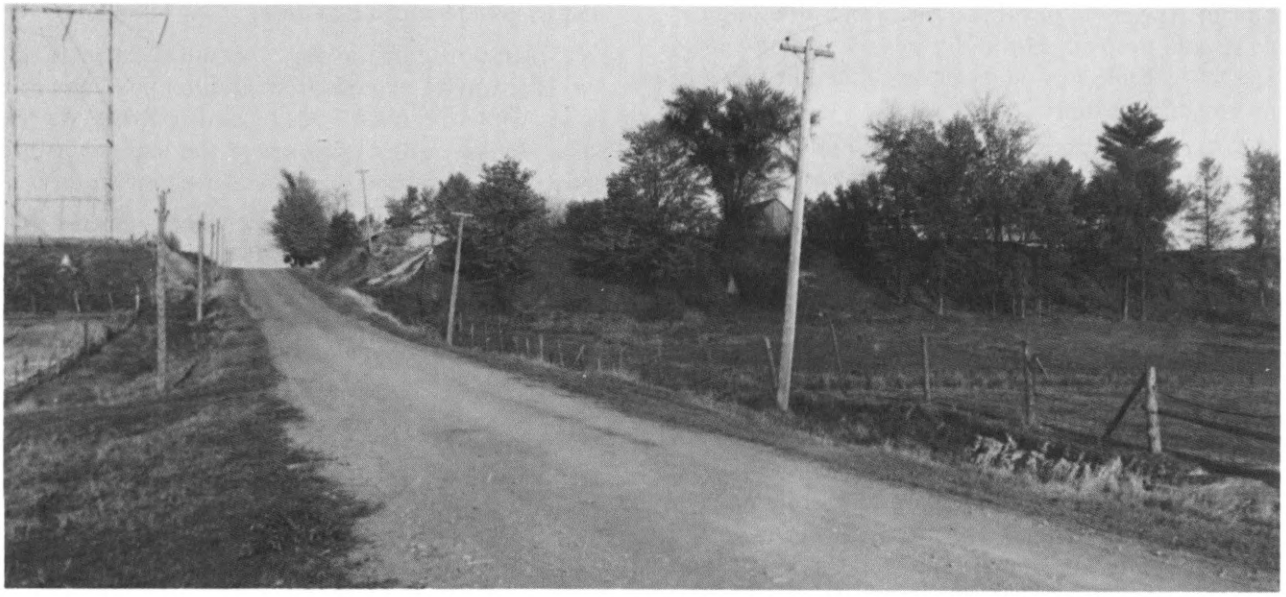
Near Fournier the South Nation River, rather unexpectedly, leaves the broad main channel leading eastward, and enters the Ottawa by way of the narrow valley past the Village of Plantagenet. The Azatica Brook took over the drainage of the lower stretch of the main channel but proved so inefficient that another big bog developed in Alfred and Caledonia Townships. Both the Mer Bleue and the Alfred are raised sphagnum bogs. Drainage is generally poor in all these channels except along the Ottawa River—indeed the South Nation River above Plantagenet periodically overflows its banks, flooding the adjacent flats, and depositing a little alluvium in the process.

The edges of these stream-eroded channels through the sand and clay of Clarence Township contain some areas of very choppy topography which are the result of mud flows when, or very soon after, these channels were cut and at a time when the clays were oversaturated. These marine clays from which the salt has been leached are sensitive and easily disturbed so that landslips and mudflows readily occur. Another such area in the same region is found along the valley of Bear Brook. Similar phenomena may be seen in clay deposits north of the Ottawa in the Province of Quebec. Very similar also were the collapses of the clay which were so troublesome during the building of the St. Lawrence Seaway. While such land has actually been cleared and farmed, its cultivation with modern machinery must be quite an ordeal.

The clay to the east of Ottawa is interbanded, pink and grey, and very plastic. It is finer in texture and lower in lime than the clay in Renfrew County. Free carbonates are lacking in most of the layers. These properties and the generally poorer drainage combine to produce soils more difficult to handle than those found above Ottawa.

In the Ottawa Valley the clay soil types described in the Winchester clay plain are found in the Regional Municipality of Ottawa-Carleton and the United Counties of Prescott and Russell, but the proportion of acid soil is greater. Another type of acid clay loam with highly leached surface horizons occurs in Renfrew County. The Renfrew clay loam is more pervious than the acid clay east of Ottawa and is a more productive soil, even though it appears to be more strongly leached and deficient in humus. The poorly drained associates of these grey acid clays have peaty surface horizons underlain by plastic grey clay. The most fertile of these soils is that developed under elm, ash, red maple, and other hardwoods in the Carp Valley and the plain north of Richmond. When artificially drained and well handled this is a highly productive and durable soil.

Farming practices vary in the different parts of these clay plains. In the vicinity of Ottawa, the Rideau clay has a high value on account of its location; most farms produce fluid milk for distribution in the city. Practically all of the land has been cleared, and a rather high proportion is used for pas-



OGS 10 736

Photo 85. Stream-cut bluff east of Ottawa.

ture. Farms, especially along the highways, have good buildings and appear to be prosperous.

In the Carp Valley, on what appear to be the most fertile soils in the whole Ottawa Valley region, a more general type of farming is practiced in which small grains and beef cattle appear to be the chief products. The grain elevator at Kinburn gives an indication of the market outlet. There is not a high proportion of pasture on the Carp clay loam, probably because of the availability of rough pasture lands along the ridges which border the valley. A few dairy herds are to be seen and undoubtedly indicate the direction of agricultural development within the next few years. Farm buildings, however, will have to be improved for, though roomy, they are mostly of the older types

The clay plains of Renfrew County, for the most part, support a general agricultural economy. One sees big square brick or frame houses, rarely stone, mostly accompanied by rather second-rate barns. Often the barns are of the "small and numerous" pioneer type. There are many log buildings, pigsties, sheepfolds, etc., even on farms where large frame barns have been built. Fences are usually of wire but many rail and stump fences are still in service.

Most farms seem to follow an extensive cropping system. Oats, barley, and mixed grain occupy 12% of the farmland. As a rule, early-sown crops are much better than late-sown because Renfrew is an area of rather light rainfall. Poor drainage, however, often causes late sowing. A striking feature of the agriculture, is the number of pure stands of alfalfa for hay or seed which may in part be due to the low rainfall. This is especially evident in Horton, Ross, and Westmeath Townships where one sees many stacks of alfalfa hay, perhaps for sale to the alfalfa mill in Renfrew. Another crop which does well is peas; one-third of all the dry peas in Ontario were grown in Renfrew County at one time but they are no longer important.

The beef breeds of cattle are commonly seen in the pastures but dairy cattle are increasing. This is especially noticeable near Pembroke, where, also, one sees many silos and good corn crops. Some of the new hybrids seem very well suited to the area. The proportion of pasture on the Renfrew clay is rather small (about 7 or 8%) and crops dominate the scene rather than livestock.

East of Ottawa the clay plains are in the floors of the channels eroded, as already described, by a bigger Ottawa River in early postglacial time. An exception is the area of heavy clay soil on high ground in Cumberland Township. In places in the channels there are thin surface deposits of silt and fine sand which make more easily worked soil, but mostly there is clay soil developed on interstratified pink and grey, plastic clay. Poor drainage is prevalent and the fields are often plowed in narrow "lands" with high crowns to affect surface drainage. On the better drained sites the surface soil is light grey in colour. It is called "terre grise" in that area. These clay soils are not as productive as the clay loams of the Winchester clay plain to the south but the cropping pattern is similar. Hay and pasture and corn for silage and grain are the main crops. Alfalfa is increasing and some red clover seed is produced. Mostly it is a cheese-producing area in contrast to the beef economy of the clay plains above Ottawa.

Ottawa with its huge population (562,782 in the "greater city") dominates the valley. Of the numerous towns of the lumbering period, only one, Pembroke (13,760), has grown to city size and may be counted as a subregional centre. Renfrew (8,195) and Arnprior (5,869) are important in their local umlands as well as having some industries which compete on a wider market. East of Ottawa there is no incorporated centre larger than Rockland (3,887) until Hawkesbury (9,525) is reached. These larger places are manufacturing centres but they serve, also, as farmer's towns in their respective constituencies.

There are many smaller centres in the Ottawa Valley clay plains. In the east one might mention L'Orignal (1,815), Alfred (1,043), Plantagenet (864), Chute-à-Blondeau, and St. Eugène. West of Ottawa are Cobden (996), Beachburg (687), Carp, and Westmeath (300). The former Village of Richmond is a peculiar example. Older than Ottawa, it was laid out in 10-acre lots in the hope of establishing people on the basis of part-time handcraftsmanship and part-time husbandry. However, it never became more than a small local supply point until recently. A considerable number of Ottawa commuters now reside in that area.

Transportation favours centralization in Ottawa; Highway 17 extends from end to end of the clay plains while the main lines of both railways do the same. In the mid-portion where the clay plains are wide, there is a radial road net centred on the city.

Being the capital of the country, Ottawa has grown with great rapidity and shows as yet no signs of slowing down. As a market outlet for the farms of the clay plains, and as a place where operators find off-the-farm employment, its importance is bound to increase.

50 RUSSELL AND PRESCOTT SAND PLAINS

In the United Counties of Prescott and Russell, and the Regional Municipality of Ottawa-Carleton, there is a group of large sand plains separated by the

clays of the lower Ottawa Valley. They consist of one continuous belt, 65 miles in length, from Ottawa to Hawkesbury, together with three fairly large areas lying to the north of it, in Alfred, North Plantagenet, and Clarence Townships, and a number of smaller sandy remnants dispersed over the clay plains (Figure 28). Taken altogether, these sand plains comprise an area of about 575 square miles.

The sand plains have a level surface whose elevation is approximately 250 feet a.s.l., while the bottoms of the intervening clay-floored valleys lie below 200 feet. The boundaries, usually, are abrupt bluffs, although in some places there are intermediate terraces.

Excepting the higher sands south of Ottawa the whole complex was at first a continuous delta built by the Ottawa River and its north-bank tributaries into the Champlain Sea. Formed during one stage, it was cut to pieces later by the Ottawa River when it first rose above sea level. Some sand and gravel of glaciofluvial origin south of Ottawa is conveniently mapped with the delta.

The depth of the sand varies from 20 to 30 feet, as seen along the edges of the valleys in the north, to 10 feet or less in the mid-portions, thinning out along the clay plain to the south. The texture of the sand also varies, being coarse toward the north and grading into fine sand and silt south of the Castor River. Everywhere the sands are underlain by stratified red and grey clay. Both the sand and the clay are low in lime, suggesting an origin in the granitic rocks of the Canadian Shield.

Most of the area lies within the drainage basin of the South Nation River, but smaller parts drain to the Rideau and the Ottawa. Drainage is good for a short distance back from the bordering escarpments but becomes progressively poorer toward the interiors. There are few streams within the sand plains as the water percolates into the sand beds and issues from the bluffs as springs to drain into the clay-floored valleys. The South Nation River cuts a canyon 75 feet deep across the plain from Casselman to Lemieux. Within the valley there are several well-preserved remnants of terraces representing earlier stages of the river. Some of these are wide enough for building sites and narrow fields. It is rather remarkable that the steep escarpments of clay and sand have not been gullied and dissected, but in only a few places does such topography appear, as near Martel.

The original vegetation of these areas included a great many pines on the coarser, better-drained sands. In wetter locations, American elm, red maple, white ash, black ash, basswood, and yellow birch were found. On wet sands, verging on bog conditions, larch, white spruce, black spruce, alder, and willow are common. In the abandoned fields of the sand plains, white birch, and trembling aspen are the most abundant early invaders. The sand plains, while a unit from the standpoint of physiographic origin, are thus divisible into three land types, which from the practical standpoint influence the trends of land utilization. The types are dry sand plains, wet sand plains, and fine sand and silt plains. Within each of these, there is associated certain definite soil types. The sands and fine sands are shown on Figure 28.

The dry sand plains have mature Podzol soils with thin ash-grey horizons. Humic Podzols also occur where the water table is high. In the latter, where the sand is coarse, iron and humus hardpans sometimes develop. All these soils are low in fertility, being deficient in lime, nitrogen, potash, phosphorus, and manganese.

The finer sandy loams, described fully in the Carleton County soil report under the name of

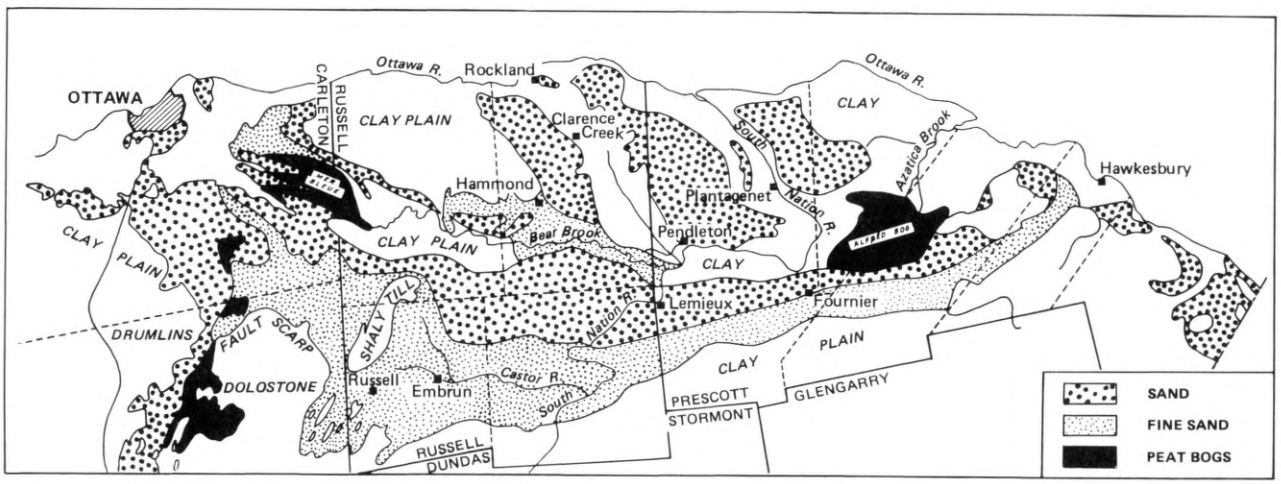


Figure 28. Russell and Prescott sand plains.

Castor, present excellent prospects for improvement. They are mostly poorly drained, even close to streams and bluffs, and require deep drains to effect drainage of the subsoil. When drainage is established, these soils can be productive when a fertility program involving legumes and fertilizers is used.

The pattern of land utilization shows some rather striking contrasts. Whereas the fine sands and silts have become fairly prosperous dairy farming areas, the coarser sands show a poor development of agriculture. It has long been evident that large areas of sand plain should be withdrawn from general agricultural use. The United Counties of Prescott and Russell took an early lead in returning such land to forest. In 1928, upon the recommendation of Mr. Ferdinand LaRose, a block of 100 acres was purchased and planted to young trees. In 1937, by agreement between the county authorities and the Ontario Department of Lands and Forests (now the Ontario Ministry of Natural Resources) an area of several square miles was set aside along the borders of Cambridge and Clarence Townships to be known as the LaRose Forest. Since then additional parcels have been added to the original plantations and also many separate lots have been reforested under the same management plan. By 1984 the reforested area in the Russell and Prescott sand plains had grown to more than 26,000 acres, of which 7,500 acres are owned by the South Nation Conservation Authority. The forest area is still being enlarged as land becomes available for purchase.

The solution for the problem on the areas of fine sand and silt is the amelioration, rather than the abandonment, of land. The provision of good drainage outlets and the raising of fertility levels are important. It is possible, of course, that certain special crops might be introduced to supplement the already well-established dairy economy. Flax is a crop that, at times, has had some success; potatoes do fairly well, and the main trend recently has been an increase in grain corn which now occupies 20% of the farmland.

51 MUSKRAT LAKE RIDGES

The Ottawa Valley is interrupted in several places by prominent rocky ridges which are the protruding crests of fault blocks. One such block lies along the northeast side of Muskrat Lake, presenting a steep scarp toward the southwest, while sloping gently away under a cover of sand to the northeast. A similar ridge borders Olmstead Lake, while a third is found between Haley Station and Renfrew and extends northwestward beyond Cobden. To this collection of rocky uplands the name Muskrat Lake ridges is applied, but there are other smaller areas which do not appear in Figure 19 although they are outlined on Map 2715 (back pocket) and the four miles to one inch maps.

These high fault blocks are all composed of Precambrian rocks, chiefly reddish and reddish grey gneiss and granite, but with fairly large areas of crystalline limestone. Some of this is dolomitic, such as the area north of Haley Station where a plant for the extraction of metallic magnesium is located. The tops of these ridges escaped being covered with clay. The scanty overburden being predominantly sand and gravel.

These ridges, in the main, are non-agricultural. Some land has been cleared, but a great deal of farm abandonment has taken place. In a sense, the ridges form a complement to the contiguous clay plains. The latter have been completely deforested and fuel is scarce; consequently, farmers have secured woodlots on the "mountain". Sometimes, in addition to firewood, enough pine logs are cut "to pay the taxes". Another and perhaps somewhat questionable use of this land is as pasture for young cattle and dry cows. It is droughty and the carrying capacity is low. Moreover the grazing of the cattle tends to check the regeneration of the woodlots, which, after all, must be looked upon as the important resource.

52 PETAWAWA SAND PLAIN

The solid block of settled country in the Ottawa Valley ends near Petawawa in a sand plain, on the Ontario side of the river, interrupted by several outcrops of Precambrian rocks. It extends south of Pembroke and covers an estimated 130 square miles. In origin, it is a delta built in the Champlain Sea by the Petawawa, Barrow, Indian, and Ottawa Rivers during the Fossmill stage of Lake Algonquin.

The farms average about 157 acres each with about 70% cleared and 30% in crop, mainly hay, oats, and barley. Although the farms are generally poor, there are many large square brick and frame houses similar to those in other parts of Renfrew County. It is probable that some of these were built by money made from timber rather than crops and livestock.

Agriculture is no longer of any importance. Petawawa Township has a total rural population of 3,600, but less than 80 actually live on farms. Population is attracted to the area because of the location of the Petawawa Military Camp. Farther north also is the Village of Chalk River, the Town of Deep River, and the nuclear research station.

53 ALGONQUIN HIGHLANDS

This region takes in much of the area underlain by granite and other hard Precambrian rocks, covering an area of 15,500 square miles (9,934,000 acres). Overall it is broadly dome shaped, the crown standing 1,600 to 1,800 feet a.s.l. sloping down to 900 feet, more or less, in the west and 600 feet in the east. Locally, the relief is rough, rounded knobs and ridges standing up usually 50 to 200 feet but with occasional ridges 500 feet high. There are frequent outcrops of bare rock but they do not amount to more than 5% of the total area. The soils are generally shallow (Photo 86) but thickness over the bedrock varies greatly over short distances (Figure 29). Also, they are stony, sandy and acid, so they are mostly submarginal for agriculture. Many of the valleys are floored with outwash sand and gravel. The frequent swamps and bogs in hollows also detract from their usefulness for farming, but they are very useful forest soils. As an exception to the foregoing, several areas have deeper till and few rock outcrops, and the surface of the till is smoothed and moulded with occasional drumlins appearing. These areas are indicated by the mapping of drumlins. The farms in north Hastings and southwest Haliburton are on moulded till plains. Other exceptions to be mentioned are the groups of sand and gravel hills with associated outwash sand flats in the northern part of Algonquin Park, around Round Lake and Golden Lake and in a few smaller tracts which are shown on Map P.2715 (back pocket) and the four miles to one inch maps.

Soils

The type of weathering and profile development in the soils of any region is governed primarily by climate. This is a region of cool, moderately moist climate. Mean annual temperature varies from 42°F in the southern parts of lower altitude to under 40°F in the uplands of Algonquin Provincial Park. Rainfall and snowfall are heaviest on the westerly slope facing Georgian Bay (Figure 30) and lightest on the eastern, lee slope, varying from a high of 40 inches of annual precipitation as recorded at Beatrice to a low of 30 inches at Renfrew. This difference in moisture is reflected in tree growth and is taken into account in a forester's classification of sites (Hills 1959) which considers both soil and climate. As a rule, precipitation exceeds evaporation except in June, July, and August when upward movement of water in the soil predominates over downward movement. Moisture deficiencies are fairly common but on the deeper soils severe droughts are rare. On the average the runoff varies from 20 to 10 inches a year. In keeping with these conditions, under a forest of mixed hardwoods and some conifers the typical soil profiles developed consist simply of a dark surface layer under the leaf litter, up to 6 inches thick, underlain by a brownish horizon 8 to 10 inches

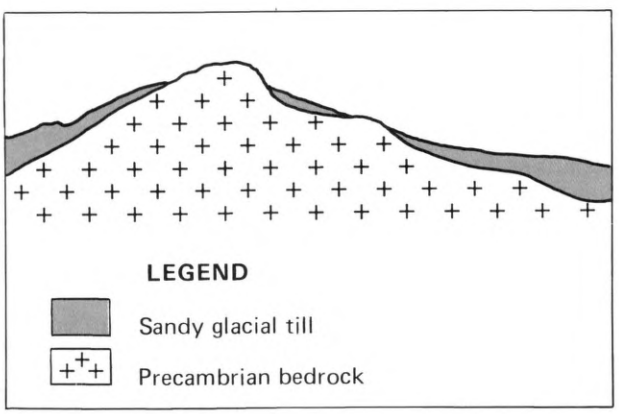


Figure 29. Diagram illustrating the shallow soil over bedrock, typical of the Algonquin highlands.

OGS 10 737

Photo 86. Shallow layer of till over granite bedrock, along Highway 60 in southwestern Algonquin Provincial Park (photo courtesy of Ontario Tree Improvement and Forest Biomass Institute, Ontario Ministry of Natural Resources, Maple).

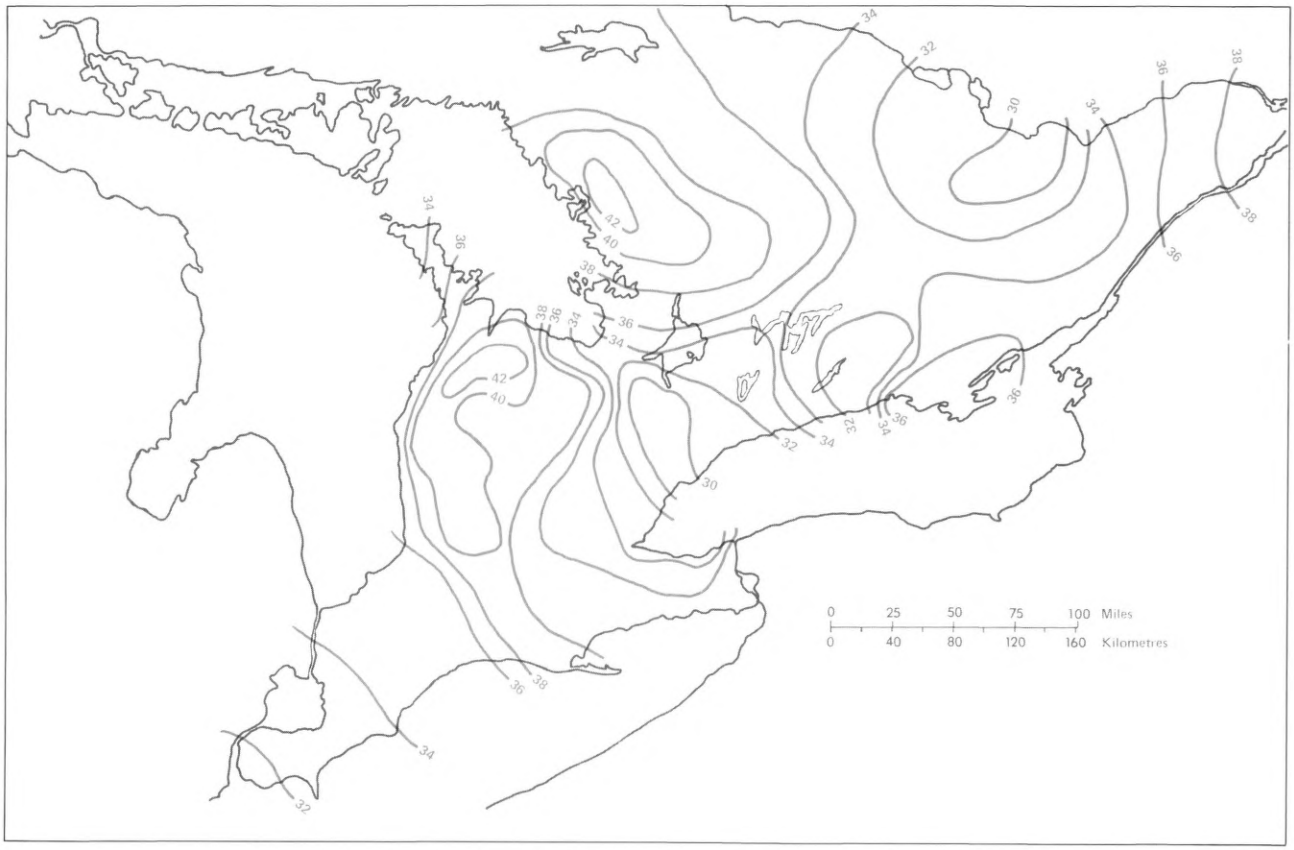


Figure 30. Mean annual precipitation in inches for Southern Ontario (based on data from the years 1951 to 1980, published by Atmospheric Environment Services, Environment Canada).

thick over the unweathered material. The soil is acid and low in nutrient elements. These soils are called Brunisols. They lack the ashy grey horizon under the dark surface layer of the more highly leached Podzols which are found in places. On the other hand, they do not have the light-coloured horizon under the surface layer or the brownish clayey horizon between it and the unweathered parent material of more fertile Grey Brown Luvisols which prevail in much of the area south of the Canadian Shield. In the Minden-Haliburton area and in Muskoka and Parry Sound a few small areas of soil on lacustrine clay, silt, and fine sand are included with this region. On these lacustrine sediments, Grey Brown Luvisols are found on well-drained sites. These better soils on lacustrine silt and clay serve to illustrate the important effect of parent materials on soils.

The vast majority of soil in this region is forested, being nonagricultural mainly because of the rock outcrop and associated shallow soil, rough topography, stones, and swamp. Sandy texture, acidity, and low fertility all contribute to low crop productivity on what deep soil there is. However in the upland part of Renfrew, Lanark, Lennox and Addington, and Hastings Counties there is a sprinkling of farms on the deeper, smoother areas of till. Viable farms are primarily in drumlin areas.

In view of the usually acidic character of the soil it would not be surprising to find more productive soil in areas where crystalline limestone bedrock is found. This appears to be the case only in limited areas directly over the limestone. Generally, throughout the area in which crystalline limestones occur there are no appreciable amounts of carbonates in the till.

Except in Algonquin Provincial Park and Haliburton County, the soils are mapped and described by the Ontario Soil Survey in reports for Renfrew, Lanark, Frontenac, Lennox and Addington, and Hastings Counties and the Parry Sound District. These are listed in Appendix C.

The soil classification developed by foresters (Hills 1953, 1959) differs from the above-mentioned agricultural classification in two respects. Firstly, it separates the shallow soils over Precambrian rocks into three classes, rather than two. These are: 36 to 12 inches, 12 to 2 inches and 2 inches to bare rock. These depths vary an inch more with coarse, dry, sandy materials and an inch less with clay loam. This finer subdivision is needed because of the effect of depth and resulting soil moisture supply and root range on tree growth. Also, noncalcareous parent materials are divided into two types, one containing largely granite and the other having more basic rocks in the mixture. This is done because of known effects

on tree growths. For example, the more acidic type produces better quality yellow birch than the more basic type whereas the reverse holds true for sugar maple. The land classification develped as a basis for forest management has been applied to all of the Georgian Bay-Ottawa Valley region and maps on the scale of 1:125 000 are available for the whole region (Burger 1972).

Agriculture

The inland position of this region with a land mass stretching far to the north and east reduces the moderating effect of the Great Lakes on temperature. The higher and more northerly part has the coldest climate of any part of Southern Ontario. The average frost-free period is under 90 days (June 5 to September 5). Killing frosts occur occasionally even in July and August. It is well to mention, too, that local variations are great in this rough terrain, the slopes of the higher ground often escaping frosts that damage gardens in the hollows adjacent. The cool, short growing season seriously limits the crops which may be grown. There are almost no farms on the crown of this upland part, and the climate prevents the culture of sweet corn, tomatoes, peppers, and other tender crops in gardens. Apples, cherries, raspberries, and other fruits do not survive the cold winters. Thus, even if the soils were good, agriculture would not prosper.

Even in the warmest part of this large region near the southern border the growing season is too short, with less than 2,500 corn heat units (Brown *et al.* 1968), to grow grain corn and even silage corn successfully. The farms there operate under a climatic handicap.

Cleared farmland makes up only about 2% of this area. Most of it is based on deeper, moulded till which includes a scattering of drumlins. Very little of the soil in this region can be rated as Class 1 farmland. Classes 2 and 3 farmland amounts to about 127,000 acres, two-thirds of it being Class 3 (Hoffman 1970). In size, the majority of farms fall in the 100- to 500-acre range, the average size being about 325 acres. Mostly, the farm economy is based on beef cattle, hogs, and a few poultry. Milk for cheese is produced around Eldorado for the one cheese factory still operating in the whole region and from the upland part of Lanark County some cream goes to the creamery at Almonte. The main crops are hay, oats, mixed oats and barley, and silage corn grown for winter feed for beef cattle. It must be said that generally agriculture is not flourishing in this region and many of the operators have other off-the-farm jobs. However, these farms have a latent capacity to produce food when the need arises.

Mining

The Algonquin highlands and the adjacent parts of the Georgian Bay fringe have seen a great deal of varied mining activity over the years. At the present time nepheline is being mined near Blue Mountain in Belmont and Methuen Township; basalt is being quarried near Marmora and crushed to produce roofing granules; terrazzo chips are being produced from marble quarries near Madoc, and in Haliburton and north Lanark Counties; talc is being mined near Madoc and, together with tremolite, in north Frontenac Township; decorative gneiss is being quarried near Parry Sound; decorative granite is being quarried near Orillia and, in small amounts, in southern Leeds County. In previous years, graphite was mined at Black Donald Mine in Renfrew County, in north Hastings County (Hewitt 1954), and in south Lanark County. Corundum was mined at Craigmont and at Burgess Mines in north Hastings County. Uranium was mined at Bancroft and Wilberforce. Feldspar was mined in many places, particularly in north Hastings and Lanark Counties, and near Madawaska and Verona. A mica industry flourished for many years in south Frontenac County and east of Lake Nipissing. Iron was mined in many locations, notably near Marmora and in north Hastings, west Lanark, and central Frontenac Counties. Diatomite was mined in the area between Bracebridge and Huntsville. A niobium mine was opened on the Manitou Islands in Lake Nipissing. Molybdenum has been mined in south Renfrew County and fluorspar near Madoc. Gold was first discovered in Ontario at Eldorado in south Hastings County and numerous small gold mines have operated in central Lennox and Addington County. Nepheline was mined in north Hastings County. Copper has been mined in the District of Parry Sound, together with silver and antimony at Clyde Forks, and with nickel in central Hastings County. Zinc has been recoverd from the Long Lake Mine in central Frontenac County. Lead has been mined near Madoc. Most of the operations discussed are small, and are either closed or operating intermittently. Additional details are outlined in Springer and Vos(1983).

Forestry

The 98% or 9,306,660 acres of this region with non-agricultural soil is forested except for scattered, open clearings and bare rock areas. The upland sites with deeper soils support sugar maple, yellow birch, and a scattering of white pines, hemlock, and balsam fir. The pines (white, red, and jack) concentrate in the sandy and gravelly soils of the outwash in the hollows and the kames and eskers. White pine thrives on the finer sands and jack pine is found on the drier coarser sand. The sandy soils also support some white spruce. Black spruce and white cedar are

found on swamplands and bogs. These latter wetlands occupy about a tenth of the area and are patchy in distribution.

This region accounts for one-third of the maple syrup produced in Ontario, not a major item in the economy but one which supplements many farm incomes.

It was through lumbering that this part of Ontario was opened up, the history of lumbering being a story in itself which cannot be dealt with here. It will suffice to say only that the country is dotted with the dilapidated or burned-out and overgrown remains of lumber camps and sawmills. At present, there are only 20 sawmills operating in the District Municipality of Parry Sound. Most are small, having an average annual output of slightly less than 113 000 m^3. At first, the hardwoods were passed by in favour of the pines but now the hardwoods, used for plywood, furniture stock, and pulpwood, account for over half of the current cutting. Pulpwood of black spruce off wetlands, poplar, and hardwood chips account for about one-third of the current harvest. Possibly because there are no large continuous stands of pulpwood, there are no paper plants in this region, the wood going to pulp mills outside its boundaries.

Anyone visiting this area in summer might well conclude that recreation and tourism are the most important sources of income. However, lumbering in its several forms is still the primary industry by a wide margin, and will likely maintain this position.

Recreation

The forests, streams, and more than 1,000 lakes in this region and the fish, game, and wildlife have made it a summer recreational area for city dwellers. Deer hunting causes a brief flurry of activity in the fall and there is some partridge and duck hunting. In recent years skiing and snowmobiling have created some business in winter and many cottages are used on weekends all year. The winter sports are related to the fairly heavy snowfall (75 inches to 125 inches) and persistent snow cover. There are now 16 alpine ski resorts and more than 30 cross-country ski areas in operation on the Canadian Shield. Another recreational activity flourishing in this region is rock collecting, the Bancroft area in particular being a mecca for rock hounds. In Algonquin Provincial Park, a natural park of 2,925 square miles, the streams and lakes are used for canoe routes through wilderness as well as camping. Finally, this region affords a wealth of lovely natural landscapes and it is no accident that Tom Thompson lived here and roamed the hinterland to paint the scenes which caught his eye. Cavalcades of motorists come to see the autumn colours when they are most brilliant and indeed the beauty of lakes, streams, rocks, and forest is one of the attractions at any time of year.

54 GEORGIAN BAY FRINGE

A broad belt bordering Georgian Bay, characterized by very shallow soil and bare rock knobs and ridges, has been separated from the Algonquin Highlands. It occupies much of Parry Sound and Muskoka and extends eastward from Muskoka in patches into the area north of the Kawartha Lakes, covering about 1,290 square miles (826 000 acres). This type of landscape may be familiar to more people than that of the Algonquin Highlands because Highway 69 passes through it and Highway 11 contacts it in places. In Parry Sound and Muskoka the bare rock ridges are due partly to the fact that they were washed by the waves when glacial Lake Algonquin inundated this area. However, the covering of drift was scanty before that, as it is not deep even in the hollows and this holds true in the area north of the Kawartha Lakes which was never submerged. The bare rocks and shallow soil have resulted in a scrubby growth of red oak, jack pine, hemlock, and hardwoods. The few farms of the region are mostly based on narrow strips of fine sand, silt, and clay loams in valleys. Both forestry and agriculture are restricted by the limited amount of good soil.

There are no mines in the part of Georgian Bay Fringe that lies west of Number 11 strip, however numerous mining activities are carried out in the eastward extension of this region which lies immediately south of the Algonquin highlands and they were discussed in that section.

Being within driving distance of Toronto and other cities in the south this region has become the major recreational area of Ontario. The Muskoka Lakes and many of those in Parry Sound have strings of summer cottages on their shores. In the District Municipality of Muskoka there are close to 19,000 seasonal dwellings. Swimming and boating and the sylvan surroundings are the main attractions. While the main influx of vacationers comes in summer, the heavy snowfall of this area and the amount of unsettled land attracts skiers and snowmobilers in winter. Unfortunately, there are very few hills high enough for downhill ski runs. There is a short period of activity during deer-hunting season. Fishing is not of major importance. The limited fish population of the lakes, mainly lake trout, are now further lowered by acidification of the water by sulphur dioxide in the atmosphere and by over fishing.

55 THE NUMBER 11 STRIP

Highway 11 from Gravenhurst to North Bay follows a narrow strip in which sand, silt, and clay deposits occupy the hollows. This strip was just below the shoreline of glacial Lake Algonquin. The streams entering this lake from the upland adjacent dropped

sand as deltas and the silt and clay settled out in deeper water offshore. Also, there was another source of sediments; an esker followed this same strip from near Bonfield to Gravenhurst. This sand and gravel ridge has been mostly levelled by the waves but here and there the ridge is still evident and the irregular bedding of the esker still intact. The deep soils developed on the fine sand, silt, and clay have been cleared and support farming settlements. These soils stand in striking contrast to the bare rock ridges and poor shallow soil of the adjacent high ground. They constitute most of the farmland in Parry Sound and Muskoka. Bracebridge (8,832), Huntsville (11,063), Burk's Falls (895), Sundridge (752), South River (1,126), Trout Creek (646) and Powassan (1,105) developed as supply points for these farming settlements. It should be added that agriculture has been displaced by recreational activities, particularly in Muskoka, as the primary industry in this strip. Many of the comments regarding recreational activities in the Georgian Bay fringe apply also to the Number 11 strip.

The most extensive of the soils developed on the finer sediments is classified as Magnetawan silt loam. Being based on noncalcareous sediment and being strongly leached, it is an acid soil with thin surface soil. When plowed, the light grey, leached horizon makes up the bulk of the surface soil and bare fields are light grey in colour. However, these are pervious soils and are moderately productive when fertilized regularly. Most of the 29,400 acres of this type of soil mapped in Parry Sound are located in the Number 11 strip. The best of the sandy types is the Berriedale fine sandy loam. Although acid and low in nutrients it has silty or fine sandy subsoil which holds moisture to make it fairly productive. These better soils make up about 22% of the 130,000 acres in this strip, the remainder being drier sands and shallow, stony soils on the scattered rock ridges which do not support agriculture.

Most of the farmland in Parry Sound and Muskoka is in the Number 11 strip so the census data for these districts may be used to describe the agriculture. In 1981, woods occupied 41% of the farmland; rough pasture 23%; seeded pasture 12%; hay 17%, and oats, barley and mixed grain only 2%. There was very little silage corn so the system of farming is based mainly on hay, pasture, and mixed grain. Actually, nearly all the farmers also have off-the-farm jobs, indicating that there are few self-sufficient farms in this region. Most of these are in the vicinities of Powassan and Burk's Falls.

SUMMARY

Southern Ontario, in this edition, is Ontario south of North Bay, and includes Manitoulin, Cockburn, and St. Joseph Islands. It falls naturally into two parts: the largely agricultural, well-settled south, based on Paleozoic limestones and shales; and the largely forested, sparsely populated north, based on rugged Precambrian rocks. The limestones and shales in the south are mostly covered by deep soils containing plenty of lime. In the north the granites and other igneous and metamorphic rocks, have a shallower drift cover and frequent rock outcrops, the shallow soils being deficient in lime. Because of the better soils and the great place-to-place differences in landforms and soil materials the south commands most of our attention in this book. Also our survey is less accurate in the north due to the lack of a systematic road network.

In the south part of Southern Ontario, the bedrock surface is one of low topographic relief except for the Niagara Escarpment and two other, much lower, northeast-facing scarps in the peninsular section and several short, but abrupt, fault-line scarps in the Ottawa Valley. West of the Niagara Escarpment, a broad arch of the bedrock forms the Dundalk upland, the crown of which is more than 1,700 feet a.s.l. Eastward from the section of the escarpment known as the Caledon Hills, another height of land, the Oak Ridges Moraine, extends for 120 miles through south-central Ontario. It is a great ridge of glacial drift, the highest parts of which stand between 1,000 and 1,300 feet a.s.l. Thus the build of the southern part is dominated by two features, the broad half-dome of the Niagara cuesta and the Oak Ridges Moraine. A lower arch of the bedrock, known as the Frontenac Axis, exposes the granite knobs east of Kingston, while, to the northeast, the St. Lawrence-Ottawa Lowland shows little relief with its lowest parts being less than 200 feet a.s.l.

In the north, between Georgian Bay and the Ottawa Valley, the bedrock is also warped, forming a dome with its crown in Algonquin Provincial Park at 1,600 to 1,900 feet a.s.l. Locally, the topography is rough, consisting of knobs and ridges of granite and other Precambrian rocks. On these hard rocks the glacial overburden is shallow and rock outcrops are frequent. The local relief is generally 50 to 200 feet and occasionally 500 feet. The depressions between the rock ridges are mostly poorly drained and boggy, and many are occupied by lakes. Except for a few areas of deeper soil the mosaic of shallow, acid, sandy soil, rock outcrops, bogs, and lakes make this part unfit for agriculture. It is mostly forested and is still Crown Land.

South of the Precambrian bedrock there are some fairly level belts of limestone and dolostone on which very little overburden was left after the melting of the ice. Most extensive of these areas is the rock plain extending northward from Kingston toward Arnprior and Ottawa. Other such areas are found along the low escarpment, westward from Kingston to the Kawartha Lakes and Georgian Bay, and in association with the Niagara cuesta, especially on the Bruce Peninsula and Manitoulin Island. The total area of such land types exceeds 4,500 square miles.

Apart from the large tracts of shallow soil on limestones, and a few small areas of shallow soil on shale, the overburden is generally deep and composed of calcareous materials from which fertile soils have developed. The higher inland portions are mostly till plains. The lower lands bordering the Great Lakes were submerged in glacial lakes, and the plain between the St. Lawrence and the Ottawa Rivers was inundated by saltwater following the disappearance of the last ice sheet, the Wisconsinan. Altogether, these waterlaid sand and clay plains cover nearly half the area of the southern part. Although this book is concerned with surface beds

rather than the underlying drift strata, these lower strata should not be ignored since they were a source of material for the last glacier and from them is derived most of our well water. The uniformly fine-textured tills bordering the Great Lakes derived much of their silt and clay from the underlying lacustrine beds.

The process of glaciation and deglaciation by the Wisconsinan ice sheet created the present configuration of moraines, abandoned spillways, drumlins, eskers, abandoned shorelines, and various types of stillwater sediments as shown on Map P.2715 (back pocket). The history of the recession of this ice sheet has been reinterpreted here and there in this edition as a result of new observations and a reassessment of the evidence previously collected, and this is one of the more important contributions of the study. To present the many different concepts that have been recently proposed is beyond the scope of this monograph. More detailed discussions are available in the reports and maps published by the Ontario Geological Survey (Appendix A) and numerous other geological publications.

The major patterns of physical features in Southern Ontario are shown on Map P.2715 (back pocket). This map is the product of field mapping, supplemented by the examination of air photos. It provides a fairly complete survey of moraines, drumlins, and eskers. Sandy kame moraines are distinguished from till moraines and two types of till plains are shown. One is drumlinized, well moulded, and smooth even if no drumlins are present; the other has a subdued morainic topography exhibiting a mosaic of irregular knolls and shallow depressions. The map illustrates the abundance and importance of glacial drainage channels west of the Niagara Escarpment but, because of the scale, the bluffs, terraces, and swamps which are their component parts are not shown. The shorelines of extinct lakes must also be shown without finer detail, but the larger clay plains, sand plains, bogs, and marshes of the old lake basins appear on the map. Although not shown on the map, other Pleistocene features were discussed in the text, notably the shallow silty covering, probably wind deposited, which smooths the surface and reduces the stoniness of the soils in many areas; and small areas of sand dunes, sometimes in association with ancient shorelines and sometimes arising in outwash sand plains. Almost all of these dunes are old, were eventually covered with vegetation, and so have become stable landforms; but the recent removal of forests has, in some cases, caused them to begin to move again. The ribbed and hummocky relief produced by mudflows in the marine clay beds of the Ottawa Valley constitutes an exceptional pattern which has also been dealt with separately.

Most of the surface of Southern Ontario, moulded by the moving ice sheets or veneered by lacustrine deposits, remains relatively unaltered as an assemblage of depositional landforms. The period since the disappearance of the ice sheet and the uncovering of any submerged areas has been too short for stream erosion to assume complete control of the landscape. Nevertheless there are some marks of erosion. The streams, which carry off on the average between 10 and 19 inches of water or between one-third and one-half of the precipitation, have begun to refashion the surface of the land. We have not tried to map these erosional forms on Map P.2715 (back pocket) as a larger scale would be needed for this purpose. However, the stream valleys have been discussed in some detail with special emphasis on their relation to the Pleistocene deposits and related landforms. In the upland area west of the Niagara Escarpment the valleys of the present rivers must be distinguished from the channels made by the meltwaters draining away from the waning glacier. Many of the streams follow the Pleistocene spillways and obviously are misfits. The fact that the spillways often cut through the drift to the bedrock has limited the rate of development of the modern stream valleys. Within the glacial lake plains the stream valleys are all erosional and in these areas the amount of dissection due to the streams and their tributaries is related in no small measure to the texture of the lacustrine deposits. The deep beds of silt and fine sand are most readily eroded, and it is on these soils that soil erosion is most serious. Soil erosion and geological erosion are the same process.

In order to point up the variety and contrast of the landscape 52 minor regions have been delineated in the southern part. The Niagara Escarpment, with grey, carbonate rock cliffs overlooking long slopes carved in red shale, stands in sharp contrast to the gentler glaciated landscapes of the plains which flank it at both upper and lower levels. But the escarpment itself is somewhat complex: the two deep reentrant valleys, the Beaver and the Bighead, as well as the broad clay terraces of the Cape Rich foreland, warrant separate descriptions. The Horseshoe and the Dummer Moraine systems, with a combined area of about 2,750 square miles, include the roughest and the stoniest of the glaciated surfaces. Less rugged till moraines, separated by smooth till plains, occupy the regions north and south of London. Four sandhill areas, regarded for the most part as interlobate and terminal kame moraines, occupy about 860 square miles. While there is some good land in these areas, the dry, hilly sands are subject to both blowing and gully erosion, and constitute a well-known reforestation problem. Much has been done in recent years to take care of this situation, but much still remains to be done. The Peterborough drumlin field and six smaller drumlin fields cover an area of about 3,300 square miles characterized by the pres-

ence of oval hills. Undulating till plains, without drumlins, cover at least another 4,000 square miles. The clay plains which were the floors of ancient lakes occur as 12 separate regions with a total area of 7,300 square miles, not counting an estimated 1,000 square miles of clay land scattered throughout the Algonquin and Iroquois lake plains. The sand plains, amounting to more than 4,500 square miles, border Lake Erie, Lake Ontario, and Lake Simcoe, as well as comprising sizable areas in the Ottawa Valley. Six sand plain regions are described, chief among them being the Norfolk tobacco belt.

In the northern part three regions have been distinguished and outlined on the map of regions (Figure 18). The main body of the area with rock outcrops, although they frequently occupy no more than 5% of the surface, is called the Algonquin highlands. On the western fringe of this upland area is a fairly broad belt, in Parry Sound and Muskoka, which extends eastward intermittently to the area north of the Kawartha Lakes in which the soil is very shallow and bare rock knobs and ridges are common. This has been named the Georgian Bay fringe. The third region in the Canadian Shield to be distinguished is the narrow strip of sand, silt, and clay deposits with occasional rock ridges, on either side of Highway 11 from Gravenhurst to North Bay. Most of the better farmland in the northern part is found in this Number 11 strip, particularly on the silt and clay loams

Regional differentiation is primarily physical, with most attention being given to the topographic form and composition of the surface deposits. These are basic to the classification of the soils which are developed upon them through the agency of climate and vegetation. Our original studies of these areas included observations of a broad reconnaissance nature concerning the soils, not all of which were published. Since that time the Ontario Soil Survey has published detailed reconnaissance reports covering all the counties in Southern Ontario (Appendix C), and we have drawn upon this material rather freely in this edition. Major soil types and the pattern of associated soils show a close correspondence with the materials and landforms while, in turn, the land-use patterns are at least partly correlated within the different climatic zones.

In Southern Ontario there are 78,700 farms occupying 13,706,000 acres of land of which 10,571,000 acres are classed as improved. Crops occupy 8,857,000 acres, the other 1,714,000 acres being mostly in pasture. About 250,000 acres of cropland are in the Canadian Shield and the Dundalk till plain where the growing season is too short to be favourable for grain corn and soybeans. The 8,600,000 acres of improved land, where "corn heat units" amount to more than 2,500, constitute the one large block of land in Canada with this advantage. In this area agriculture in the last 20 years has changed greatly. Corn acreage has increased from 664,000 acres to 2,815,000 acres and soybeans from 212,000 to 689,000 acres. The dramatic increase in grain corn is due to the breeding of good, earlier-maturing hybrids which has resulted in the corn belt expanding northward and eastward from the traditional corn area of Essex and Kent Counties. For example, grain corn in Huron and Perth Counties in 1961 occupied 13,000 acres but by 1981 had increased to 317,000 acres. This increase in grain corn at the expense of oats and pasture has also been aided by increased corn yields.

The dramatic increase in grain corn now appears to have levelled off and soybeans are following a similar trend. Barley and wheat have remained about the same, aided by the introduction of better varieties. The tobacco acreage is due to decline and, likely, much of this acreage will be used for corn, and peanuts may take over a little of this land. Another new crop, canola (a special rape seed used mainly for oil), may come into the crop rotations, particularly in cooler sections.

The pattern of livestock production has changed also. In 1941 the densest livestock population was in Winchester Township, followed by the Woodstock area where dairy cattle predominated. By 1961 Woolwich Township, representing the beef cattle, hogs, and dairy cattle mixture of Waterloo County, had the densest livestock population. The 1981 census, on a township basis, shows Elderslie Township in first place due to its high beef cattle population. This is surprising, as the Saugeen clay plain area is on the fringe of the grain corn zone and the soils, though good, are not exceptional. The answer is indicated by the frequent feedlots to be seen in this area. In the last 20 years the number of cattle in Essex and Kent Counties has declined. Overall, the livestock population has risen slightly.

Southern Ontario continues to have a rapid increase in population, most of it in the cities and surrounding areas. Perhaps the most striking change, particularly in sandy and hilly landscapes is the enormous increase in the use of land for scattered non-farm residential sites. This is determined by the distance from large cities but soil conditions and water supply are also important. Sand plains are more favoured than clay plains. The Niagara Escarpment and the Oak Ridges Moraine north of Toronto provide the most striking examples of physiographic attractions for rural residences. One of the primary desires of those who seek to build a rural residence is an attractive view and, if possible, a stream and some woods nearby. For others cheap land seems to be the main consideration, as, for instance for those who build in a cedar swamp.

Thus we have placed considerable emphasis on population density and distribution in the regional discussions, but our main purpose has been to describe the terrestrial surface. This study provides a background for the classification and mapping of the soils of the region. Even in this highly industrialized area, society is still founded on the soil, and proper land use is the key to continued development. The map will serve to indicate the occurrence of gravel, sand, and clay deposits. Those interested in the engineering properties of soils and in water supply may find this book useful. We hope also, that this book will stimulate an interest in the landforms of this complex area which supports more than one-third of the population of Canada.

APPENDIX A

Quaternary Geology reports and maps for Southern Ontario published by the Ontario Geological Survey and the Geological Survey of Canada

ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Preliminary Maps

P.238 : St. Thomas Area, West Half (40 I/14W), 1964
P.606 : St. Thomas Area, East Half (40 I/14E), 1970
P.727 : Dundalk Area (41 A/1), 1972
P.749 : Windsor-Essex Area (40 G/15; J/2,3,6,7), Western Part, 1972
P.750 : Windsor-Essex Area (40 G/10,15; J/2,7), Eastern Part, 1972
P.764 : Niagara Area (30 M/3,6), 1972
P.796 : Welland Area (30 L/14,15), 1972
P.835 : Alliston Area (31 D/4), 1973
P.836 : Newmarket Area (31 D/3), 1973
P.906 : Alexandria Area (31 G/7), 1973
P.919 : Collingwood-Nottawasaga Area (41 A/8,9), 1974
P.975 : Orr Lake Area, Western Half-Nottawasaga Area, Eastern Half (31 D/12W; 41 A/9E), 1974
P.978 : Barrie Area (31 D/5W), Western Half, 1974
P.981 : Dunnville Area (30 L/13), 1974
P.993 : Grimsby Area (30 M/4), 1975
P.1010: Hawkesbury-Lachute Area (31 G/9,10), 1975
P.1011: Vaudreuil-Huntingdon Area (31 G/1,8), 1975
P.1048: Lucan Area (40 P/3), 1975
P.1232: Goderich Area (40 P/12E), 1977
P.1233: Seaforth Area (40 P/11), 1977
P.1556: Durham Area (41 A/2), 1977
P.1972: Strathroy Area (40 I/13), 1978
P.1973: Bothwell-Ridgetown Area (40 I/5, 12), 1978
P.2204: Toronto and Surrounding Area (30 M/NW), 1980
P.2222: Sarnia-Brights Grove Area (40 J/16;40 O/1), 1979
P.2314: Chesley-Tiverton Area (41 A/5SE, 6), 1979
P.2365: Renfrew Area (31 F/7), 1980
P.2366: Cobden Area (31 F/10), 1980
P.2367: Fort Coulonge (31 F/15), 1980
P.2368: Wallaceburg-St. Clair Flats Area (40 J/9, 10E), 1980
P.2376: Bancroft Area (31 F/4), 1980
P.2532: Campbellford Area (31 C/4; 31 N/13), 1984
P.2536: Coe Hill Area (31 C/13), 1982
P.2540: Belleville Area (31 C/3), 1982
P.2541: Wellington Area (30 N/14), 1982
P.2558: Brudenell Area (31 F/6), 1982
P.2559: Wiarton Area (41 A/11), 1982
P.2586: Trenton-Consecon Area (31 C/4; 31 N/13), 1984
P.2587: Sydenham Area (31 C/7), 1984
P.2588: Bath-Yorkshire Island Area (31 C/2; 30 N/15), 1983
P.2596: Fenelon Falls Area (31 D/10), 1983
P.2604: Cambridge Area (40 P/8), 1983
P.2605: Hamilton Area (30 M/5), 1983
P.2608: Algonquin Park, NW Part (31 E/14,15; 31 L/2,3), 1983
P.2609: Algonquin Park, NE Part (31 F/12,13; 31 K/4), 1983

P.2615: Tweed (31 C/6), 1983
P.2616: Long Point Area (40 I/9), 1983
P.2624: Port Burwell Area (40 I/10), 1983
P.2697: Orillia Area (31 D/11), 1984
P.2698: Algonquin Map Sheet (31 E/10,11), 1984
P.2703: Algonquin Park North Central Part (31 E/16; 31 L/1), 1984
P.2704: Opeongo Lake Area (31 E/9), 1984
P.2705: Kawagama Lake Area (31 E/7), 1984
P.2706: Whitney Area (31 E/18), 1984

Geoscience Reports

*GR 16: Pleistocene Geology of the Hamilton-Galt Area (30 M/5; 40 P/8) (with Maps 2029, 2030, 2033, 2034), 1963

GR 46: Pleistocene Geology of the Scarborough Area (31 M/11,14) (with Maps 2076, 2077), 1983

GR 59: Pleistocene Geology and Ground Water Resources, Township of Etobicoke, York County (30 M/11,12,13) (with Map 2111), 1968

GR 61: Pleistocene Geology of the Guelph Area (40 P/9) (with Map 2153), 1968

GR 117: Quaternary Geology of the Bolton Area (30 M/13) (with Maps 2275, 2276), 1975

GR 119: Quaternary Geology of the Woodstock Area (40 P/2) (with Maps 2281, 2282), 1974

GR 141: Quaternary Geology of the Orangeville Area (40 P/16) (with Maps 2326, 2327, 2328), 1976

GR 148: Quaternary Geology of the St. Mary's Area (40 P/6) (with Map 2336), 1977

GR 162: Quaternary Geology of the Simcoe Area (40 I/16) (with Maps 2369, 2370, 2371), 1978

GR 180: Quaternary Geology of the Merrickville Area (41 A/5SE, 6) (with Maps 2387, 2388), 1979

GR 181: Quaternary Geology of the Sudbury Basin Area (41 I/10W, 11) (with Map 2397), 1979

GR 187: Quaternary Geology of the Palmerston Area (40 P/15) (with Maps 2383, 2384), 1979

GR 188: Quaternary Geology of the Grand Bend-Parkhill Area (40 P/4,5) (with Maps 2400, 2401, 2402, 2403), 1979

GR 220: Quaternary Geology of the Tillsonburg Area (40 I/15) (with Map 2473), 1982

Geological Circulars

GC 8: Pleistocene Geology of the Hamilton Map-Area (30 M/5), 1959

GC 9: Pleistocene Geology of the Galt Map-Area (40 P/8) (with Map 2010), 1961

Industrial Mineral Reports

IMR 23: Industrial Mineral Resources of the Brampton Area, Halton, Peel, and York Counties (30 M/12) (with Maps 2176, 2179), 1969

IMR 24: Industrial Mineral Resources of the Markham-Newmarket Area (30 M/14) (with Map 2124), 1969

IMR 32: Pleistocene Geology of the Thornhill Area (30 M/14d) (with Maps P.244*, P.574*), 1970

IMR 37: Pleistocene Geology of the Brantford Area (40 P/1) (with Maps 2240, 2241), 1972

*Out of print

GEOLOGICAL SURVEY OF CANADA PUBLICATIONS

Memoirs

*M 256: Pleistocene Geology of Lake Simcoe District (with Maps 992A, 993A), 1950

*M 288: Surficial Geology of the Lindsay-Peterborough Area, Ontario, Victoria, Peterborough, Durham, and Northumberland Counties, 1957

Bulletin

B 121: Surficial Geology of the Cornwall and St. Lawrence Seaway Project Areas (with Map 1175A), 1965

Papers

70-18: Surficial Geology of Brockville and Mallorytown Map Areas (with Map 6-1970), 1970.

70-34: Quaternary Geology of the Stratford-Conestogo Area (with Maps 26-1970, 27-1970, 28-1970, 29-1970), 1971

71-26: Quaternary Geology of the North Bay-Mattawa Region (with Map 3-1971), 1972

72-48: Surficial Geology of Kingston (north half) Map Area (with Maps 7-1972, 8-1972), 1973

75-35: Surficial Geology and Landslides of Thurso-Russell Map Area (with Map 4-1975), 1976

Maps

1132-A: Surficial Geology, Chalk River, 1963

13-1965: Surficial Geology, Gananoque-Wolfe Island (with paper 65-21), 1966

1425-A: Surficial Materials and Terrain Features of Ottawa-Hull, 1978

1488-A: Surficial Geology, Vaudreuil, 1982

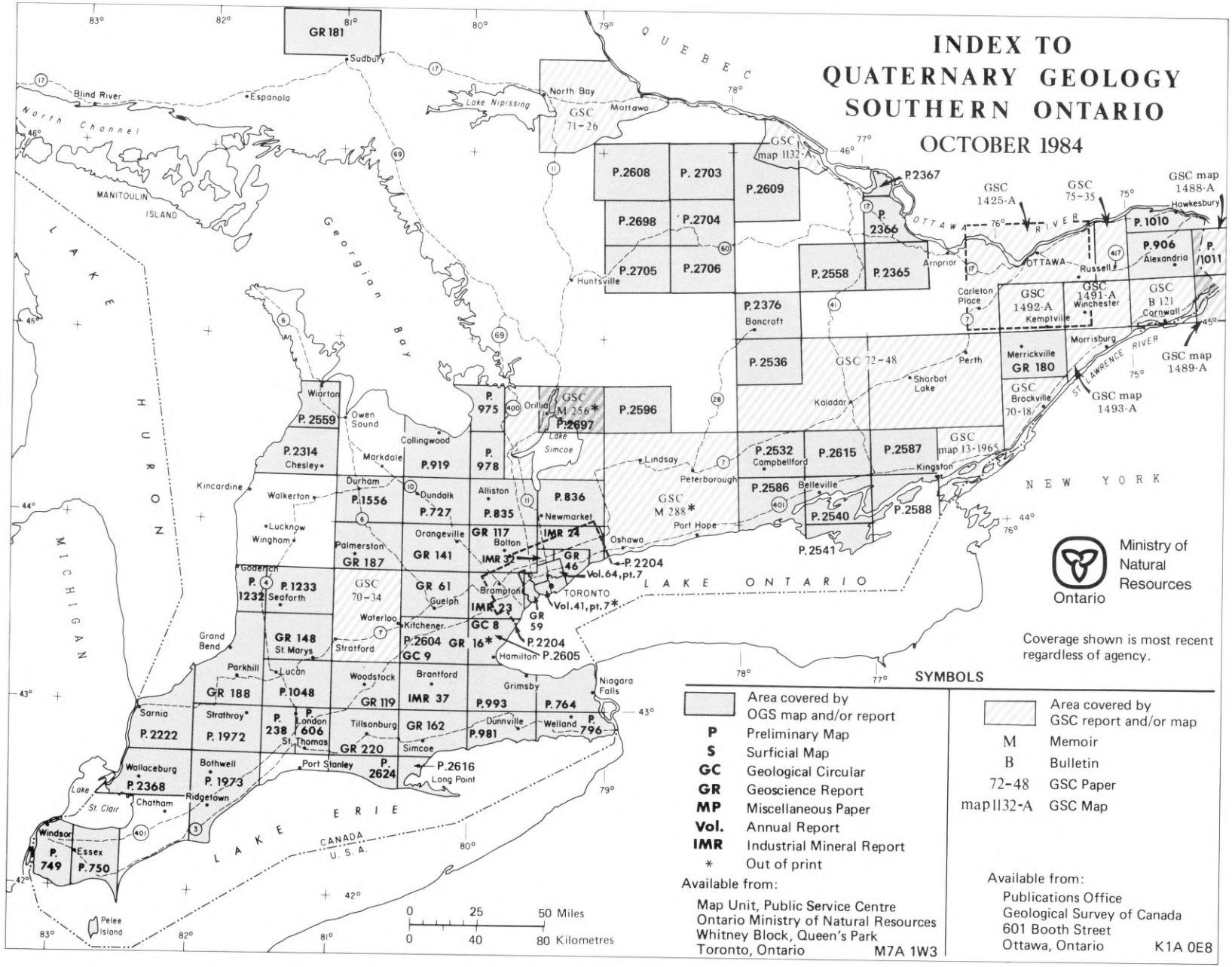
1489-A: Surficial Geology, Huntingdon, 1982

1491-A: Surficial Geology, Winchester, 1982

1492-A: Surficial Geology, Kemptville, 1982

1493-A: Surficial Geology, Morrisburg, 1982

*Out of print


INDEX TO
QUATERNARY GEOLOGY
SOUTHERN ONTARIO
OCTOBER 1984
GR 181
Sudbury
Blind River
Espanola
North Channel
MANITOULIN ISLAND
Lake Nipissing
North Bay
Mattawa
GSC 71-26
QUEBEC
GSC map 1132-A
P.2608
P. 2703
P.2609
P.2698
P.2704
P.2705
P.2706
P.2558
P.2365
P.2367
P. 2366
GSC 1425-A
GSC 75-35
GSC map 1488-A
Hawkesbury
P. 1010
P.906 Alexandria
P. /1011
OTTAWA
Russell
Arnprior
Carleton Place
GSC 1492-A Kemptville
GSC 1491-A Winchester
GSC B 121 Cornwall
Morrisburg
GSC map 1489-A
ST LAWRENCE RIVER
Georgian Bay
LAKE HURON
Huntsville
P.2376
Bancroft
P.2536
GSC 72-48
Perth
Sharbot Lake
Merrickville GR 180
GSC Brockville 70-18
GSC map 1493-A
Wiarton
P. 975
Orillia
GSC M 256*
P.2697
P.2596
P.2559
Owen Sound
Collingwood
Lake Simcoe
P.2314 Chesley
Markdale
P.919
P. 978
Lindsay
Peterborough
P.2532 Campbellford
P.2615
P.2587
GSC map 13-1965
Kingston
NEW YORK
Kincardine
Walkerton
Durham
P.1556
Dundalk
P.727
Alliston
P.835
P.836
Newmarket
P.2586
Belleville
P.2588
P.2540
P.2541
GSC M 288*
Port Hope
Oshawa
Lucknow
Wingham
Palmerston GR 187
Orangeville
GR 141
GR 117
Bolton
IMR 24
IMR 32
GR 46
Vol.64,pt.7
P.2204
Goderich
P. 1232
P.1233 Seaforth
GSC 70-34
GR 61
Guelph
Brampton
IMR 23
TORONTO
Vol.41,pt.7*
LAKE ONTARIO
MICHIGAN
Waterloo
Kitchener
GC 8
GR 59
Grand Bend
GR 148 St. Marys
Stratford
P.2604
GR 16*
GC 9
Hamilton
P.2605
Parkhill
Lucan
GR 188
P.1048
Woodstock
GR 119
Brantford
IMR 37
Grimsby
P.993
P.764
Niagara Falls
Sarnia
P.2222
Strathroy
P.1972
P. 238
P. 606
London
St. Thomas
Tillsonburg
GR 162
Dunnville
P.981
Welland
P. 796
GR 220
Simcoe
P. 2624
P.2616
Long Point
Wallaceburg
P.2368
Bothwell
P. 1973
Port Stanley
Lake St. Clair
Chatham
Ridgetown
LAKE ERIE
CANADA
U.S.A.
Windsor
P. 749
Essex
P.750
Pelee Island
0 25 50 Miles
0 40 80 Kilometres
Ministry of Natural Resources
Ontario
Coverage shown is most recent regardless of agency.
SYMBOLS
Area covered by OGS map and/or report
P Preliminary Map
S Surficial Map
GC Geological Circular
GR Geoscience Report
MP Miscellaneous Paper
Vol. Annual Report
IMR Industrial Mineral Report
* Out of print
Available from:
Map Unit, Public Service Centre
Ontario Ministry of Natural Resources
Whitney Block, Queen's Park
Toronto, Ontario M7A 1W3
Area covered by GSC report and/or map
M Memoir
B Bulletin
72-48 GSC Paper
map1132-A GSC Map
Available from:
Publications Office
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

APPENDIX B

Aggregate Assessment Inventory Reports for Southern Ontario published by the Ontario Geological Survey

1. Mono Township, Dufferin County
2. Adjala Township, Simcoe County
3. Town of Whitchurch-Stouffville, Regional Municipality of York
4. Town of Pelham, Regional Municipality of Niagara
5. Mulmur Township, Dufferin County
6. Township of Brock, Regional Municipality of Durham
7. Manvers Township, Victoria County
8. Brantford Township, Brant County
9. Blanshard Township, Perth County
10. South Dumfries Township, Brant County
11. Township of King, Regional Municipality of York
12. Erin Township, Wellington County
13. Township of Uxbridge, Regional Municipality of Durham
14. Township of North Dumfries, Regional Municipality of Waterloo
15. Smith Township, Peterborough County
16. Ops Township, Victoria County
17. Douro Township, Peterborough County
18. Asphodel Township, Peterborough County
19. Emily Township, Victoria County
20. Ennismore Township, Peterborough County
21. Melancthon Township, Dufferin County
22. Mariposa Township, Victoria County
23. Town of Caledon, Regional Municipality of Peel
24. Otonabee Township, Peterborough County
25. Dummer Township, Peterborough County
26. Fenelon Township, Victoria County
27. West Garafraxa Township, Wellington County
28. East Garafraxa Township, Dufferin County
29. Bexley Township, Victoria County
30. West Luther Township, Wellington County
31. East Luther Township, Dufferin County
32. Eldon Township, Victoria County
33. Oakland Township, Brant County
34. Maryborough Township, Wellington County
35. Peel Township, Wellington County
36. Pilkington Township, Wellington County
37. Nichol Township, Wellington County
38. Arthur Township, Wellington County
39. Eramosa Township, Wellington County
40. City of Oshawa, Regional Municipality of Durham
41. Town of Whitby, Regional Municipality of Durham
42. Verulam Township, Victoria County
43. Burford Township, Brant County
44. Minto Township, Wellington County
45. City of Burlington, Regional Municipality of Halton
46. Town of Halton Hills, Regional Municipality of Halton
47. Town of Milton, Regional Municipality of Halton
48. Carden Township, Victoria County
49. Township of Wellesley, Regional Municipality of Waterloo

50. Regional Municipality of Hamilton-Wentworth
51. Proton Township, Grey County
52. Town of Markham, Regional Municipality of York
53. Amaranth Township, Dufferin County
54. Puslinch Township, Wellington County
55. London Township, Middlesex County
56. Flos Township, Simcoe County
57. Biddulph Township, Middlesex County
58. Lobo Township, Middlesex County
59. City of Nanticoke, Regional Municipality of Haldimand-Norfolk
60. Vespra Township, Simcoe County
63. Township of East Zorra-Tavistock, Oxford County
65. Oro Township, Simcoe County
66. Township of Norwich, Oxford County
67. Town of Dunnville, Regional Municipality of Haldimand-Norfolk
68. Township of Blandford-Blenheim, Oxford County
73. Artemesia Township, Grey County
74. North Dorchester Township, Middlesex County
75. Westminster Township, Middlesex County
76. Delaware Township, Middlesex County
77. West Nissouri Township, Middlesex County
81. Township of Wilmot, Regional Municipality of Waterloo
82. Bentinck Township, Grey County
83. Glenelg Township, Grey County
84. Normanby Township, Grey County
85. Egremont Township, Grey County
86. Osprey Township, Grey County
94. Town of Newcastle, Regional Municipality of Durham
97. Township of Delhi, Regional Municipality of Haldimand-Norfolk

ADDITIONAL AGGREGATE REPORTS PUBLISHED BY THE ONTARIO GEOLOGICAL SURVEY

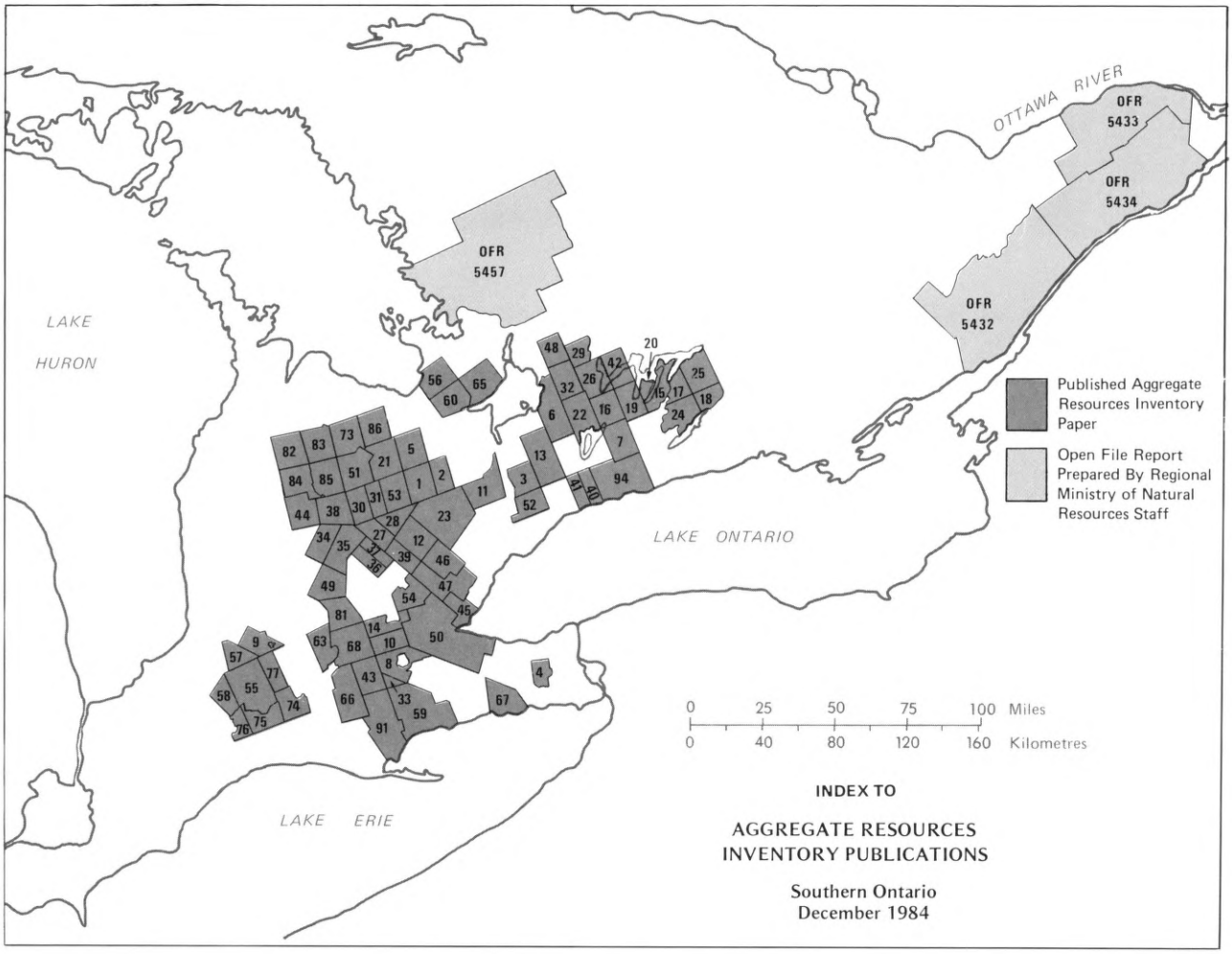
OFR 5432 Sand and Gravel Assessment for the United Counties of Leeds and Grenville

OFR 5433 Sand and Gravel Assessment for the United Counties of Prescott and Russell

OFR 5434 Sand and Gravel Assessment for the United Counties of Stormont, Dundas and Glengarry

OFR 5457 Aggregate Resources Assessment, District Municipality of Muskoka

OFR 5484 Sand and Gravel Resources of the Espanola Area


OTTAWA RIVER
OFR 5433
OFR 5434
OFR 5457
OFR 5432
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Published Aggregate Resources Inventory Paper
Open File Report Prepared By Regional Ministry of Natural Resources Staff
0 25 50 75 100 Miles
0 40 80 120 160 Kilometres
INDEX TO
AGGREGATE RESOURCES INVENTORY PUBLICATIONS
Southern Ontario
December 1984

APPENDIX C

Ontario Soil Survey reports for Southern Ontario
published by Canada Department of Agriculture, Research Branch
(date of publication is shown in brackets)

1. Norfolk County (surveyed 1927, 1928)
2. Elgin County (surveyed 1929)
3. Kent County (1936)
4. Haldimand County (surveyed 1935)
5. Welland County (surveyed 1935)
6. Middlesex County (surveyed 1931)
7. Carleton County (1944)
9. Durham County (1946)
10. Prince Edward County (1948)
11. Essex County (1949)
12. Grenville County (1949)
13. Huron County (1952)
14. Dundas County (1952)
15. Perth County (1952)
16. Bruce County (1949)
17. Grey County (1954)
18. Peel County (1953)
19. York County (1955)
20. Stormont County (1954)
22. Lambton County (1957)
23. Ontario County (1957)
24. Glengarry County (1957)
25. Victoria County (1957)
26. Manitoulin Island (1959)
27. Hastings County (1962)
28. Oxford County (1961)
29. Simcoe County (1962)
30. Soil Associations of Southern Ontario (1964)
31. Parry Sound District (1962)
32. Wentworth County (1965)
33. Russell and Prescott Counties (1962)
34. Lincoln County (1963)
35. Wellington County (1963)
36. Lennox and Addington County (1963)
37. Renfrew County (1964)
38. Dufferin County (1964)
39. Frontenac County (1966)
40. Lanark County (1967)
41. Leeds County (1968)
42. Northumberland County (1974)
43. Halton County (1971)
44. Waterloo County (1971)
45. Peterborough County

ADDITIONAL PUBLICATIONS

Canada Soil Survey Committee, Subcommittee on Soil Classification
1978: The Canadian System of Soil Classification; Canada Department of Agriculture Publication 1646, Supply and Services Canada, Ottawa, Ontario, 164p.

Harcourt, R., Iveson, W.L., and Cline, C.A.
1923: Preliminary Soil Survey of Southwestern Ontario; Ontario Department of Agriculture, Bulletin 298.

Legget, R.F.
1961: Soils in Canada: Geological, Pedological, and Engineering Studies; Royal Society of Canada, Special Publication Number 3, 229p.

Logan, W.E., and Others
1863: Geology of Canada; Geological Survey of Canada, Report of Progress from its Commencement to 1863, 983p.

Martini, I.P., Protz, R., and Chesworth, W.
1970: The Rocks and Soils of Southern Ontario; Department of Soil Science, University of Guelph, Guelph, Ontario, 35p.

Morwick, F.F., and Heeg, T.J.
1939: The Relationship of Certain Chemical Characteristics to the Geological Origin of Some Southern Ontario Soils; Scientific Agriculture, Volume 19, p.5.

APPENDIX D

Counties, districts, and regional and district municipalities in Southern Ontario

Counties

Brant
Bruce
Dufferin
Elgin
Essex
Frontenac
Grey
Haliburton
Hastings
Huron
Kent
Lambton
Lanark
Lennox and Addington
Middlesex
Northumberland
Oxford
Perth
Peterborough
Prince Edward
Renfrew
Simcoe
Victoria
Wellington

United Counties

Leeds and Grenville
Prescott and Russell
Stormont, Dundas, and Glengarry

Regional Municipalities

Durham
Haldimand-Norfolk
Halton
Hamilton-Wentworth
Niagara
Ottawa-Carleton
Peel
Waterloo
York

Districts

Manitoulin
Parry Sound

District Municipality

Muskoka

Municipality

Metropolitan Toronto

Present locations of former municipalities in Southern Ontario

Former	Present
Acton, Town	Town of Halton Hills
Albion, Tp.	Town of Caledon
Ancaster, Tp.	Town of Ancaster and Town of Dundas
Ayr, Vg.	Township of North Dumfries
Bala, Town	Township of Muskoka Lakes
Barton, Tp.	City of Hamilton
Beachville, Vg.	Township of South-West Oxford
Beaverton, Vg.	Township of Brock
Beamsville, Town	Town of Lincoln
Bertie, Tp.	Town of Fort Erie
Beverly, Tp.	Township of Flamborough
Bicroft, Improvement District	Township of Bicroft
Binbrook, Tp.	Township of Glanbrook
Blandford, Tp.	Township of Blandford-Blenheim
Blenheim, Tp.	Township of Blandford-Blenheim
Bolton, Vg.	Town of Caledon

Bowmanville, Town	Town of Newcastle
Brampton, Town	City of Brampton
Bridgeport, Vg.	City of Kitchener
Bronte, Vg.	Town of Oakville
Brunel, Tp.	Town of Huntsville
Burlington, Town	City of Burlington
Caistor, Tp.	Township of West Lincoln
Caledon, Tp.	Town of Caledon
Caledonia, Town	Town of Haldimand
Caledon, East, Vg.	Town of Caledon
Canborough, Tp.	Town of Dunnville
Cannington, Vg.	Township of Brock
Cardwell, Tp.	Township of Muskoka Lakes
Carleton, County	The Regional Municipality of Ottawa-Carleton
Cartwright, Tp.	Township of Scugog
Cayuga, Vg.	Town of Haldimand
Cayuga, North, Tp.	Town of Haldimand
Cayuga, South, Tp.	Town of Haldimand
Chaffey, Tp.	Town of Huntsville
Charlotteville, Tp.	Town of Simcoe and Township of Delhi
Chinguacousy, Tp.	City of Brampton and Town of Caledon
Chippawa, Vg.	City of Niagara Falls
Clarke, Tp.	Town of Newcastle
Clinton, Tp.	Town of Lincoln
Courtright, Vg.	Township of Moore
Crowland, Tp.	Town of Thorold, City of Niagara Falls, and City of Welland
Crystal Beach, Vg.	Town of Fort Erie
Dalhousie and North Sherbrooke, Tp.	Township of Lavant, Dalhousie and North Sherbrooke
Darlington, Tp.	Town of Newcastle
Delhi, Town	Township of Delhi
Dereham, Tp.	Town of Tillsonburg and Township of South-West Oxford
Draper, Tp.	Town of Bracebridge
Dunn, Tp.	Town of Dunnville
Eastview, City	City of Vanier
Elmira, Town	Township of Woolwich
Embro, Vg.	Township of Zorra
Esquesing, Tp.	Town of Halton Hills and Town of Milton
Etobicoke, Tp.	Borough of Etobicoke (now city)
Etobicoke, Borough	City of Etobicoke
Fitzroy, Tp.	Township of West Carleton
Flamborough, East, Tp.	Township of Flamborough
Flamborough, West, Tp.	Town of Dundas and Township of Flamborough
Fonthill, Vg.	Town of Pelham
Forest Hill, Vg.	City of Toronto
Franklin Tp.	Township of Lake of Bays
Freeman Tp.	Township of Georgian Bay
Gainsborough, Tp.	Township of West Lincoln
Galt, City	City of Cambridge
Georgetown, Town	Town of Halton Hills
Georgian Bay North Archipelago, Tp. and, Georgian Bay South Archipelago, Tp.	Township of The Archipelago

Glanford, Tp.	Township of Glanbrook
Gower, North, Tp.	Township of Rideau
Grantham, Tp.	City of St. Catharines and Township of Niagara
Grimsby, North, Tp.	Town of Grimsby
Grimsby, South, Tp.	Township of West Lincoln
Gwillimbury, North, Tp.	Township of Georgina
Hagersville, Vg.	Town of Haldimand
Haldimand, County	The Regional Municipality of Haldimand-Norfolk
Halton, County	The Regional Municipality of Halton
Hespeler, Town	City of Cambridge
Houghton, Tp.	Township of Norfolk
Humberstone, Vg.	Town of Port Colborne (now city)
Humberstone, Tp.	City of Niagara Falls, City of Port Colborne, and City of Welland
Huntley, Tp	Township of West Carleton
Jarvis, Vg.	City of Nanticoke
La Salle, Town	Township of Sandwich West
Lavant, Tp.	Township of Lavant, Dalhousie, and North Sherbrooke
Leaside, Town	Borough of East York
Lincoln, County	The Regional Municipality of Niagara
Long Branch, Vg.	Borough of Etobicoke (now city)
Louth, Tp.	Town of Lincoln and City of St. Catharines
Macaulay, Tp.	Town of Bracebridge
March, Tp	City of Kanata
Markham, Tp.	Town of Markham, Town of Richmond Hill, and Town of Whitchurch-Stouffville
Marlborough, Tp.	Township of Rideau
McLean, Tp.	Town of Bracebridge and Township of Lake of Bays
Medora and Wood United Townships	Town of Gravenhurst and Township of Muskoka Lakes
Merritton, Town	City of St. Catharines
Middleton, Tp.	Town of Tillsonburg, Township of Delhi, and Township of Norfolk
Mimico, Town	Borough of Etobicoke
Mississauga, Town	City of Mississauga
Monck, Tp.	Town of Bracebridge and Township of Muskoka Lakes
Morrison, Tp.	Town of Gravenhurst
Moulton, Tp.	Town of Dunnville
Muskoka, Tp.	Town of Bracebridge and Town of Gravenhurst
Nassagaweya, Tp.	Town of Milton and Township of Eramosa
Nelson, Tp.	Town of Burlington (now city)
Newcastle, Vg.	Town of Newcastle
New Hamburg, Town	Township of Wilmot
New Toronto, Town	Borough of Etobicoke
Niagara, Town	Town of Niagara-on-the-Lake
Niagara, Tp.	Town of Niagara-on-the-Lake
Nissouri, East, Tp.	Township of Zorra

Norfolk, County	The Regional Municipality of Haldimand-Norfolk
Northumberland and Durham County	The Regional Municipality of Durham and County of Northumberland
Norwich, Vg.	Township of Norwich
Norwich, North, Tp.	Township of Norwich
Norwich, South, Tp.	Township of Norwich
Oakley Tp.	Town of Bracebridge
Ojibway, Town	City of Windsor
Oneida, Tp.	Town of Haldimand
Ontario, County	Metropolitan Toronto, The Regional Municipality of Durham, and County of Simcoe
Oxford, East, Tp.	Township of Norwich
Oxford North, Tp.	Township of East Zorra-Tavistock and Township of Zorra
Oxford West, Tp.	Township of South-West Oxford
Peel, County	The Regional Municipality of Peel
Pelham, Tp.	Town of Pelham
Pickering, Vg.	Town of Ajax
Pickering, Tp.	City of Scarborough, Town of Ajax, and Town of Pickering
Port Carling, Vg.	Township of Muskoka Lakes
Port Colborne, Town	City of Port Colborne
Port Credit, Town	City of Mississauga
Port Dalhousie, Town	City of St. Catharines
Port Dover, Town	City of Nanticoke
Port Perry, Vg.	Township of Scugog
Port Rowan, Vg.	Township of Norfolk
Port Sydney, Vg.	Town of Huntsville
Portsmouth, Vg.	City of Kingston
Preston, Town	City of Cambridge
Rainham, Tp.	City of Nanticoke and Town of Haldimand
Reach, Tp.	Township of Scugog
Richmond, Vg.	Township of Goulbourn
Ridout, Tp.	Township of Lake of Bays
Riverside, Separated Town	City of Windsor
Ryde, Tp.	Town of Gravenhurst
Saltfleet, Tp.	Town of Stoney Creek
Sandwich, East, Tp.	City of Windsor and Township of Sandwich, South
Scarborough, Tp.	Borough of Scarborough (now city)
Scarborough, Borough	City of Scarborough
Scott, Tp.	Township of Uxbridge
Seneca, Tp.	Town of Haldimand
Sherbrooke, Tp.	Town of Dunnville
Smith's Falls, Town	Separated Town of Smiths Falls
Stamford, Tp.	City of Niagara Falls
Stephenson, Tp.	Town of Huntsville
Stisted, Tp.	Town of Huntsville
Stittsville, Vg.	Township of Goulbourn
Stoney Creek, Town	City of Stoney Creek
Stouffville, Vg.	Town of Whitchurch-Stouffville
Streetsville, Town	City of Mississauga
Sutton, Vg.	Township of Georgina

Swansea, Vg.	City of Toronto
Tavistock, Vg.	Township of East Zorra-Tavistock
Teck, Tp.	Town of Kirkland Lake
Thorah, Tp.	Township of Brock
Thorold, Tp.	Town of Pelham, Town of Thorold, City of Welland
Torbolton, Tp.	Township of West Carleton
Toronto, Tp.	Town of Mississauga (now city)
Toronto, Gore, Tp.	City of Brampton
Townsend, Tp.	City of Nanticoke and Town of Simcoe
Trafalgar, Tp.	Town of Oakville
Uxbridge, Town	Township of Uxbridge
Vaughan, Tp.	Town of Vaughan and Town of Richmond Hill
Walpole, Tp.	City of Nanticoke and Town of Haldimand
Walsingham, North, Tp.	Township of Norfolk
Walsingham South, Tp.	Township of Delhi and Township of Norfolk
Wasaga Beach, Vg.	Town of Wasaga Beach
Waterdown, Vg.	Township of Flamborough
Waterford, Town	City of Nanticoke
Waterloo, Tp.	City of Cambridge, City of Kitchener, City of Waterloo, and Township of Woolwich
Waterloo, County	The Regional Municipality of Waterloo
Watt, Tp.	Township of Muskoka Lakes
Welland, County	The Regional Municipality of Niagara
Wellesley, Vg.	Township of Wellesley
Wentworth, County	The Regional Municipality of Hamilton-Wentworth
Weston, Town	Borough of York
West Ferris, Tp.	City of North Bay
Whitby, Tp.	Town of Whitby
Whitby, East, Tp.	City of Oshawa
Whitchurch, Tp.	Town of Whitchurch-Stouffville, Town of Aurora, Town of Newmarket, and Town of Richmond Hill
Willoughby, Tp.	Town of Fort Erie and City of Niagara Falls
Windemere, Vg.	Township of Muskoka Lakes
Windham, Tp.	Township of Delhi and Town of Simcoe
Woodbridge, Vg.	Town of Vaughan
Woodhouse, Tp.	City of Nanticoke and Town of Simcoe
York, Tp.	Borough of York (now city)
York, Borough	City of York
York, East, Tp.	Borough of East York
York, North, Tp.	Borough of North York (now city)
York, North, Borough	City of North York
York, County	The Regional Municipality of York
Zorra, East, Tp.	Township of East Zorra-Tavistock
Zorra, West, Tp.	Township of Zorra

GLOSSARY

Animal livestock unit: Represents 1 horse, 1 cow, 5 hogs, 7 sheep, and 100 hens.

Back slope: A synonym of dip slope; the term is used where the angle of dip of the underlying rocks is somewhat divergent from the angle of the land surface.

Barrier beach: A beach, usually of gravel, built across the entrance of a bay.

Baymouth bar: A barrier beach or several of them combined.

Beaches (abandoned beaches or strandlines): Smooth, horizontal ridges of gravel and sand, often at the boundary between level lake plains below and rolling till plains above. The gravel is usually well rounded, and evenly graded in the different strata.

Before Present (B.P.): Prior to 1955; used for Carbon-14 dating.

Boulder clay: Denotes a clayey bouldery till as opposed to a sandy till.

Boulder pavement: A boulder-strewn surface on a wave-cut or stream-cut terrace.

Brunisolic soils: In Southern Ontario, consist of well-drained to imperfectly drained soils developed under a forest of either hardwoods or conifers. The profiles have a brown, oxidized horizon under the dark surface layer, and in this subsurface position lack either the ash-grey horizon of the Podzols or the grey brown horizon of the Luvisols.

Cap rock: The hard upper strata of a rock formation.

Catena: A group of soils within one soil zone developed from similar parent material but having differing characteristics due to differences in relief and drainage.

Clean cultivated orchard: An orchard that does not have grass growing between the trees.

Cuesta: A ridge or belt of low hills formed between lowlands in a region of gently dipping sedimentary rocks, having a gentle slope conforming with the dip of the rocks and a relatively steep slope descending abruptly from its crest.

Dip slope: *See* **back slope.**

Dissection: Gullying or the cutting of valleys by streams.

Dolomite: A mineral consisting of mixed magnesium and calcium carbonate, but rich in magnesium carbonate.

Dolostone: A term used for the sedimentary rock dolomite, in order to avoid confusion with the mineral of the same name.

Drift: All unconsolidated mineral material on the bedrock.

Drumlins: Celtic for little hill. Oval hills of glacial till with smooth convex contours. In any area the drumlins all point in the same direction which is considered to be the direction of movement of the glacier which formed them.

End moraine: A moraine that has been deposited at the lower or outer end of a glacier.

Escarpment: A system of steep slopes formed by differential erosion or by a fault (break) in the bedrock.

Esker: A knobby, crooked ridge of coarse gravel and sand considered to be deposited by meltwater in crevasses and tunnels near the front of a glacier.

Fault scarp: An abrupt slope due to a fault in the bedrock.

Flutings: Parallel grooves and low edges on a rock surface or on a drumlinized till plain.

Fluvium, flood deposits: Silt, sand, and gravel deposited by running water, often meltwater from a glacier.

Glacial lake: A lake dammed by a glacier.

Gley: A compact, sticky, bluish grey or olive grey soil horizon formed under wet conditions.

Gleysolic soils: Are saturated with water and are under reducing conditions continuously or during some period of the year, unless they are artificially drained.

Graben: A valley formed by a down-dropped block of bedrock and so bounded by fault scarps on either side.

Gravel train (valley train): The extended gravel terraces of an abandoned river channel.

Grey Brown Luvisol: A great group of soils in the luvisolic order occurring in a moderate climate, higher than 5.5°C (42°F) mean annual temperature, and developed under deciduous and coniferous forest cover, they have an eluviated light-coloured surface (A_e) horizon, a brownish illuvial $B_{(Bt)}$ horizon in which silicate clay has accumulated, and usually a calcareous C horizon.

Hinge line: The boundary between regions undergoing postglacial uplift and those of no uplift.

Horst: The rock on the brow of a fault scarp overlooking a down-dropped area of rocks.

Illinoian: Pertaining to the classical third glacial stage of the Pleistocene Epoch in North America, between the Yarmouthian and Sangamonian interglacial stages.

Interglacial stage: The time interval between two glacial stages. Is characterized by a relatively long period of warm or mild climate.

Indurated: Hard, often weakly cemented.

Interlobate moraine: A moraine formed between two lobes of the glacier; usually a sandy kame moraine.

Isostatic depression: The depression caused by loading by large masses such as glaciers and large, temporary lakes.

Isostatic uplift (or isostatic rebound): The process whereby the earth surface rebounds to a state of equilibrium following a state of depression caused by loading by large masses such as glaciers and large, temporary lakes.

Kame moraine: An extended ridge consisting mainly of kames and outwash.

Kames: Knobby hills of irregularly stratified sand and gravel, formed at the edge of a melting glacier.

Kettles: Depressions in moraines or other drift having no surface drainage.

Leaching: The removal in solution of constituents such as mineral salts and organic matter from an upper to a lower soil horizon by the action of percolating water.

Loam: A soil composed of a mixture of relatively equal and moderate proportions of clay, silt, and sand particles, and which may or may not contain organic matter (humus).

Loess: Wind-deposited silt and fine sand.

Luvisolic soils: *See* Grey Brown Luvisols.

Marl: A soft, greyish to white, earthy or powdery, usually impure calcium carbonate precipitated on the bottoms of present-day fresh water lakes and ponds forming deposits that underlie marshes, swamps, and bogs that occupy the sites of former glacial lakes.

Meanders: The semi-circular bends in the course of a slow-flowing mature stream.

Mesa: A broad terrace or comparatively flat plateau along a river valley, marked by an abrupt slope or escarpment on one side.

Milk shed: The region from which fluid milk is trucked to an urban area.

Moraine: A knobby ridge either of *(a)* boulder clay built by a thrust of a glacier or of *(b)* gravel and sand deposited at the edge of glacier by escaping meltwater.

Outwash: Sand and gravel deposited in stream terraces or broad fans by water draining away from a glacier. The beds are unusually pitted by depressions with no surface drainage.

Oxbows: The loops of a stream meandering over its flood plain.

Peneplain: A gently undulating bedrock surface of considerable area which was produced during a period of long-continued subaerial erosion.

Pleistocene: An epoch of the Quaternary period, after the Pliocene of the Tertiary and before the Holocene; it began two to three million years ago and lasted until the start of the Holocene some 8,000 years ago.

Plow sole: Compacted layer under the surface soil caused by the farm machinery.

Podzolic soils: Are well and imperfectly drained soils that have developed under coniferous and mixed-forest vegetation and heath, mostly in moist, cool to temperate climates. The profiles have a distinctive ash-grey horizon under the dark, humified surface horizon. They are acid soils of low fertility.

Pondings: Small glacial lakes, sometimes short-lived and so without definite shore features.

Quaternary: The second period of the Cenozoic era, following the Tertiary; it began two to three million years ago and extends to the present. It consists of two epochs: the Pleistocene, up to about 8,000 years ago, and the Holocene since that time.

Recessional moraine: An end or lateral moraine built during a temporary but significant pause in the final retreat of a glacier. Also a moraine built during a slight or minor readvance of the ice front during a period of general recession.

Sangamonian: Pertaining to the third classical interglacial stage of the Pleistocene Epoch in North America, after the Illinoian glacial stage and before the Wisconsinan.

Scarp: A bluff or very steep slope in bedrock due to faulting or differential erosion.

Shield (Canadian Shield): The ancient worn-down surface of Precambian bedrock in Canada.

Shorecliff: A wave-cut bluff, usually having a bouldery terrace at its base.

Silt: Mineral particles smaller than sand and greater than clay sizes.

Solum: The upper part of a soil profile, including the A and B horizons, in which soil-forming processes occur. Plural: **sola.**

Spillway: The abandoned channel of a glacial meltwater stream.

Spit: A point of land, often a wave-built sand bar, projecting into a body of water.

Strandline: *See* Beaches.

Striae: Scratches on the surface of the bedrock produced by the moving glacier.

Terrace: *(a)* River terrace - the beds of gravel and sand left by a stream; *(b)* wave-cut terrace - the strip of level land at the base of a shorecliff.

Till: The heterogeneous mixture of clay, sand, pebbles and boulders deposited directly by a glacier.

Umland: The geographic zone of influence of a town or city.

Varves (varved clay): Regularly stratified clay, dark clayey layers alternating with lighter coloured siltier layers; considered to be annual deposits of winter and summer sediments in glacial lakes.

Wisconsinan: Pertaining to the classical fourth glacial stage of the Pleistocene Epoch in North America, following the Sangamonian interglacial stage and preceding the Holocene.

Zonal soil: Embraces well-drained soils with well-developed profile characteristics that reflect the influence of the agents of soil genesis, especially climate and plants.

REFERENCES

Ayres, L.D., Lumbers, S.B., Milne, V.G., and Robeson, D.W.
1971: Ontario Geological Map, Southern Sheet; Ontario Department of Mines and Northern Affairs, Map 2197, scale 1:1 013 760. Compilation 1970.

Barnett, P.J.
1978: Glacial Lake Whittlesey and the Reinterpretation of the Port Huron Morainic System; Geological Society of America, Abstracts with Programs, Volume 10, p.31-32.

1979a: Glacial Lake Whittlesey: the Probable Ice Frontal Position in the Eastern End of the Erie Basin; Canadian Journal of Earth Sciences, Volume 16, Number 3, Part 1, p.568-574.

1979b: Quaternary Geology of the Simcoe Area, Southern Ontario; Ontario Division of Mines, Geoscience Report 162, 74p. Accompanied by Maps 2369, 2370, and 2371, scale 1:50 000.

1982: Quaternary Geology of the Tillsonburg Area, Southern Ontario; Ontario Geological Survey, Report 220, 87p. Accompanied by Map 2473, scale 1:50 000, and 2 charts.

Brown, D.M., McKay, G.A., and Chapman, L.J.
1968: The Climate of Southern Ontario; Climatological Studies, Number 5 Meteorological Branch, Canada Department of Transport, Toronto, Ontario, 50p.

Burger, D.
1967: Distribution and Origin of Parent Soil Materials in Part of the Ottawa and Bonnechere River Valleys, Ontario; Canadian Journal of Earth Sciences, Volume 4, Number 3, p.397-411.

1972: Maps of Land Type Patterns, Numbers S-1-71 to S-10-71; Ontario Ministry of Natural Resources, Forest Research Branch, scale 1:125 000.

Carman, R.S.
1940: Wilmot Creek Drainage Unit; Publication of Ontario Forestry Branch.

Catto, N.R., Patterson, R.J., and Gorman, W.A.
1982: The Late Quaternary Geology of the Chalk River Region, Ontario and Quebec; Canadian Journal of Earth Sciences, Volume 19, Number 6, p.1218-1231.

Chapman, L.J.
1954: An Outlet of Lake Algonquin at Fossmill, Ontario; Geological Association of Canada, Proceedings, Volume 6, Part 2, p.61-68.

1975: The Physiography of the Georgian Bay-Ottawa Valley Area of Southern Ontario; Ontario Division of Mines, Geoscience Report 128, 33p. Accompanied by Map 2228, scale 1:253 440, and 1 chart.

In Press: On the Origin of the Oak Ridges Moraine, Southern Ontario; Canadian Journal of Earth Sciences.

Chapman, L.J., and Dell, C.I.
1963: Revisions in the Early History of the Retreat of the Wisconsin Glacier in Ontario Based on the Calcite Content of Sands; Geological Association of Canada, Proceedings, Volume 15, Part 1, p.103-108.

Chapman, L.J., and Putnam, D.F.
1940: The Physiography of Eastern Ontario; Scientific Agriculture, Volume 20, Number 7, p.424-441.

1943a: The Physiography of Southwestern Ontario; Scientific Agriculture, Volume 24, Number 3, p.101-125.

1943b: The Moraines of Southern Ontario; Transactions of the Royal Society of Canada, Third Series, Volume 37, Section 14, p.33-41.

1949: The Recession of the Wisconsin Glacier in Southern Ontario; Transactions of the Royal Society of Canada, Third Series, Volume 43, Section 4, p.23-52.

Clark, D., and Karrow, P.F.
1983: Till Stratigraphy in the St. Lawrence Valley near Malone, New York, Revised Glacial History and Stratigraphic Nomenclature; Geological Society of America Bulletin, Volume 94, p.1308-1318.

Close, H.M.
1867: Notes on the General Glaciation of Ireland; Journal of the Royal Geological Society of Ireland, Volume 1, p.207-242.

Coleman, A.P.
1901: Marine and Fresh Water Beaches of Ontario; Geological Society of America Bulletin, Volume 12, p.129-146.

1937: Lake Iroquois; Annual Report of the Ontario Department of Mines for 1936, Volume 45, Part 7, p.1-36.

Cooper, A.J., Fitzgerald, W.D., and Clue, Jack
1977: Quaternary Geology of the Seaforth Area, Southern Ontario; Ontario Geological Survey, Preliminary Map P.1233, scale 1:50 000.

Coventry, A.F.
1940: Desiccation in Southern Ontario; Abstract in Proceedings of the Royal Society of Canada, Third Series, Volume 34, Section 5, p.166.

Cowan, W.R., Cooper, A.J., and Pinch, J.J.
In Preparation: Quaternary Geology of the Wingham-Lucknow Area, Southern Ontario; Ontario Geological Survey, Preliminary Map, scale 1:50 000.

Cowan, W.R., Sharpe, D.R., Feenstra, B.H., and Gwyn, Q.H.J.
1978: Glacial Geology of the Toronto-Owen Sound Area; p.1-16 *in* Toronto '78 Field Trips Guidebook, Edited by A.L. Currie and W.O. Mackasey, Geological Association of Canada, 361p.

Cramm, E.W.R.
1962: An Analysis of the Urban Process in Pickering Township; Unpublished M.A. Thesis, University of Toronto, Toronto.

Crawford, C.B.
1961: Engineering Studies in Leda Clay; p.200-217 *in* Soils in Canada, Edited by R.F. Leggett, The Royal Society of Canada, Special Publications Number 3, 240p.

Crerar, A.D.
1961: The Loss of Farmland in the Metropolitan Regions of Canada; Background Papers, Resources for To-morrow Conference, Montreal, October.

Deane, R.E.
1946: Pleistocene Deposits and Beaches of Orillia Map-Area, Simcoe and Ontario Counties, Ontario (preliminary account); Geological Survey of Canada, Paper 46-20, 29p.

1950: Pleistocene Geology of the Lake Simcoe District, Ontario; Geological Survey of Canada, Memoir 256, 180p.

Dreimanis, Aleksis
1966: Lake Arkona, Whittlesey, and Post Warren Radiocarbon dates from "Ridgetown Island" in Southwestern Ontario; Ohio Journal of Science, Volume 66, p.582-586.

Dreimanis, Aleksis, and Karrow, P.F.
1972: Glacial History of the Great Lakes-St. Lawrence Region, the Classification of the Wisconsin(an) Stage, and its Correlatives; Quaternary Geology, Section 12, International Geological Congress, 24th Session, p.5-15.

Duckworth, Peter B.
1975: Paleocurrent Trends in the Latest Outwash at the Western End of the Oak Ridges Moraine, Ontario; Unpublished Ph.D. Thesis, University of Toronto, Toronto, 274p.

1979: The Late Depositional History of the Western End of the Oak Ridges Moraine, Ontario; Canadian Journal of Earth Sciences, Volume 16, Number 5, p.1094-1107.

Fairchild, H.L.
1907a: Drumlin Structure and Origin (Abstract); Geological Society of America Bulletin, Volume 17, p.702-706.

1907b: Gilbert Gulf (Marine Waters in the Ontario Basin); Geological Society of America Bulletin, Volume 17, p.712-718.

1929: New York Drumlins; Rochester Academy of Science, Proceedings, Volume 7, Number 1, p.1-37.

Farrand, W.R., and Gajda, R.T.
1962: Isobases on the Wisconsin Marine Limit in Canada; Canada Department of Mines and Technical Surveys, Geographical Branch, Geographical Bulletin 17, p.5-22.

Feenstra, B.H.
1975: Quaternary Geology of the Markdale Area (41 A/7), Grey County; p.116-118 *in* Summary of Field Work, 1975, by the Geological Branch, Edited by V.G. Milne, D.F. Hewitt, K.D. Card, and J.A. Robertson, Ontario Division of Mines, Miscellaneous Paper 63, 158p.
1981: Quaternary Geology and Industrial Minerals of the Niagara-Welland Area, Southern Ontario; Ontario Geological Survey, Open File Report 5361, 260p. Accompanied by Maps P.537 (Revised), P.764, P.796, P.2400, P.2403, and P.2486, scale 1:50 000.

Fox, W. Sherwood
1958: 'Tain't Runnin' No More; Wendell Holmes, Oxford Book Shop, London, Ontario.

Fullerton, David S.
1980: Preliminary Correlation of Post-Erie Interstadial Events (16,000-10,000 Radiocarbon Years Before Present), Central and Eastern Great Lakes Region, and Hudson, Champlain, and St. Lawrence Lowlands, United States and Canada; United States Geological Survey, Professional Paper 1089, 52p. Accompanied by 2 charts.

Gadd, N.R.
1963: Surficial Geology of Ottawa Map-Area, Ontario and Quebec; Geological Survey of Canada, Paper 62-16, 4p.
1976: Surficial Geology and Landslides of Thurso-Russell Map-Area, Ontario; Geological Survey of Canada, Paper 75-35, 7p. Accompanied by Map 4-1975, scale 1:50 000.
1980: Late-Glacial Regional Ice-Flow Patterns in Eastern Ontario; Canadian Journal of Earth Sciences, Volume 17, Number 1, p.1439-1453.

Gilbert, G.K.
1890: The History of the Niagara River, New York; Commissioners State Reservation at Niagara, Sixth Annual Report, p.61-84.

Goldthwait, J.W.
1910: An Instrumental Survey of the Shorelines of the Extinct Lakes Algonquin and Nipissing in Southwestern Ontario; Geological Survey of Canada, Memoir 10, 57p.
1924: Physiography of Nova Scotia; Geological Survey of Canada, Memoir 140, 179p.

Grabau, A.W.
1901: Guide to the Geology and Paleontology of Niagara Falls and Vicinity; New York State Museum Bulletin 45, p.1-284.

Gravenor, C.P.
1957: Surficial Geology of the Lindsay-Peterborough Area, Victoria, Peterborough, Durham, and Northumberland Counties, Ontario; Geological Survey of Canada, Memoir 288, 60p.

Guillet, G.R.
1967: The Clay Products Industry of Ontario; Ontario Department of Mines, Industrial Mineral Report 22, 206p.
1977: Clay and Shale Deposits of Ontario; Ontario Geological Survey, Mineral Deposits Circular 15, 117p.

Gwyn, Q.H.J., and Cowan, W.R.
1978: The Origin of the Oak Ridges and Orangeville Moraines of Southern Ontario; Canadian Geographer, Volume 22, Number 4, p.345-352.

Harrison, J.E.
1972: Quaternary Geology of the North Bay-Mattawa Region; Geological Survey of Canada, Paper 71-26, 37p. Accompanied by Map 3-1971, scale 1:125 000.

Henderson, Eric P.
1967: Surficial Geology north of the St. Lawrence, Kingston to Prescott; p.199-207 *in* Guidebook—Geology of Parts of Eastern Ontario and Western Quebec, Edited by S.E. Jenness, Geological Association of Canada-Mineralogical Association of Canada, 346p.
1970: Surficial Geology of Brockville and Mallorytown Map-Areas, Ontario; Geological Survey of Canada, Paper 70-18. Accompanied by Map 6-1970, scale 1:50 000.

Hewitt, D.F.
1954: Geology of the Brudenell-Raglan Area; Ontario Department of Mines, Annual Report for 1953, Volume 62, Part 5, 123p. Accompanied by Map 1953-2, scale 1 inch to 1 mile, and Geological Map of Craigmont Corundum Mine, scale 1 inch to 300 feet.

Hewitt, D.F., and Karrow, P.F.
1963: Sand and Gravel in Southern Ontario; Ontario Department of Mines, Industrial Mineral Report 11, 151p.

Hills, G.A.
1953: The Identification and Description of Forest Sites; Ontario Department of Lands and Forests, Research Division, Site Research Manual Number 4, 71p.
1959: A Ready Reference to the Description of the Land of Ontario and Its Productivity; Ontario Department of Lands and Forests, Research Division Preliminary Report, 141p.

Hoffman, D.W.
1970: The Canada Land Inventory Report Number 2, Soil Capability Classification for Agriculture; Ontario Department of Agriculture and Food, 59p.

Hough, J.L.
1958: Geology of the Great Lakes; University of Illinois Press, Urbana, 313p.

1963: The Prehistoric Great Lakes of North America; American Scientist, Volume 51, p.84-109.

Hunter, A.F.
1903: The Algonquin Shore-line in Simcoe County, Ontario; Geological Survey of Canada, Annual Report for 1902-03, Volume 15, Report A, p.281-304.

Johnson, M.D., Russell, D.J., and Telford, P.G.
1983: Oil Shale Assessment Project, Volume 1, Shallow Drilling Results 1981-1982; Ontario Geological Survey, Open File Report 5458, 36p.

Johnston, W.A.
1912: Geology of Lake Simcoe Area, Ontario, Brechin and Kirkfield Sheets; Geological Survey of Canada, Summary Report for 1911, p.253-261.

1916: The Trent Valley Outlet of Lake Algonquin and the Deformation of the Algonquin Waterplane in Lake Simcoe District, Ontario; Geological Survey of Canada, Museum Bulletin 23, 27p.

Karrow, P.F.
1959: Pleistocene Geology of the Hamilton Map-Area; Ontario Department of Mines, Geological Circular Number 8, 6p.

1963: Pleistocene Geology of the Hamilton-Galt Area; Ontario Department of Mines, Geological Report 16, 68p. Accompanied by Maps 2029, 2030, 2033, and 2034, scale 1:63 360.

1977: Quaternary Geology of the St. Marys Area, Southern Ontario; Ontario Division of Mines, Geoscience Report 148, 59p. Accompanied by Map 2366, scale 1:50 000.

1981: Late-Glacial Ice Flow Patterns in Eastern Ontario: Discussion; Canadian Journal of Earth Sciences, Volume 18, Number 8, p.1386-1390.

Karrow, P.F., Anderson, T.W., Clarke, A.H., Delorme, L.D., and Sreenivasa, M.R.
1975: Stratigraphy, Paleontology, and Age of Lake Algonquin Sediments in Southwestern Ontario, Canada; Quaternary Research, Volume 5, Number 1, p.49-87.

Kay, G.M.
1942: Ottawa-Bonnechère Graben and Lake Ontario Homocline; Geological Society of America Bulletin, Volume 53, Number 4, p.585-646.

Krueger, R.R.
1960: Land Use Changes in the Niagara Fruit Belt; Geographical Bulletin 14, p.5-24.

Lee, C.F.
1943: The Middle Grand River Valley: A Study in Regional Geography; Unpublished Ph.D. Thesis, University of Toronto, Toronto.

Leverett, F., and Taylor, F.B.
1915: The Pleistocene of Indiana and Michigan and the History of the Great Lakes; United States Geological Survey, Monograph 53, 529p.

Lewis, C.F.M.
1969: Late Quaternary History of Lake Levels in the Huron and Erie Basins; p.250-270 *in* Proceedings of the 12th Conference on Great Lakes Research, International Association for Great Lakes Research, 923p.

Loken, O.H., and Leahey, E.J.
1964: Small Moraines in Southeastern Ontario; Canadian Geographer, Volume 8, Number 1, p.10-21.

MacClintock, Paul, and Terasmae, Jaan
1960: Glacial History of Covey Hill; Journal of Geology, Volume 68, Number 2, p.232-241.

MacLachlan, D.C.
1938: Warren Shore Line in Ontario and in the Thumb of Michigan and its Deformation; Unpublished Thesis, University of Michigan.

Mather, K.F.
1917: The Champlain Sea in the Lake Ontario Basin; Journal of Geology, Volume 25, p.542-554.

Mercier, R.G., and Chapman, L.J.
1956: Peach Climate in Ontario; 1955-56 Report, Horticultural Experiment Station and Products Laboratory, Vineland, Ontario.

Mirynech, Edward
1963: Pleistocene Geology of the Trenton-Campbellford Map-Area, Ontario; Unpublished Ph.D. Thesis, University of Toronto, Toronto.

Nichols, G.C.
1972: Analysis of Some Raised Strandlines in the Southern Bruce Peninsula, Ontario, with Particular Reference to Water Planes of Lake Simcoe and Georgian Bay; Unpublished M.Sc. Thesis, University of Waterloo, Waterloo, Ontario.

Prest, V.K.
1970: Quaternary Geology of Canada; p.676-764 *in* Geology and Economic Minerals of Canada, Fifth Edition, Edited by R.J.W. Douglas, Geological Survey of Canada, Economic Geology Report Number 1, 838p.

Putnam, D.F., and Chapman, L.J.
1936: The Physiography of South-Central Ontario; Scientific Agriculture, Volume 16, p.457-477.

1943: The Drumlins of Southern Ontario; Transactions of the Royal Society of Canada, Series 3, Volume 37, Section 4, p.75-88.

Putnam, R.G.
1962: Changes in Rural Land Use Patterns on the Central Lake Ontario Plain; Canadian Geographer, Volume 6, p.60-68.

Richardson, A.H.
1944: The Ganaraska Watershed; Ontario Department of Planning and Development Publication.

Roy, T.
1837: On the Ancient State of the North American Continent; Proceedings of the Geology Society of London, Volume 2, Number 51, p.537-538.

Sado, E.V., White, Owen L., Barnett, P.J., and Sharpe, D.R.
1983: The Glacial Geology, Stratigraphy, and Geomorphology of the North Toronto Area: A Field Excursion; p.112-134 *in* Correlation of Quaternary Chronologies Symposium, Abstracts-with-Program and Field Guide, May 26-30, 1983, York University, Toronto, 168p.

In Preparation: The Glacial Geology, Stratigraphy, and Geomorphology of the North Toronto Area: A Field Excursion; *in* Quarternary Chronologies, Edited by W.C. Mahaney, Geo Book Limited, Norwich, England.

Sharpe, D.R.
1977: Quaternary Geology of the Chesley-Tiverton (41 A/5, A/6) and Wiarton (41 A/11) Areas, Bruce and Grey Counties; p.146-148 *in* Summary of Field Work, 1977, by the Geological Branch, edited by V.G. Milne, O.L. White, R.B. Barlow, and J.A. Robertson, Ontario Geological Survey, Miscellaneous Paper 75, 208p.

1978: A Revised Correlation of the Port Huron Moraine System in Southern Ontario; Geological Society of America, Abstracts with Programs, Volume 10, p.284.

Sharpe, D.R., and Edwards, W.A.D.
1979: Quaternary Geology of the Chesley-Tiverton Area, Southern Ontario; Ontario Geological Survey, Preliminary Map P.2314, scale 1:50 000. Geology 1976, 1977.

Spencer, J.W.
1881: Discovery of the Preglacial Outlet of the Basin of Lake Erie into that of Lake Ontario; with Notes on the Origin of the Lower Great Lakes; Proceedings of the American Philosophical Society, Volume 19, p.300-337, 353.

1890: The Iroquois Beach; A Chapter in the Geological History of Lake Ontario; Proceedings and Transactions of the Royal Society of Canada, Volume 7, Section 4, p.121-134.

1891: High Level Shores in the Region of the Great Lakes and Their Deformation; American Journal of Science, Third Series, Volume 41, p.201-211.

Springer, J.J., and Vos, M.A.
1983: Industrial Minerals Program, Introduction; p.286-291 *in* Summary of Field Work, 1983, by the Ontario Geological Survey, Edited by John Wood, Owen L. White, R.B. Barlow, and A.C. Colvine, 313p.

Stanley, G.M.
1936: Lower Algonquin Beaches of Penetanguishene Peninsula; Geological Society of America Bulletin, Volume 47, p.1933-1960.

1937: Lower Algonquin Beaches of Cape Rich, Georgian Bay; Geological Society of America Bulletin, Volume 48, Number 11, p.1665-1686.

1938: Impounded Early Algonquin Beaches at Sucker Creek, Grey County, Ontario; Papers of the Michigan Academy of Science, Arts and Letters, Volume 23, p.477-495.

Taylor, F.B.
1894: The Limit of Post Glacial Submergence in the Highland East of Georgian Bay; American Geologist, Volume 14, p.273-289.

1909: Field Work on the Pleistocene Deposits of Southwestern Ontario; Geological Survey of Canada, Summary Report for 1908, p.103-111.

1910: Field Studies on the Pleistocene Deposits of Southwestern Ontario; Geological Survey of Canada, Summary Report for 1909, p.164-167.

1913: The Moraine Systems of Southwestern Ontario; Transactions of the Royal Canadian Institute, Volume 10, p.57-79.

Watt, A.K.
1954: Correlation of the Pleistocene Geology as Seen in the Subway with that of the Toronto Region; Geological Association of Canada, Proceedings, 1953, Volume 6, Part 2, p.69-81.

White, Owen, L., and Karrow, P.F.
1971: New Evidence for Spencer's Laurentian River; p.394-400 *in* Proceedings of the 14th Conference on Great Lakes Research, International Association for Great Lakes Research, 834p.

1975: Quaternary Geology of the Bolton Area, Southern Ontario; Ontario Division of Mines, Geological Report 117, 119p. Accompanied by Maps 2275 and 2276, scale 1 inch to 1 mile.

Wilson, A.E., Stewart, J.S., and Caley, J.F.
1941: Sedimentary Basins of Ontario, Possible Sources of Oil and Gas; Transactions of the Royal Society of Canada, Series 3, Volume 35, Section 4, p.167-185.

Wilson, A.W.G.
1901: Physical Geology of Central Ontario; Transactions of the Royal Canadian Institute, Volume 7, p.139-186.

INDEX

Acton 50,51,56,98,128,129
Adelaide Tp. 63
Adjala Tp. 179
Adolphustown 187
Adolphustown Tp. 187
Aggregate 79,121,143
See also: Sand and gravel.
Agincourt 56
Ailsa Craig 48,127
Ajax 194
Albion Falls 101
Albion Hills 52
Albion Hills Conservation Area and Field Centre 168
Albion Tp. 52
  Photo 53
Aldborough Tp. 147
Alden Moraine 28
Aldershot 78,115,191
Alexandria 203
Alfalfa 208
Alfred 208
Alfred peat bog 40,107,207
Alfred Tp. 207,209
Algoma 25
Algoma, Lake 40
Algonquin, Lake 14,25,54-61*passim*, 69,71,76,77,89,92,104,109, 116,126,164-166,178,181, 182,184,210
  Beaches 24,25,68,73,77,78,87, 90,118,119,121,123,178
    Photos 73,123,142
  Bluffs 24,70,73,117,162
    Photos 75,76
  Deltas 85,86
  Figure 35
  Lake bed 57,71,74
  Plain 77,78,118,181,219
  Sediments 76,77
  Shorelines 69,74,76,77,125,141,180
    Figure 62
Algonquin Arch 2
Algonquin highlands 211-214,219
  Location; figure 113
Algonquin Park dome 2,217
Algonquin Provincial Park 1,2,5,15,17, 38,61,83-85,108,109, 211,214,217
Alice 83,109
Allan Park 49
Allenford 143
Allenwood 180
Alliston 21,74,125,179,180
Alliston sandy loam 179
Allumette Lake 110
Allumette Rapids 110
Almonte 108,199,213
Alnwick Tp. 171
Alvinston 63,64,93,147
Amabel Creek 61
Amabel du Fond River 25,110
  Valley 39
Amabel Formation 56,115,117,118, 122,126,138,163
Amabel Tp. 88,89,141,162
  Photo 142
Amaranth Tp. 44
Amber 67
Ameliasburgh 188,189
Ameliasburgh clay loam 189
Ameliasburgh loam 189
American (Niagara) Falls 99
Amherstburg 68,147
Amherst Island 186,187
Amphibolite 1
Amulree spillway 44
Ancaster 52,99,101,114,191
Angus 74,180
Annan 73,126
Ansnorveldt 181
Antimony 213
Apples 6,64,123-125,193
See also: Fruit; Orchards.
Appleton 108
Ardtrea 76
Arkona 27,45,63,92
Arkona, Lake 23,27,61
  Beach 65
Armstrong Station 64
Arnprior 4,10,108,109,206,208,217
Arran drumlin field 51,57,90,141
  Location; figure 113
Arran Lake 90,141
Arran Tp. 89,90,141
Artemesia Tp. 127
Arthur 96,97,132
Ashgrove 67
Athens 197,199
Atherley 182
Atherton 65
Atwood 45,27,61
Auburn 91
Augusta Tp. 55
Ausable River 64,65,92,161
  Tributaries 46
  Valley 45,70
Avonmore 201
Avon River 93,135
Aylmer 145,156

Ayr 44,46,47,98
Ayton 141
Azatica Brook 207

Baden hills 136
  Photo 136
Badlands 103,115
  Photo 115
Baie de l'Orignal 110
Bailey Creek 179
Bailieboro 170
Bala 85
Balaclava 73,126
Ballantyne Tp. 84
Balm Beach 180,181
Balsam Creek 39
Balsam Lake 78,104
Balsover 76
Baltimore 94
Bancroft 83,108,109,213,214
Banks 48,51
Banks Moraine 28,48,51,64
  Figure 33
Bannock 45
Bark Lake 108
Barret Chute 109
Barrie 76,177,182
Barrie Island 77,164
Barron River 39,80,110
Barrow Bay 119,163
Barrow River 210
Bass Lake 54,76
Bath 187
Baudet River 201,205
Bayfield 70,161,162
Bayfield River 48,65,92
Bayfield Sound 164
Bayham 95
Bay of Quinte 2,54,56,102,104-106,188,195
Bayview 124
Beachburg 206,208
Beachville 143,144
Beachville quarries 93
Beamsville 114
Bear Brook 107,207
Bearbrook (community) 60
Bearbrook series (clay) 204
Bear Creek 40,64,92
Beatrice 211
Beatty River 90
Beaver Lake 59,105,106,170
Beaver River 51,87,116,122,123
  Delta 73
  Power plant 124
Beaverton 76,181,182
Beaverton River 170,171,181
Beaver Valley 6,49,51,117,122,218
  Block diagram; figure 122
  Location; figure 113
  Moraines 51
    Photo 49
  Ski run 121
Beckwith Tp. 197
Bedrock geology of Southern Ontario:
  Figure 2
Bedrock topography of Southern Ontario:
  Figure 3
Beef cattle 126,135,136,138,160,163,
  165,172,177,180,185,187
See also: Livestock production.
Beekmantown Formation dolomite 80
Beekmantown Group 10,196
Beeton 21,74,180
Belfountain 102,121
Belfountain outlet 28
Belgrave 141
Belgrave Creek 91
Belleville 5,56,105,187
Bellrock 106
Belmont 146
Belmont and Methuen Tp. 213
Belmont Tp. 185
Belmont vale 145
Belwood 44,96,136
Belwood, Lake 96,98
Benmiller 91
Bentinck Tp. 127,129
Bereley 48
Bernard Lake 60
Berriedale fine sandy loam 215
Berrien sandy loam 146,147
Berrien soil profile 160
Berwick 107
Beverly loam 65
Beverly Swamp 56,101,129
Beverly Tp. 65
Biddy Lake 59,79,194
Big Bay 189
Big Chute 195
  Power plant 86
Big Clear Lake 105
Big Creek 50,68,95,145,154,156
Big Eddy:
  Power plant 85
Biggar Tp. 15
Bighead River 6,87,117,124,125
  Deltas 21,73
    Photo 74
Bighead Valley 117,124,218
  Drumlins 57
  Location; figure 113
Big Otter Creek 95
Big Swamp 189
Billings Tp. 165
Binbrook 52,158,159

Bingham Chute:
Power plant 85
Bird's-foot delta; St. Clair River 92,151
Birnam 63
Bishop Tp. 15
Bisset Creek 110
Black Creek 106,165,201
Black Donald Mine 213
Black River 86,171,181
Blackwater 170
Blackwell 69,70
Blackwell marsh 162
Blair 46
Blake 64
Blakeney 108
Blandford-Blenheim, Township of 136
Blantyre 125
Blenheim 44,64,65,147,149
Blenheim Moraine 44,63-65,149
Bloomfield 189
Blowouts 41,68,70,167,218
Photo 71
See also: Soil erosion.
Blowsand 161,167
See also: Soil erosion.
Blueberries 156
Blue Jay Creek 165
Blue Lake 65
Blue Mountain (Georgian Peaks) 5,48,51,116,117,122
Block Diagram; figure 117
Ski run 117,121
Photo 6
Blue Mountain Formation 164
Blue Springs Creek 98
Bluevale 91,141
Bluewater Highway (Highway 21) 143,161
Blyth 45,91
Bobcaygeon 186
Bobcaygeon Formation 185,186
Bognor 87,88,126
Bogs:
Nottawasaga basin 74,179
Smith Falls limestone plain 197
Winchester clay plain 203,204
See also: Peat bogs.
Bois Blanc Formation 56,57,157
Bolton 103,167
Bondhead loam 171,174
Bondhead sandy loam 81
Bonfield 25,60,215
Gravel pits 60
Bonfield Tp. 15,78,110
Bonnechère caves 109
Bonnechère River 4,109,209
Booth Lake 2
Bothwell 147
Bothwell sand plain 147
Location; figure 113
Boulder beach near Greenfield:
Photo 80
Boulder belt, Kingsville 44
Boulder pavements 74,80,110,123,161,182
Photo 202
Boulter Esker 39,60
Boulter Tp. 60,84
Boundary Island 151
Bower Tp. 15
Bowmanville 79,174,194
Bowmanville Creek 102
Boyne Creek 95
Boyne River 74,87,115,179
Hoggs Falls; photo 88
Bracebridge 21,24,84,85,215
Power plant 85
Bradford 76,170,177,181
Brady soil series 160
Brampton 59,67,103,173,175,176
Branchton 65
Brant County 50,154
Brantford ... 19,28,50,51,63-65,82,83,96-98,129,156
Brechin 182
Brent 1
Brent access road 61
Breypen soil series 162
Brice Hill Esker 58
Bridgman sand 200
Brigden 93
Bright 144
Brighton 54,56,194,195
Brighton series 168
Brights Grove 162
Brinston Flood Area in South Nation Valley 107
Brisbane 50,98
Brock Tp. 170,181
Brockville 10,26,106,196,199
Brodhagen 27,45,61,93
Bronte 192
Bronte (Twelve mile) Creek ... 102,115,130,174,191
Valley 115
Brooke Tp. 63
Brookston clay 150,152
Brookston clay loam 149
Soil profile; figure 134
Brookston series 131,134
Brookston silt loam 81,131
Brownsville ridge 145
Bruce Beach 162
Bruce County 89,139,160,161,163
Photos 71,142
Brucefield 48
Bruce Peninsula 2,5,6,17,70,71,114, 118,119,161,162,217
Cliffs 118
Highest point 117
Location; figure 113
Population; table 163

Bruce Tp. 64
Bruce Trail 121,163
Brudenel 38
Brunisol 212
Brunisolic profiles 131
Brussels 45,91,141
Buck Lake 105
Bull Lake 105
Burford 63,156
Burford catena 138
Burford gravelly loam 146
Burford loam 81
Burford series 128
Burford Tp. 95
Burgess Mines 213
Burgessville 47,146
Burk's Falls 1,60,215
Burleigh Falls 104
Burlington 191,192
Burlington bar 120
Burnamthorpe Road 54
Burnt River 185
Burpee 77
Burpee flats 165
Byng Inlet 85

Cabot Head 118,119,163
Cabot Head Formation 164
Caistor clay 150
Caistor clay loam 157
Calabogie 3
Caledon 14,28,46-52*passim*, 63,83,102,114,121,127,128
Caledonia 16,55,56,157,158
Caledonia Tp. 207
Caledon Lake 44,136
Caledon mountain 102
Caledon soil series 128
Calvin Tp. 39,78,110
Cambridge 47,50,63,96,98,128,129,137
Cambridge Tp. 210
Camden East 106,187
Camden East Tp. 188
Cameron Creek 106
Cameron Lake 59,170
Camlachie 67
Campbellford 79,105,169,172,195
Campbellville 19,24,28,65,115,121,130
Camp Borden 21,74,179,180
Camperdown 117
Canada Company 135
Canadian Shield 1,3,6,10,61,81,85,104,108,219
Cannamore 204
Canning crops 149,150,158,174,189,194
Canning Lake 61
Cannington 170
Cannington Esker 170
Canoe Lake 85
Canola 219
Canyons 110,209
Cape Commodore 74,118
Cape Croker 70,118
Cape Croker Indian Reserve (IR 27) 70
Cape Dundas 118
  Cliffs 163
Cape Rich 73,118,218
  Block Diagram; figure 126
Cape Rich Steps 126
  Location; figure 113
Caradoc Indian Reserve (IR 42) 94,147
Caradoc sand plains 63,146
  Location; figure 113
Caradoc Tp. 19,45,94,146
Carbon-14 dating 25,27,38,39,40
Carcajou Lake 39
Carden plain 184
  Location; figure 113
  Photo 184
Carden Tp. 184,185
Cardinal, Village of 200
Cargill 160
Carholme 50,95
Caribou, Lake 5
Carillon Rapids 110
Carleton County 209
Carleton Place 108,196-199
Carp 208
Carp clay loam 204,208
Carp River valley 3,197,206-208
Carrick Tp. 139
Carrol Wood Bay 77
Carrying Place 188
Carterton 77
Casa Loma 192
Cash crops 146,147,150,176,180
Cass Bridge 205
Casselman 107,203,205,209
Castleford 109
Castor River 107,209
Castor sandy loam 210
Castor series 205
Cataract 49,102
Cataraqui 187
Cataraqui River 106
Catfish Creek 47,94,145,156
Cathcart 47
Cauchon Lake 5,109
Cavans 213
Caves, Bonnechère 109
Cayuga 158
Cedar Creek 93
Cedar Lake 1,5,39,109
Cedar Springs 44,65,149
Cedar Valley 44
Cement factory 189
Cement manufacture 135
Central Experimental Farm 206

Centralia 45
Centralia Moraine 45
Ceramic products 120
Chalk River 5,83,210
Champlain Sea 38-40,61,80,109,200,201,209,210
  Delta 39
  Figure 35
  Seafloor; photo 206
  Shoreline; figure 62
Champlain Valley outlet, New York 38
Charing Cross 149
Chatham 2,65,68,94,150
Chatham flats 150
  Location; figure 113
  Photo 151
Chatham Tp. 150
Chats Falls 110
Chatsworth 129
Chaudière Falls 110
Chazy Group shales 80
Cheese 161,189,199,203,205,208,213
Cheltenham 115,121
Chenaux power plant on Ottawa River 110
Chepstow 160
Cherry Beach 192
Chesley 28,49,127,160
Chesley Lake 90,141
Chesley silty clay loam 160
Chesterville 107,205
Chicago, Lake 68
Chicago outlet, Illinois 12,24,25,37,40
Chinguacousy clay loam 68,174
Chippawa 99,120,158
Chippawa-Queenston power canal 99
Chisholm Tp. 55,78,84
Churchville 103
Chute-à-Blondeau 208
Chute du Rocher Fendu 110
Cincinnati Arch 2,149
Clachan 63,65
Clairville 104
Clandeboye 45,92
Claremont 53
Clarence Tp. 206-210*passim*
Clarke Tp. 167
Clarksburg 87,123,124
Clarkson 78,191,192
Clavering 70
Claybanks 73,74
"Clay Banks" at Cape Rich 117
Clay plain, Winchester 107
Clifford 139,141
Cliffs:
  Beaver Valley 122
  Bruce Peninsula 118
  Cape Dundas 163
  Cape Rich 117
  Lion's Head 163
  Niagara Escarpment 114,115
Clinton 47,127,161
Clinton Moraine 27,48
Cloyne 105
Clyde clay 152
Clyde clay loam 150
Clyde Forks 213
Clyde River 108
Clyde silt loam 150
Coates Creek 74
Cobble hills 45
Cobden 206,208,210
Coboconk 185
Cobourg 56,194,195
Cobourg Creek 102
Cockburn Island 77,166
  Location; figure 113
Codrington 59,170,195
Codrington Esker 17,59
Coe Hill 58
Coffin Hill 73,74
Colborne 59,82,194,195
Cold Creek 105
Coldstream 23,46
Coldwater 77,178,184
Coldwater Creek 86
Coldwater River 76
Colebrook 106
Collingwood 2,5,6,24,69-77*passim*,116,117,121
  Crevasses 116
  Photo 6
Collingwood Tp. 6,73,122,124,127
Colpoys Bay 17,70,71,73,118,141,163
Colpoys Range red shale 73
Colwell 74,76
Combermere 108
Comet 149
Concord 67
Conestogo conservation dam 97
Conestogo River 44,95,97,133,136
Conestogo Valley 61,97
Connaught Rifle Range 206
Cook Bay 76,181
Cooks Mills 24,25,39,67
Cookstown 21,74,180
Cooksville 79,191
Cooper 185
Copetown 19,52
Copper 213
Corn 147,149,155
  Seed 152
Cornhill Moraine 51,54,74
Cornwall 3,203
Corundum 213
Corunna 150
Cottam 67,149
Couchiching, Lake 86,182
Coulonge Fault 5,110
  Scarp 5

Courtland 46,156
Courtland Moraine 46
Courtright 150
Covey Hill outlet, New York 38,79
Cox Creek 98
Craigleith 74,117
Craigmont 213
Cramahe Hill 79
Crampton 47
Cranberry Lake 180,197
Crater near Brent 1
Credit, Forks of the 6,102,115
Credit River 49,50,102,115,121,139,173-175,191
  Dam at Orangeville 103
Credit Valley 67,79
  Gravel bar 79
"Credit Valley Sandstone" 121
Creemore 51,74,116
Cretaceous faults 5
Crevasses at Collingwood 116
Cromarty 45
Crossland 54,180
Crowe River 105
Crow Lake 61
Crowland 69,157
Croydon 106
Crumlin 62,146
Crustal depression 12
See also: Isostatic depression.
Crustal rebound 12
See also: Crustal uplift; Isostatic uplift.
Crustal uplift 24,26,38,171
See also: Crustal rebound; Isostatic uplift.
Crysler 107,203,205
Crystal Beach 67,69,157,158
Crystal Beach Moraine 48
Cuesta
See: Niagara Cuesta.
Cuesta and vale topography 5
Culloden Strand 145
Culross Tp. 139
Cumberland Tp. 207,208
Cutten Fields 50

Dacre 4
Dairy cattle 135,172,180,187
Dairy farming 144,196-203*passim*
Dairying 158,189,204,207,210
Dale 194
Dams, water control:
  Ausable River
    Morrison 92
    Parkhill 92
  Credit River
    Orangeville 103
  Ganaraska River
    Garden Hill 104
  Moira River
    Deloro 105
    Lingham Lake 105
  Napanee River
    Depot Lakes 106
  South Nation River
    Chesterville 107
    Spencerville 107
    Ventnor 107
  South Thames River
    Gordon Pittock 94
  Sydenham River
    Darcy McKeough 93
  Thames River
    Fanshawe 93,94
    Mitchell 94
    St. Marys 94
    Stratford 94
  Trent River
    Hastings 105
  West Don River
    G. Ross Lord 104
  West Humber River
    Clairville 104
Dana, Lake 24,68
Darcy McKeough Dam and Diversion
    on Sydenham River 93
Darling Tp. 61
Darlington loam 174,193
Darlington series 189
Dashwood 64,92
Davenport Road 53,191
Davenport Road hill 79
Dawes Road 79
De Cew Falls power plant 101
Deep River, Town of 210
Deer Creek 159
Deer hunting 166,214
Delaware 146
Delaware Tp. 94
Delhi 50,95,156
Delisle River 201
Delmer 145
Deloro 105
Demorestville 188
Denfield 46
Depot Creek 106
  Power plant 106
Derby Mills 141
Derby Tp. 141
Dereham Centre 145
Derwent 47
Desboro 89
Desjardins Canal 120,191
Deux-Rivières 61,83,84,110
Devil's Glen 6,86,116
Devine Tp. 15
Diatomite 213

Dingman Creek 23,47,145
Disappearing streams 88
  Photo 89
Dixie 79
Dodd's Hill 118
Dolostone:
  Amabel Formation 114,115,163
  Beekmantown Formation 80
  Lockport Formation 114
  Manitoulin Formation 117,126
  Niagara Escarpment 116
  Photo 162
Don River 79,103,104,173,174,191,192
  G. Ross Lord Dam 104
Don Valley 193
Don Valley Brickyard 10
Donnybrook series 127
Door Peninsula, Wisconsin 6
Doré, Lake 4,109,206
Doré Scarp 4
Dorset 5,24
Douglas 109
Douglas Point:
  Nuclear-powered generating station 162
Douro Tp. 57
Dover Tp. 68,150
Dow Lake 206
Downeyville 170
Drayton 132
Dresden 67,68
Dresden, Lake 67
  Figure 34
  Shorelines 68,69
Drumbo 47
Drumlin fields 54,218
  Arran 51,141
    Location; figure 113
  Guelph 44,137
  Location; figure 16
  Peterborough 169,218
    Location; figure 113
  Teeswater 139
    Location; figure 113
  Woodstock 44,81
Drumlins 11,16-17,55-58
  Beaver Valley 122
  Bighead Valley 117,124
  Composition of tills 57
  Flamborough plain 129
  Gould Lake 90
  Manitoulin Island 165
  Oxford plain 143
  Photos 11,17,58,125,169
  Texture of tills; figure 15
Drummond Island, Michigan 166
Drumquin 67,175
Duart 44,63,64
Dublin Moraine 45
Duck Islands 77
Duck shooting at Point Pelee 153
Dufferin County 50,130,132
Duffin's Creek 102
Dumblane 90
Dumfries soil series 128,136
  Soil profile; table 128
Dummer Moraines 14,37,54,185,218
  Location; figure 113
Dummer Tp.
  Drumlins 57,185,186
Duncan 51,122
Duncan Brook 122
Dundalk 2,90,95,130,132
Dundalk (Algonquin) Arch 2
Dundalk-Arthur plain 56
Dundalk till plain 27,58,81,130,219
  Location; figure 113
  Photos 130,133
Dundalk upland 217
Dundas 21,51,101,120,130,191
Dundas County 14,204
  Population; table 204
Dundas Valley 6,28,51,78,101,115,130
Dundonald sandy loam 81
Dundonald series 171,174
Dunedin 51
Dungannon 64,91
Dunks Bay 71,119
Dunnville 21,24,67-69,96,98,157-159
Dunnville, Lake:
  Figure 34
Duntroon 51
Durham, R.M. of 28,83,125,129,172-174,193
  Drumlins 57
  Gravel pit 49
Durham forest 168
Dyer Bay 71,118,163

Early Lake Algonquin 24,37,67-69
  Figure 34
Early Wisconsinan 10
Earthquakes 3,5
Eastcross Creek 171
East Gwillimbury, Town of 24
Easthope Moraine 93
East Lake 188,189
East Linton 71
East Luther Tp. 130
Eastnor Tp. 71,162,163
East River 60,85
East Wawanosh Tp. 47
Eastwood 47
Eden Grove 90,159
Eden Mills 51,98,139
Edenvale 25,76,180
Edenvale Moraine 54,87,179

Edgars 149
Edward Lake 116
Edwardsburg sand plain 200
  Location; figure 113
Edwardsburg Tp. 55,200
Eganville 4,109
Egerton Esker 58
Egypt 76
Eighteen Mile River 89
Ekfrid clay plain 146
  Location; figure 113
Ekfrid Tp. 63,146,147
Elderslie silty clay loam 160
"Elderslie swamp" 159,160
Elderslie Tp. 51,159,160,219
Eldon Tp. 54
Eldorado 185,213
Elgin County 153
Elginfield 45
Elkton, Lake 24
Ellengowan 159
Ellice Marsh 27,45
Elliot Chute:
  Power plant 85
Elma Tp. 61
Elmira 58,98
Elmira Moraine 13
Elmvale 24,180
Elmvale clay plain 180
Elmwood 65,160
Elora 96-98,139
Elora Gorge 97
  Photo 97
Embro 27,93,144
Embrun 107
Emily Tp. 57
Emsdale 83
Enniskillen 174
Eramosa River 50,98,139
Eramosa Tp. 57
Erie, Lake
  Basin 67
  Shorecliffs 9,67,94
  Shore erosion 153
  Water level 99
Erie ice lobe 13,23,43,46,62
Erie plain 69,219
Erie Spits 153
  Location; figure 113
Erin 50,139
Erindale 79,103
Erinsville 59
Erin Tp. 57
Erosion by wind 41,65
See also: Blowouts; Blowsand; Soil erosion.
Eskers 17,58-61,84,218
  Contour map; figure 60
  Location; figure 19
  Peterborough drumlin field 170
  Photos 18,20,59
Essa flats 179
Essa sand plains 180
Essa Tp. 74
Essex 28,149
Essex clay plain 147
  Location; figure 113
Essex County 2,65,67,147,151,219
Essex Moraine 44
Essex ridge 67
Esther Cliff 118,119
Etobicoke 173
Etobicoke Creek 103,174,191
Etobicoke Tp. 176
Eugenia 124
Eugenia Falls 87
Eugenia Lake (reservoir) 87
Euphrasia Tp. 49,88,127
Evansville flats 165
Everett 74
Everton 98,139
Exeter 23,46,92,135

Fairchild Creek 98
Falconbridge 146
Fall River 108
Fanshawe Dam on Thames River 93,94
Farm equipment manufacture 139
Farming
  See: General Farming.
Farmington series 188,197
Farmington soil 165
Farquhar 45
Fault lines 85
Fault-line scarps 217
Faults 2-4
  Ages of; 5
  Coulonge 5
  Location; figure 4
  Hopefield 5
  Pakenham 4
Fault scarp at Muskrat Lake 210
Fee's Landing 170
Feldspar 213
Fenella 168
Fenelon Falls 104,186
Fergus 98,139
Feronia 39
Feversham 87,129
Finch 60,107,201,205
Fingal 28,47,65,147
Fish Creek 45,93
Fisherville 158
Fishing port, Tobermory 163
Fishing villages along Lake Erie shore 156
Fish Lake 188

Flamborough plain 129
Location; figure 113
Flamborough Tp. 65,129
Flat Creek 93
Flax 132,135,205,210
Fleetwood Creek 170,171
Flesherton 6,27,47-49,87,122,129
Flooding:
Ausable River 92
Chatham flats 150
Don Valley 104
Etobicoke Creek 103
Ganaraska River 104
Guelph 98
Nottawasaga basin 179,180
South Nation Valley 107,205
Thames Valley 93,94
Floradale 44
"Flowerpots" 118
Photo 119
Fluorspar 213
Flutings 10,164,169,171
Photos 11,12,164
Fonthill 52,65,66,101,121,157-159
Fordwich 91,141
Forest 64
Foresters Falls 206
Forestry 213
Forks of the Credit 6,102,115
Formosa 141
Formosa Creek 139
Fort Ann, Lake; New York 38
Fort Erie 6,99,157,158
Fort Erie Moraine 52
Forty Mile Creek 101,157
Fossils 10,14,92
Fossmill 55,60
Fossmill outlet 25,38,39,109,110,210
Four Mile Creek 101
Valley 114
Fournier 207
Foxboro 59,105
Fox fine sandy loam 146
Fox sandy loam 160
Fox series 154,155
Frankford 59,79,170,172,195
Fraxa 132
Freelton 55,129
French Bay road (Highway 21) 143,161
Frenchman Bay 70
French River 85
French River outlet 25
Frontenac, Lake 38
Frontenac Axis 1,3,196,217
Frontenac County 196,213
Frontenac Tp. 213
Fruit 149,157,159,189
See also: Apples; Grapes; Orchards; Peaches.
Fullarton 27,45
Fur farms 166
Furniture manufacture 129

Galletta 108
Galt 96
Galt Moraine 14,28,50-51,56,63,65,96,101
Gananoque 106,196
Gananoque River 106
Ganaraska Forest 104
Ganaraska River 104,168,194
Valley 79
Garafraxa Road (Highway 6) 132
Garden Hill 104
Gardez-Pieds cross fault 109
General farming 140,145,166,194,195,208
See also: Mixed farming.
Genesee outlet 38
Georgetown 55,69,102,103,120,121,128
Georgian Bay 2,6,24,76,78,121,122,177,217
Drainage to; 85,86
Georgian Bay Formation 164,173,175,191
Georgian Bay fringe 213,214,219
Georgian Bay ice lobe 13,16,27,28,
43-48*passim*,54,141
Figure 30
Georgian Bay Islands National Park 163
Georgian Bay-Ottawa Valley
region 1,5,15,60,61,83,213
Faulting 4
Georgina Tp. 181
Gesto 14
Gibraltar 49
Gibraltar Moraine 27,28,48-51
Gillies Hill 159
Ginseng 159
Glacial Lakes, Wisconsinan 61
Ages and elevations; figure 21
Glammis 28,48
Glamworth 146
Glen Allen 97
Glencoe 63
Glenelg Tp. 58,127-129
Glengarry County 57,205
Population; table 203
Glengarry till plain 201
Location; figure 113
Glen Haffy public park 121
Glen Huron 51,116
Glen Meyer 65
Glenora 188
Glen Williams 103
Gley horizon 165
Gleysolic soils 131,149,200,204
Gloucester 3,200,207
Gneiss, decorative 213
Goat Island 99
Goderich 17,27,48,64,70,91,161,162

Goderich Moraine 48
Go Home River 85
Gold 213
Golden Lake 4,80,109,211
Gooderham 61,84
Goodwood Formation 53
Gordon Pittock Dam on South Thames River 94
Gordon Tp. 77
Gore Bay 164,165
Gorges:
  Burnstown 109
  Elora 96
  Niagara 99
  St. Davids (buried) 101
Goring 88
Gorrie 91,141
Gould Lake 70,90,141
  Photo 142
Graben, Ottawa-Bonnechère 3,5,55
  Physiographic sketch; figure 4
Granby sandy loam 200
Granby soils 147
Grand Bend 24,25,69,70,92,161,162
Grand Desert 15,60
Grand Lake 39
Grand River ... 27,28,50,67,95,130,131,136,157,158
  Basin 46,138
  Delta in glacial lake 19,21,69,154
  Power plants 98
  Valley 81,98,129
Grand River outlet, Michigan 24,27,28
Grand Valley 96,132
Granite, decorative 213
Grantham Tp. 191
Granton 45
Grapes 190
See also: Fruit; Vineyards.
Graphite 213
Grassmere, Lake 24,28,61,67
  Beaches 44,67
Gravel 52,55
  Deleterious materials distribution; figure 82
  Pits 46,49,64,76,79
  Spit 74
  Terraces 46,81
Gravelly Bay 74
Gravenhurst 84,215,219
Grays 64
Great Duck Island 77
Great Western Railway 120
Greely 60
Greenleaf Lake 39
Greenock Swamp 27,28,48,49,90,127,140
Green's Creek 207
Greenwood 193
Grenville County 80,200
Grenville loam 201,203
Grenville Province 1
Grey County 57,89,126-130,139,163
Grier Creek 122
Griersville 122
"Griersville Rock" 117,122,124,125
Griffith 109
Griffith Island 118
Griffith Tp. 5
Grimsby 101,114,190
Guelph 16,50,58,98,128,129,137,138
Guelph, University of 58,138
Guelph catena 138,140
Guelph Collegiate Institute 138
Guelph drumlin field 27,44,49,55,56,58,98,137
  Location; figure 113
Guelph Formation 56,138,156
Guelph loam 138,143
Guelph soil series 136
Guelph till plain 138
  Till samples 137
Guelph Tp. 137
Guilmette Lake 39
Gull River 10
  Valley 78
Gull River Formation 6,54,169,185,186
Gustin Grove 69,162

Hagersville 6,158
Haldimand clay loam 157
Haldimand clay plain 156
  Location; figure 113
  Photo 158
Haldimand County 6
Haldimand loam 65
Haldimand-Norfolk, R.M. of 128,153,158
Haley Station 206,210
Haliburton 212,213
Haliburton County 61,86,108,211
Halliday Hill 118
Hallowell Tp. 188,189
Halton, R.M. of 24,56,67,137,174
Halton County 175
Halton Hills, Town of 120,129
Halton Till 28
Hamilton 2,5,16,52,78,83,120,158,190,191
Hamilton Harbour 101,102
"Hamilton Mountain" 51
Hamilton-Wentworth, R.M. of 137
Hanna Chute:
  Power plant 85
Hanover 28,49,129,160
Harkaway 88
Harkaway silt loam 141
Harrison Park 88
Harriston 91,132,139,141
Harriston catena 138,140
Harriston series 131,136,140
Harriston soil 127
Harrow 28,149

Hastings 79,105,172,195
Hastings County 57-59,105,108,169-172,211-213
Havelock 61,186
Hawkesbury 205,208,209
Hawkesville 44,97
Hay Bay 187
Hay Island 118
Hazeldean 3
Healey Falls 105
Heathcote 51,87,122,123
Heathcote Moraine 123,124
Heavy industry 120
Hemlock Creek 157
Hemstock Mills 88
Hendrie forest 183
Hensall 27,28,127,135
Hepworth 24,48,70,89,90
Hepworth Creek 88,90
  Disappearing stream; photo 89
Hepworth Lake 88,90
Hespeler 98
Hiatella arctica 60
Hickey Settlement 83
Hickson 144
High Falls 39,110
High Falls (settlement) 85
  Power plant 85
High Hill 164,165
Highland Creek 102,193
Highways:
  2 46,62,79,103,172,188,194,196
  3 63,67
  4 92
  5 54,65,101
  6 128,132,160,163
  7 45,50,59,128,136,166
  8 78
  9 160
  10 43,44,132
  11 21,76,78,83,166,181,214,219
  16 200
  17 25,40,83,206,208
  19 145
  21 143,161
  24 65
  27 53,166
  28 166
  29 196
  33 188
  35 166
  46 194
  47 166
  48 166
  50 166
  60 84
  62 83
  69 85,214
  400 167,181
  401 128,145,172,176,188,194
  403 176
Hillier 189
Hillier series 188
Hillier Tp. 188
Hillsburgh 43,44,102,136
Hillsburg sandhills 135
  Location; figure 113
Hillsburgh spillway 136
Hillsdale 76
Hills Green 48
Hilton Beach 77,78
Hockley road 49
Hockley Valley 6,51,86,179
  Kames 44
  Outwash terraces; photo 116
  Ski run 121
Hofstetter Lake 136
Hog Creek 86
Hogg 71
  Algonquin beach; photo 73
Hoggs Falls 87
  Photo 88
Hogs 135,136,138,144
See also: Livestock production; Pigs; Pork.
"Hogsback" 170
Holland Landing 76,176,181
Holland Marsh 24,76,86,181
  Photo 182
Holland River 86,176,181
  Delta 76
Holland Tp. 49,51,127
Hollen 97
Holmesville 91
Holstein 47,129
Homer 78
Honeywood 48,81,131,132
Honeywood loam 132
  Soil profile; table 131
Hoople Creek 201
Hope Bay 71,119,163
Hope Tp. 172
Hopefield Fault 5
Hopewell Creek 98
Horner Creek 145
Horning's Mills 43,48,131
Horseshoe (Canadian Niagara) Falls 99
Horseshoe Lake 105
Horseshoe Moraine system 90,116,127,218
  Location; figure 113
  Sand and gravel 82
Horton Tp. 208
Howdenvale 163
Howe Island 196
Howick Tp. 139
Hudson Valley outlet, New York 12,26,38
Humber College, site of:
  Photo 175

Humber River 53,79,103,115,121, 167,173-175,191,192
Dam at Clairville 104
Valley 68,193
Humberstone 69
Humberstone peat bog 157
Hungerford Tp. 185
Huntington Tp. 185
Huntsville 14,55,85,215
Huron, Lake:
Basin 6,68,69
Drainage 89
Huron catena 134,145
Huron clay loam 127,145
Soil profile; figure 134
Huron County 81,127,139,161,219
Hurondale 46
Huron fringe 161
Location; figure 113
Huronia Regional Centre 76
Huron ice lobe 13,16,23-28*passim*,43-45,48,133,134
Figures 30,31
Huron series 131
Huron silt loam 81,145
Huron slope 160
Location; figure 113
Hurontario Street (Highway 10) 43,44,132
Huttonville 103
Hyde Park 93

Ice Lake 165
Ilderton 45,93
Illinoian glaciation 10
Indian Brook 122,123
Indian River 83,104,109,210
Ingersoll 27,46,47,93,95,144,145
Ingersoll Moraine 27,46,47,95,145
Inglewood 102
Inglis Falls 88,118
Inner Bay 95,153
Innerkip 144
Innisfil Creek 179
Innisfil Tp. 179
Innisfil uplands 183
Inverhuron 70,89,162
Ipperwash 161
Iron 213
Irondale River 61
Valley 84
Iroquois 203
Iroquois, Lake ... 26,37,38,54,56,78-80,170,190,196
Basin 61
Beaches 78,79,104
Figure 34
Shorecliffs 54,79,192
Shoreline 37,114,191,194
Figure 62
Iroquois plain 56,101,172,190,195,219
Location; figure 113
Irvine Creek 96
Islington 79
Isostatic depression 12,24-26
See also: Crustal depression.
Isostatic uplift 25,39
See also: Crustal rebound; Crustal uplift.

Jack Lake 54,77,87
Basin 180
Jack Miner's Bird Sanctuary 153
Jacksons Point 182
Jarvis 158
Jeannettes Creek 150
Jessopville 58
Esker; photo 59
Johnson 126
Joly Tp. 84
Jones Bluff 118
Jones Falls 106
Jordan Harbour 101,191

Kagawong 165
Kagawong Lake 163
Kamaniskeg Lake 108
Kame moraines 47,218
Photo 49
Kames 44-66*passim*,82,83,143
Materials in; photo 14
Kars 60,200
Katchiwano Lake 104
Kathmore 109
Kawartha Lakes 6,14,54,59,104,185,217
Kawartha Lakes ice sheet 59
Kawawaymog (Round) Lake 83,110
Keefer Creek 74
Kemble 73
Kempenfelt Bay 182,183
Kemptville 14,60,200
Kendal 172,174
Kennebec Lake 105
Kenny Creek 145
Kentbridge 68
Kent County 65,68,94,147,149,219
Keppel Tp. 88,89,90,141,162
Kerwood 63,147
Keswick 182
Kettle Creek 28,47,94,145,156
Dissection; figure 95
Kettle Lakes:
Mount Elgin Ridges 145
Oak Ridges Moraine 168
Waterloo Hills 136
Kettle Point 69,161
Kettle Point Indian Reserve (IR 44) 162
Kettles 12
"Kettles" in Horseshoe Moraines 128
Key River 5

Kilbride 51,59
Killaloe 15,83
Kilrush Lake 39
Kimberley 6,87,122,124
Kinburn 45,208
Kincardine 70,89,161,162
Kincardine Tp. 64
King clay loam 174
King silt loam 81
King Tp. 9,52,53
Kingscourt 63,64
Kingshurst 48
Kingsmere, Que. 13,80
Kings Point Bluffs 118
Kingston 55,83,106,187,196,217
Kingsville boulder belt 44
Kingwood 97
Kinmount 78
Kinnard Point 157
Kintyre 64,65
Kioshkokwi Lake 5,110
Kirby 174
Kirkfield 69,76,185
Kirkfield outlet 24,37,38,69,78
Kirkton 45
Kitchener 16,44,98,129,137
Kitley 199
Kleinburg 103
Klock 83
Kolapore 51
Komoka 63,146

Lac de Chats 110,111
Lac Dechênes 110
Lac Rocher Fendu 110
Lady Bank 49
Lafontaine 76,183
Lake Clear 3,45,109
Lakefield 172,186
Lake of Bays 85
Lake-on-the-Mountain 188
Lakeside 45,143
Lakeview 192
Lambeth 47
Lambton clay plain 149
  Location; figure 113
Lambton County 65,92,127,147,149,150
Lanark 108,213
Lanark County 61,80,84,196,198,212,213
Lancaster 106
Lancaster flats 106,205
  Location; figure 113
Lancaster Tp. 205
Langside 47
Langton 50,65
Lansdowne 196
La Pointe Flood Area in South Nation Valley ... 107
Lapp Point 157
LaRose forest 210
Late Algonquin 39
Laurentian uplands, Que. 80,205
Laurier Tp. 84
Lavender 50
Lead 213
Leamington 28,44,63,65,67,149
Leamington Moraine 44,64
Leda clays 107
Leeds and Grenville, United Counties of 14,196
Leeds County 80,196,213
Leeds knobs and flats 196
  Location; figure 113
  Photo 197
  Structure; figure 196
Lehman Dam on Big Creek 95
Leith 73,74
Lemieux 107,209
Lennox and Addington
    County 56,57,105,108,187,212,213
Lester B. Pearson International Airport 67
Lighthouse Point 151,152
Limehouse 50,115
Lime Lake 59
Limestone 1-7*passim*,120
  Bluffs on Prince Edward Peninsula 188
  Bonnechère Valley 109
  Domes:
    Amherstburg 147
    Pelee Island 152
  Grand Valley 96
  Maitland Valley 91
  Mesas in Ottawa Valley 206
  Plains 70,129,184-188,196
  Scarp 78
  Thames Valley 93
Lindenwood 71
Lindsay 6,104,170-172
Lindsay Formation 6,56,169,173,185,188
  Photo 188
Lingman Lake 105
"Linton moraine" 53
Lions Head 70,71,118,121,162
  Cliffs 163
  Photo 118
Lisbon 44,97
Lisle 179
Listowel 17,27,45,132,135
Listowel series 131,140
Listowel soils 136
Little Ausable River 70,92
Little Britain 172
Little Current 77,165,166
Little Hell Hill 181
Little Lake 79,104
Little Lake depression 76
Little Maitland River 91
Little Otter Creek 95

Little Swamp 189
Livestock production 128,137,140,143,186,219
See also: Beef cattle; Dairy cattle; Hogs.
Lloydtown 177
Lobo 45
Lockport Formation 156
Loess 80-81
Logan Tp. 93
London 19,23,27,43,45-47,93,94,145,146,218
London basin 146
London loam 138,144,146
London soil 136
Long Branch 103,192
Long Lake Mine 213
Long Point 68,69,94,153
Long Sault 201
Long Sault Rapids 110
Lord, G. Ross, Dam 104
Loree 122
L'Orignal 208
Lorne Park 191
Lothian 64
Lowbanks 99,157
Lower Algonquin 39
  Beaches 70
Lower Allumette Lake 110
Lowville 115,121
Lucan 45,92
Lucan Crossing 46
Lucan Moraine 45,63,81,134
Lucknow 48,64,91,161
Lucknow River 48,64,90
Lucknow spillway 91
Lundy, Lake 24,28,37,61,66,67
  Figure 33
Lundy's Lane 37,52,66,157
Luther Dam 96
Luther Marsh 58,96,131
Luvisols, Grey Brown 81,131,134,136,143, 154,165,171,179,200,201,212
Lynde Creek 102
Lynedoch 65
Lynn River 156
Lynnville 65
Lyons 47

Mabee 46
Mabee Moraine 46
McCraney Lake 85
Macdonald Institute 139
McKillop Tp. 59
McLaughlin Tp. 15
McLennan hill 77
McMaster University 191
McNab Lake (marl) 70,90
Madawaska 61,84,213
Madawaska highlands 5
Madawaska River 5,108
  Gorge at Burnstown 109
  Power plants 109
Madoc 186,213
Madoc Tp. 61,185
Mad River 6,74,86,116,117,179
Mafeking 91
Magnetawan 85
  Dam 85
Magnetawan River 85
Magnetawan silt loam 215
Maidstone 149
Main Algonquin:
  Beach 69
  Figure 35
  Shoreline 24
Maitland River 48,65,91,130
  Valley 91
Malcolm Bluff 118
Malden Centre 68
Malvern 56,79
Manilla 170
Manitou Islands 213
Manitou Lake 163,164
Manitoulin Formation 117,118,122,126,164
Manitoulin Island 5,77,163,217
  Drumlins 17,57
  Location; figure 113
  Physiographic sketch; figure 164
  Population; table 165
Manitou River 165
Manitowaning 77
Manotick 57,201
Mansfield ski run 121
Maple 10,173
Maple Lake 78
Maple sugar and syrup 198,203
Mapleton 63
Maple Valley 48,131
Mara Moraine 54
Mara Tp. 24,54,181
Marble quarries 213
Marie, Lake 167
Marie Curtis Park 103
Marilla Moraine, New York 28
Marine beach deposits 197
  Photo 198
Marine railway 195
Mariposa Tp. 170,171
Markdale 129
Market gardens 175,181
Markham 174,176
Marl:
  Blackwell marsh 70,162
  Elma Tp. 61
  Flamborough plain 130
  McNab Lake 70,90

Minesing flats 179
Photo 179
Shallow Lake 90,143
Thedford Marsh 162
Marlbank 59,105,170,185,186
Marmora 186,213
Marmora Tp. 185
Marsville 56,57
Martel 209
Marthaville 64
Martin Creek 170
Martindale pond 101
Martintown 106
Mary Lake 85
Marysville 187
Marysville Lake 70
Massie 51,126
Matawatchan 108
Matawatchan Tp. 5
Mathias:
Power plant 86
Matilda Tp. 55
Mattawa 5,15,25,61,78,84,110
Mattawa ice lobe 25,39,60
Mattawa River 60,110
Canyon 110
Outlet 25
Valley 5,15,25,39,60
Maumee, Lake 46,47,61,62
Shoreline 23
Maxville 14,55,201,205
Mazinaw Lake 108
Meadowvale 103
Meaford 6,17,57,73,74,87,88,121,124-126
Medad, Lake 69
Medonte Tp. 182,184
Photo 183
Medway River 45,93
Valley 45
Melancthon Tp. 27,58,130,132
Melbourne 147
Mer Bleue peat bog 40,107,207
Merrickville 199
Metallic magnesium 210
Metcalfe 80
Metcalfe Tp. 63
Mica 213
Michigan basin, Lake 6
Middle Island 151
Middle Maitland River 91
Middlesex County 81,92,133,144
Sand plains; photo 148
Middle Thames 27,93
Midhurst 54,76,181
Midland 77,183,184
Mildmay 139,141
Milk shed; definition 174
Mill Creek 105
Milton 56,115,176
Milverton 61,96,135
Milverton Moraine 27,45,81,97,134
Figures 30
Mimico 192
Mindemoya 166
Mindemoya, Lake 77,163,165
Minden 78,212
Mines 213
Minesing 180
Minesing basin 180
Minesing flats 54,179
Photo 179
Minesing Swamp 25,76,86,87,179
Mink Lake 5,109
Minniehill 125
Minto Tp. 139
Mississauga 173,176,192
Mississippi River 108,196
Power plants 108
Mitchell 45,93,135
Mitchell Moraine 27,45,48,81,134
Figure 31
Mixed farming 132,177,183
See also: General farming.
Moffat 16,28,51,55
Mohawk Bay 51
Mohawk Point 28
Mohawk Valley outlet, New York 12,26,37,79
Moira Lake 185
Moira River 105,185
Flats 59
Molybdenum 213
Monkton 45
Mono Centre 115
Mono Hills 50,103,167
Mono Tp. 50,114
Montague 199
Montague Tp. 197
Moon River 85
Moose Creek 205
Moose Creek peat bog 107
Moraines 43-55
End 11,45
Interlobate 14
Location; figure 13
Recessional 14
See also: Kame Moraines.
Morainic belt 47
Morganstown 195
Morley 118
Mornington Tp. 97
Morrisburg 203
Morrison flood-control dam on Ausable River ... 92
Morpeth 64
Mosa Tp. 148
Mountain (Carson) Lake 73,77,118,126
Mount Albert Creek 181

Mount Brydges 146
Mount Carmel 64
Mount Elgin 47,145,146
Mount Elgin Ridges 144
  Location; figure 113
Mount Forest 56,58,59,132,139
Mount Hope 52,99
Mount Nemo 69
Mount St. Patrick 3,4
Mount Wolfe 53,167
Mud Creek 56,93
Mud flows 41
  South Nation Valley 107
Mud Lake 80,106,145
Mulmer Tp. 114,132
Murray Canal 188
Murray Hills 79,172,194
Murray Point 77
Muscote Bay 189
Muskoka 78,85,212-219*passim*
Muskoka, Lake 85
Muskoka Lakes 1
Muskoka River 60,85
Muskrat Fault 109
Muskrat Lake 4,109,206,210
Muskrat Lake ridges 210
  Location; figure 113
Muskrat River 109,206
Muskrat Scarp 4
Musquash River 85
Musselman's Lake 168

Nairn Creek 92
Nancy Island Park 87
Nanticoke Creek 156,157
Napanee 106,186,187
Napanee Lake 106
Napanee plain 186
  Location; figure 113
  Photo 186
  Population; table 187
Napanee River 106,186,187
  Flood control dams 106
Nashville 68,175
Natural gas 147
Navy Island 99
Nelson 173
Nelson Tp. 176
Nepean, City of 200
  Gravel pits 60
Nepean Formation sandstone 3
Nepheline 213
Neustadt 139,141
Newboro 199
Newbridge 91
Newburgh 106,187
Newbury 65,147
Newcastle 79,167,193,194
Newcastle loam 193
New Durham 47,95,146
Newington 201
New Lowell 54,74,181
Newmarket 69,176,177
New Sarum 94
Newtonville 79
New Toronto 192
Niagara, R.M. of 120,157
Niagara Cuesta 2,48,54,86,88,95,99,102, 114-116,122,127,162,163,166,217
  Highest point 116
Niagara Escarpment 2-10*passim*,15,28,44, 49-59*passim*,69,71,73,83-88*passim*, 99-103,114-126*passim*,217-219
  Building material 119-121
  Cliffs 115
  Location; figure 113
  Photos 6,116
  Public parks 121
Niagara Falls 99,121,158
  Photo 100
  Power plants 99
Niagara Falls, City of 51,158
Niagara Falls Moraine 28,52,66
Niagara Falls Park 99
Niagara Frontier 120
Niagara fruit belt 159,190
Niagara gorge 99
  Photo 100
Niagara Parkway 121
Niagara Peninsula 2,6,9,65-69*passim*, 89,101,114,156,158,191
  Vineyards 190
Niagara Portage Road 120
Niagara River 78,99,114
Nickel 213
Niobium 213
Nipissing 5,25,40,78
  Power plant 85
Nipissing, Lake 1,5,25,40,78,85,213
Nipissing, post-glacial Lake 61,69,71,76,87, 92,126,165,178
  Beaches 71,77
  Lake plain 77,78,179
    Photo 75
  Shore bluffs 70-78*passim*,125
  Shorecliff 51
    Photo 75
  Shoreline 24,69,117
    Warping; figure 62
Nipissing Great Lakes 25,40,110,123
  Figure 36
Nipissing Ridge 78
Nithburg 97
Nith River 44,46,47,95,97,98,133,136
  Valley 45
Nixon 65

Noganosh, Lake 5
Noisy River 6
Nonquon River 171
Norfolk County 128,154,155
Norfolk sand plain 46,63,65,95,153
  Location; figure 113
Norham 195
Normanby Tp. 127,139
North Bay 14,21,25,55,78,83,84,110,219
  Airport 24,39,78
North Bay outlet 25,39,40
Northcote Station 4
North Dumfries Tp. 65
North Easthope Tp. 44,45,136
Northern ice lobe 45,54
North Fredericksburgh Tp. 187
North Gower 200,201
North Gower clay 204
North Gower clay loam 200,204
  Soil profile; table 204
North Gower drumlin field 200
  Location; figure 113
North Keppel 70
North Plantangenet Tp. 209
North River 86
North Saugeen River 160
North Thames 27,93
Northumberland County ... 55,79,81,169-173*passim*
  Drumlins 57
Northumberland forest 168
Norval 67,103,175
Norwich 47,146
Norwich Moraine 27,47,145
Norwood 59,170,172,185
Norwood Esker 61,170
Nosbonsing, Lake 55
Nottawasaga basin 177,178
Nottawasaga Bay 126,177,180
Nottawasaga flats 21,24
Nottawasaga River 54,74,86,115, 121,130,177,179,180
  Elevations; figure 87
  Photo 179
Nottawasaga Tp. 54
North York Tp. 176
Novar 24,83
Nuclear-powered generating station at Douglas Point 162
Nuclear research station 210
Number 11 strip 214-215,219

Oak Lake 53,79,185
Oakland 156
Oak Ridges Moraine 14,17,24,28,51-54,64, 81,86,102-104,166,176,217,219
  Location; figure 113
  Overburden depth 9
  Photos 53,167
  Sand and gravel 82
  Sketch map; figure 52
Oakville 175,176,192
Oakville (Sixteen mile) Creek . 102,115,130,174,191
Oakville Seventh Line road 67
Oakwood 172
O'Connor Drive 77
Odenback 61
Odessa 187
Oil wells 147
Oliphant 163
Olmstead 206
Olmstead Lake 210
Omemee 170,172
Omemee Esker 59,170
Oneida clay loam 157,174
Onondaga Escarpment 6,10,56,96,156,157
Ontario, Lake:
  Drainage 98,102
  Water level 79,99
Ontario Agricultural College 58,139
Ontario basin 6
Ontario Correctional Centre 50
Ontario-Erie ice lobe 14,44,49,50
  Figures 31,32
Ontario ice lobe .. 13,14,16,25,28,37,43,55-59*passim*
"Ontario Island":
  Figure 30
Ontario lakehead 191
Ontario sand plain 219
Opeongo Lake 108
Opeongo River 108,109
Orangeville 16,44,49,82,129
Orangeville Moraine 13,26,43-44,96
  Location; figure 29
Orangeville Reservoir 49
Orchards 64,123,124,174,190,194
See also: Apples; Fruit; Peaches.
Ordovician Shales:
  Creemore 116
  Manitoulin Island 164
Oriel 145
Orillia 57,74,76,182,213
Orillia Tp. 24,76,86,181
Oro Moraine 54,183
Orono 56
Oro sandhills 183
Oro Tp. 10,54,182,184
Orr Tp. 183
Orton 98,136
Osceola 206
Osgoode 200,201
Osgoode loam 200
Osgoode Tp. 200,201
Oshawa 56,79,173,193,194
Oshawa Creek 102
Oshtemo sand 146
Osler Tp. 15

Osprey Tp. 27,127
Otonabee loam 171
Otonabee River 104,172
Ottawa 14,80,108,208,209
  Milkshed 201
  Parliament Hill 111
Ottawa basin 3,6
Ottawa-Bonnechère Graben 3,5,55
  Physiographic sketch; figure 4
Ottawa-Carleton, R.M. of 196,207,208
Ottawa Group sedimentary rocks 3
Ottawa River 5,55,61,80,107,108,110,210
  Power plants 110
Ottawa-St. Lawrence Lowlands 3
Ottawa Valley 2-4,38,60,80,210,217-219
  Channels; figures 36,41
  Deltas 21
  Drainage 106
  Scarps 3
See also: Georgian Bay-Ottawa Valley region.
Ottawa Valley clay plains 205
  Location; figure 113
Otter Creek 145,154,156
Otter Lake 77
Otterville 63,95
  Sand and gravel 47
Otto Holden power plant on Ottawa River 110
Ouse River 195
Ouvry 67
Owen Sound 17,71,74,118,126,141
Owen Sound, City of 88,121,126,143,163
  Harbour 118
Oxbows in Bayfield Valley 92
Oxford Centre 47
Oxford County 27,81,143,144,146
Oxford till plain 143
  Location; figure 113
Oxmead 88
Oxtongue River 85

Paisley 24,48,49,64,90,159,160
"Paisley Island" 159
Pakenham 4,108
Pakenham Fault 4
Paleozoic 7
  Bedrock 1,2,5,156
  Carbonate formations 69
  Limestones 3,5,109
  Shales 103
  Strata 164
Palgrave 28,69
Palmerston 81,132,139,141
Palmyra 64
Pancake hill 79
Papineau Esker 39
Papineau Lake 25,61
Papineau Tp. 110
Paquette Rapids 110
Paragneiss 1
Paris 50,51,97,98,129
Paris Moraine 14,28,46-51*passim*,56,63,96-98
Park Head 70,90
Park Head Creek 90
Parkhill conservation dam on Ausable River 92
Parkhill Creek 64,92
Parkhill loam 138,140
Parkhill silt loam 131
Parkhill soil series 131
Parks Creek 105
Parliament Hill 111
Parry Sound, District
  Municipality of 78,83,85,212-215,219
Payne River 107,201
Peaches 64,190,191
See also: Fruit; Orchards.
Peanuts 155,156,219
Peat bogs 40,41,107,157,179,181,197,207
Peel, Lake 24,37,67,69
  Figure 33
Peel, R.M. of 24,67,174
Peel clay 175
Peel clay loam 68
Peel County 76
Peel plain 67,69,103,104,172,174
  Location; figure 113
  Photo 175
  Varved clay 69
    Photo 67
Pefferlaw Brook 181
Pefferlaw Creek 171
Pelee Island 65,151
  Location; figure 113
  Photos 152,153
Pelton 149
Pembroke 80,83,109,205,208
Penetang Peninsula 76,77,86,178,182
  Figure 178
Penetangore River 89
Penetanguishene 184
Percy Reach 105,195
Percy Tp. 171
Perm 50
Perth 81,197-199
Perth clay loam:
  Soil profile; figure 134
Perth County 81,135,136,139,219
  Photo 20
Perth series 131,134
Perth silt loam 145
Petawawa 21,26,55,80,110,210
  Military camp 210
Petawawa River 80,109,110,210
Petawawa sand plain 111,210
  Location; figure 113
Petawawa Tp. 210

Peterborough 104,105,169-172,195
Hydraulic lift lock 104
Peterborough County 55,61,169-172
Peterborough drumlin field 169,195,218
Location; figure 113
Petworth 106
Pevensey 60
Pheasant shooting on Pelee Island 152
Photo 153
Phelpston 54
Phillipston 59
Physiographic regions:
Discussion 114
Locations; figure 113
Pickerel River 5
Pickering 173,193,194
Pickering Tp. 193
Picton 188,189
Pidgeon River 104,170,171
Flats 59
Pigs 172
See also: Hogs; Livestock production; Pork.
Pike Bay 70,71,163
Pike Lake 139
Pine River 7,51,74,86,89,115,179
Valley 27,49
Pinkerton 64,160
Pits and Quarries Control Act (1971) 81
Pittsburg Tp. 196
Plainfield 105
Plainfield sand 154,155
Plantagenet 107,207,208
Plattsville 46,98
Pleistocene 1
Deposits 109,121,191,193,218
Formations 81
Geology 76
Glaciers 164
Gravel beds 139
Overburden 103
Plevna scarp 5
Plover Mills 93
Plumb Lake 61
Plum Point 10
Podzols 131,165,209
Acid 200
Humic 200,209
Point aux Pins 153
Point Clark 24,70,160,161
Point Edward 69,162
Point Pelee 149,151,153
Photo 154
Point Pelee National Park 153
Pontypool 53,168
Pontypool series 168
Poplar 165
Poplar Hill 46
Pork 126
See also: Pigs; Hogs; Livestock production.
Port Albert 91
Port Alma 44,67
Port Bolster 182
Port Bruce 94
Port Burwell 50,95,156
Harbour 95
Port Credit 102,176,192
Harbour 103,192
Library 103
Port Colborne 67,120,158
Port Dalhousie 101
Port Dover 94,156
Port Elgin 24,48,70,162
Algonquin beaches 90,161
Port Franks 92,161,162
Port Hope 17,79,104,194,195
Port Huron, Michigan:
Arkona beaches 63
Port Huron Moraine system 14,48,51,127
Figure 32
Portlandia arctica 60
Port McNichol 184
Port Maitland 94,95,157
Port Robinson 120
Port Rowan 65,153,156
Port Stanley 94,153,156
Harbour 94
Summer resort 94
Port Talbot 10
Potatoes 131,132,149,179,183
Pot holes in bedrock 70
Pottaminie Island 151
Potawatomi River 88
Poultry 137,138,144,150
Powassan 78,83,85,215
Power Glen 101,114
Power plants:
Beaver River 124
Depot Creek 106
Grand River 98
Madawaska River 109
Mississippi River 108
Niagara Falls 99
Ottawa River 110
St. Lawrence River 201
Saugeen River 90
Twelve Mile Creek 101
York River 109
Power sites:
Lucknow River 91
Maitland River 91
Thornbury 84
Precambrian rock 1,7,46,57,83,85,106,
182,196,210,211,217
Faults 5
Figure 4
Manitoulin Island 164

Ottawa Valley:
Crystalline limestone 206
Escarpment 206
Prince Edward County 188
Precipitation, mean annual:
Figure 212
Preglacial valleys 114
Prescott 200,201
Prescott and Russell, United Counties of 204-210*passim*
Presqu'ile Bay 188
Presqu'ile Park 194
Preston 46
Pretty River 6,116
Valley 51,116
Priceville 129
Primrose 43
Prince Edward Bay 189
Prince Edward County 56,188,189
Population; table 190
Provincial parks 189
Prince Edward Peninsula 188
Location; figure 113
Sand dunes; photo 190
Princeton 156
Prospect Hill 45
Providence Bay 77,165,166
Puslinch 55,128
Puslinch Tp. 128
Putnam 93
Spillway 47
Pyette Hill 118

Quarries 120,121,135,143
Quay 26
Queen Elizabeth Way 103
Queensborough 186
Queenston 78,99,114,120,121,158
Queenston Formation 54,56,73,117, 121,122,173,175,191
Photo 115
Queensville flats 181

Racehorse farms 176
Radiant Lake 5,39,61,109
Radiocarbon dating
See also: Carbon-14 dating.
Ragged Rapids:
Power plant 85
Raglan 174
Rains Lake 77
Raisin River 106,210,205
Rama Tp. 54
Randal station 179
Rankin River 89
Rapides-des-Joachims power plant 110
Rattlesnake Point 115
Public park 121
Ravenna 122,124
Ravenswood 67
Rawdon Creek 105
Rawdon Tp. 185
Red Bay 163
Redbridge 39
Redhill Creek 101,114,190
Redickville 81,131,134
Red Wing 123,124
Reforestation 104,129,166,168,179, 183,185,186,198,210,218
Reids Mills 60
Renfrew 109,208,210,211
Renfrew clay loam 207
Renfrew County 5,55,58,80,207-213*passim*
Photo 206
Scarps 3
Reynolds Creek 47,93,145
Rice 151
Rice Lake 17,53,104,105,169,172,195
Photo 58
Richmond 198,206-208
Richmond Hill 52,176
Rideau Canal 106,108,111,198,206
Rideau Lakes 106,108,197
Rideau River 107,196,200
Rideau Tp. 197,200
Ridgemount 66,67,157
Ridgetown 24,28,44,65,147
Ridgeville 158
Ridgeway 66,157-159
Rigaud River 201
Ripley 160,161
Riverbank 97
River valleys:
Discussion 84
Riverview 58
Robert H. Saunders Power Plant 201
Robert Moses Power Dam 201
Robinson Lake 61
Roblin 187
Roblin Lake 188
Roches Point 182
Rock Chapel 69
Rockland 208
Rockwood 128,139
Rocky Saugeen River 90
Rodney 64
Rome outlet, New York 26,68,190
Romney 67
Rondeau 94,149
Rondeau Harbour 65,154
Rondeau marshes 147,149
Rondeau Park 153
Rondeau spit 153
Rossmount 172
Ross Tp. 208
Rouge Hill 79

Rouge River 79,102,173,174,193
Round Lake 4,80,109,211
Royal Botannical Gardens 78
Russell 3,107
Russell and Prescott sand plains 208
  Location; figure 113
  Map; figure 209
Russell County 204
Rutherglen 25
Rutherglen Moraine 15,39,60
Ruthven 44,65

St. Albert 107
St. Andrews Lake 39,109,110
St. Anne Island 151
Saint Anns 101,158
St. Catharines 78,101,114,120,121,158,191
St. Clair, Lake 67,92
  Basin 67
St. Clair clay plain 147
  Location; figure 113
St. Clair delta 151
  Location; figure 113
St. Clair outlet 24,25,37,39,40
See also: Sarnia outlet.
St. Clair River 92,147,151
St. Clements 44
St. Davids 99,121
St. Davids buried valley 101,114
St. Edmunds Tp. 163
St. Eugene 208
St. George 65
St. Isadore de Prescott 205
St. Joseph Island 77,166
  Location; figure 113
St. Joseph Tp. 77
St. Lawrence International Seaway 201
St. Lawrence-Ottawa Lowland 12,26,55,83,217
St. Lawrence River 196
  Power plants 201
St. Lawrence Valley 26,54,80
  Drainage 106
St. Marys 93,133,135,143
St. Patrick Fault 109
  Scarp 5,14,38,55
St. Thomas 47,94,145,147,156
St. Thomas Moraine 27,47,65,93
  Figure 31
St. Vincent 117
St. Vincent Tp. 118,126
St. Williams 155
Salina Formation 6,56
Salisbury 159
Salmon River 105,186
Salt Creek 105
Sand 3,52,66,76,78
  Bighead Valley 125
  Calcareous 70
  Ellice swamp 45
  Elma Tp. 61
  Ganaraska Valley 79
  Grand River delta 69
  Lacustrine:
    Muskoka area 85
  Orangeville moraine 43
  Stratified:
    Auburn 91
Sand and gravel .. 44,54,55,57,64,81-84,115,120,121
See also: Aggregate.
  Deposits 146,201
  Dingman Creek valley 47
  Eskers 58
  Gibraltar Moraine 49
  Otterville 47
  Pits 129
    Oak Ridges Moraine 168
  Spit 70
  Strands 74
  Thames spillway 46
  Wawanosh Moraine 47
Sand beaches 77
  Bruce Peninsula 119
Sand dunes 41,69,70,74,76,77,87
  Crystal Beach 157
  Photo 142
  Prince Edward County
    Photo 190
  Prince Edward Peninsula 189
  Sauble Beach 161
Sandhills 54,218
  Carrick Tp. 139
  Oak Ridges Moraine:
    Photo 167
Sand plain
  Ailsa Craig 127
  Bruce County:
    Photo 71
  Caradoc 63
  Hensall 127
  Norfolk 46,63
  Petawawa 111
  Warwick 127
Sandstone 6,54,56
  Gibraltar Moraine 50
  Whirlpool Formation 121
Sandusky Creek 157
Sangamon 10
Sarnia 24,67-69,78,150
Sarnia outlet 12,24,40
See also: St. Clair outlet.
Sarsfield 206
Sauble Beach 25,70,161,162
Sauble River 24,89,141,143
Saugeen 132
Saugeen catena 160

Saugeen clay plain 159,219
Location; figure 113
Saugeen clays 127
Saugeen embayment in Lake Warren 64,65
Saugeen kame moraines 27,47
Saugeen River 70,90,129,139,159
Saugeen silty clay loam 160
Saugeen Valley 24,49,159
Deltas 21
Sawmills 214
Scarborough, City of 56,173,174,193
Scarborough Bluffs 9,10,78,79,192,193
Photo 193
Scarborough moraine 53
Scarborough Tp. 176
Schomberg 24,69,170,176-177
Schomberg catena 176,177
Chemical and physical properties 176
Schomberg clay plains 176
Location; figure 113
Schomberg, Lake 67,69
Schomberg River 86
Schomberg silty clay loam 176
Scotch River 201
Scotia 83
Scotland 50,63,156
Scottsville 62
Scugog, Lake 17,53,69,104,171,176
Scugog River 104
Seaforth 45,59,91,135
Seaforth Moraine 27,45-46,91
Figure 31
Seeleys Bay 55
Severn River 86
Shale 1,5,6,51,52,54,56,57
Cape Rich 117,126
Chazy Group 80
Credit Valley 103
Creemore 116
Etobicoke Creek valley 103
Gibraltar Moraine 50
Manitoulin drumlins 57
Manitoulin Formation 126
Niagara Escarpment 114,115
Ordovician 116
Paleozoic 103
Queenston Formation 73,114,115,117
Photo 115
Red shale 114,115,117
Shallow Lake (village) 143
Shallow Lake 70,90
Shand Dam on Grand River 96,136
Sharbot Lake 108
Sharpes Creek 91
Sheep 165
See also: Livestock production.
Sheffield Lake 105
Sheffield Tp. 185
Sheguiandah 77,164
Sheguiandah, Lake 39
Shelburne 17,130-132
Sheldon Creek 115
Sheridan 173
Sherkston 67,69,157
Shields Station 64
Shorelines of glacial lakes:
Location; figure 22
Warping 13
Figure 62
Sidney Bay Bluff 118
Silt 52,53,62,63,76,78
Bighead Valley 125
Calcareous 70,71,74
Cramahe Tp. 81
Dingman Creek valley 47
Ellice swamp 45
Eolian:
Dundalk till plain 131
Photo 81
Stratified 91
Varved 65
Wind-blown 40
Siltstone 54
Calcareous 78
Waterloo Moraine 44
Silver 213
Silver Creek 103
Silver Water 165
Simcoe 51,64,65,156
Simcoe, Lake 86,182
Basin 177,181
Islands 76
Simcoe County 54,76,86,169,182
Simcoe Group 164
Simcoe ice lobe 13,27,28,37
Simcoe-Kawartha ice lobe 28
Figure 32
Simcoe lowlands 177
Location; figure 113
Map; figure 178
Simcoe silt loam 177,179
Simcoe silty clay loam 176
Simcoe uplands 178,182
Location; figure 113
Sinclairville 99
Singhampton 2,48,86,116,127
Singhampton Moraine 27,28,43-47*passim*,131
Sixteen Mile Creek 121,190
Skeleton Lake 1
Ski runs:
Algonquin highlands 214
Beaver Valley 121
Blue Mountain 117,121
Devil's Glen 116
Hockley Valley 121
Mansfield 121

Oak Ridges Moraine 168
Simcoe Uplands 183,184
Skinner Bluff 118
Skootamata River 105
Sleswick 50,167
Slough of Despond 119
Small boat harbours between Hamilton and Toronto 192
Smith Creek 97
Smiths Falls 108,196-199
Smiths Falls limestone plain 196
Location; figure 113
Population; table 199
Smithfield 54,194
Smithfield silt loam 179
Smithfield silty clay loam 176
Smith Lake 161
Smith Tp. 57
Smithville 89,101,158
Smoke Lake 85
Snake Creek 159
Snake River 51,109,206
Sobie Lake 39
Soil deterioration on Chatham flats 151
Soil erosion 218
Arran drumlin field 143
Grand River valley 98
Guelph drumlin field 139
Hillsburgh sandhills 137
Mount Elgin ridges 145
Niagara Escarpment 116,119
Oak Ridges Moraine 172
Photo 172
Peterborough drumlin field 173
Saugeen River valley 90
Schomberg clay plains 176
See also: Blowouts; Blowsand.
Sombra Tp. 150
Sophiasburg Tp. 189
Source Lake 108
Southampton 70,90,162
South Bay 189
South Baymouth 166
South Dorchester Tp. 63
South Dumfries Tp. 65
South Falls:
Power plant 85
South Fredericksburg 187
South Himsworth Tp. 39
South Maitland 91
South Mountain (village) 107,203
South Nation River 40,106,201-209*passim*
South Plantagenet Tp. 107,206
South River (village) 24,78,83,85,215
Airport 85
South River 85
South slope (of Oak Ridges Moraine) 172
Location; figure 113
Milk shed; definition 174
Population; table 174
Southwold Tp. 63
Soybeans 147-152*passim*
Sparta 47
Sparta ridge 63
Speed River 50,58,96,98,129
Spencer Creek 101,129
Photo 102
Spencerville 107,200
Spillways 15,47,63,91,218
Spongy Lake 136
Spring Bay 165
Spring Creek 97
Springtown 61
Spry 71
Squire Creek 105
Squirrel Island 151
Staffa 45
Stafford Tp. 206
Stanley, Lake 25,39,40
Figure 36
Stayner 24,74,180
Stayner clay plain 180
Stella 187
Stevensville 158
Stewarttown 103
Stewartville:
Power plant 109
Still River 5
Stirling 170,172,195
Stoco Lake 105,185
Stokes Bay 163
Stoney Creek 90,190
Stoney Creek, City of 101,190
Stoney Creek 78,145
"Stony Keppel" limestone plateau 118
Stormont, Dundas, and Glengarry, United Counties of 3,14,17,55,80,201-203
Stormont County 204
Population; table 203
Story Creek 105
Stratford 93,133,135
Stratford till plain 133
Location; figure 113
Strathcona 106
Strathroy 146
Stratton Lake 39,110
Streetsville 54,103,173,176
Striae 7,10,164
Photo 10
Stromness 67
Sturgeon Lake 104
Sturgeon River 76,86
Sucker Creek 73,126
Sullivan Tp. 51,89
Sunderland 172
Sundridge 15,215

Sunfish Lake 136
Sunnidale Tp. 54
Superior basin 6
Sutherland Creek 205
Sutorville 64
Sutton 181
Swamps 49,96,105,129,130,136
Swan Creek 98
Sydenham 187
Sydenham River 64,88,92,147
  Darcy McKeough Dam 93
Sydenham Tp. 126
Sydney Bay 119
Sylvan 160

Talbot Road 47
Talbotville Royal 47
Talc 213
Talon, Lake 110
Tamworth 59,106,185,186
Tara 51,90,141,143
Tara Strands 51,141
Tavistock 45,61,93,143
Taylor 64,196
Tay River 108
Tecumseth flats 179
Tecumseth Tp. 179
Teeswater 57,125,139,141
Teeswater catena 140
Teeswater drumlin field 27,91,139
  Location; figure 113
Teeswater loam 127,140
Teeswater River 90,91,127,159,160
Teeswater till 139,140
Teeterville 95,156
Tehkummah 57,165
Telfer Creek 74
  Valley 73
Terraces of outwash 116
  Photo 116
Tew's Falls 101
Thames clay loam 94
Thames embayment 68
Thamesford 23,93,144
Thames River 46,62,65,93,133,143,147,150
  Deltas 19,68,146,147
  Fanshawe Dam 93,94
  Spillway 45,46
  Valley 45,63
Thamesville 19,94
Thedford 64,70
Thedford Marsh 70,92,161
Thistletown 103,175
Thomasburg 59,170,185
Thompsons Mills 106
Thorah Tp. 181
Thornbury 6,51,73,74,87,122,124
Thorndale 62
Thorold 158
Thousand Islands 1,3,54,196
Thunder Bay 183
Tilbury 67
Tile plant 121
Till moraines 218
Tillsonburg 47,62,95,145,156
Tillsonburg Morraine 47,63
Tim River 83
Tioga 179
Tioga sand or sandy loam 179
Tiverton 161
Tobacco 146,155,194
  Photo 155
Tobermory 70,118,163
  Fishing port 163
  Yachting centre 163
Tonawanda Moraine, New York 52
Toronto 10,67,78,79,83,103,174,192
  Milkshed 174-177
  Surficial deposits; figure 192
Toronto, University of 103
Toronto Grey and Bruce Railway 132,160
Toronto Tp. 176
Tottenham 180
Trafalgar Moraine 14,37,51-56*passim*,172,173
Trafalgar Tp. 175,176
Tremolite 213
Trent Canal 86,105,195
Trent embayment 195
Trent lowland 195
Trenton 54,78,194,195
Trenton Moraine 54
Trent River 79,104,170,185
  Basin 195
  Valley 190
Trent-Severn Waterway 195
See also: Trent Canal.
Trent University 169
Tretheway Falls:
  Power plant 85
Trout Creek 27,93,143
Trout Creek (village) 85,215
Trout stream 90
Truck crops 125,149,157
Turkey Point 94
Turkeys 166
Turnberry Tp. 139
Tweed 29,170,185,186
Twelve Mile Creek 101,114,190
Twenty Mile Creek 52,101,157,159,190,191
Two Mountains, Lake of 110
Tyrone 174

Ubly outlet, Michigan 23,27
Union 47
Unionville 67,175
Uranium 213

Uxbridge 28,52,167,170
Uxbridge Brook 171
Uxbridge Creek 181
Uxbridge Tp. 9,53,168

Vanessa 50
Varty Lake 106
Varved clay 24,25,39,55
  Minden 78
  Muskoka 85
  Peel plain 37,69,175
  Photos 23,67,159
Vasey series 183
Ventnor 107
Verner 25
Verona 106,213
Verulam Formation 169,173,185
Verulam Tp. 185
Vesta 159
Victoria County 170-172,184
Victoria Harbour 184
Victoria Road 185
Vienna 95,156
Vinemount Moraine 51,99,101,159
Vineyards 120,190
See also: Fruit; Grapes; Niagara fruit belt.
Violet Hill
  Spillway 49
    Photo 50
  Terraces 50
Virginia 181
Vittoria 156
Vivian 53
Vivian forest 168
Vyner 69

Waba Creek 108,109
Wabush River outlet, Ohio 23
Wainfleet 158
Wainfleet peat bog 157
Wainfleet Tp. 67
Walker Pond 145
Walkerton 28,56,65,90,127,129,141,160
Wallace 61
Wallaceburg 93
Wallacetown 47,65
Wallace Tp. 139
Wallenstein 44
Walnut 63
Walpole Island 151
Walpole Island Indian Reserve (IR 46) 151
Walters Creek 126
Walters Falls 51,126,129
Walton 45
Wardsville 64
Warping in bedrock 1-2
Warren beaches 44
Warren, Lake 24,28,48,61,64-68, 89,127,147,149,156,159
  Beaches 23,24,28
  Delta 90
  Figure 33
  Sediments 63
  Warped shoreline:
    Figure 62
Warsaw 186
Warwick (village) 64,127
Warwick Tp. 64
Wasaga Beach 25,76,77,86,87,180,181
  Dunes 77
Washago 60,84,86
Waskigomog Lake 110
Waterdown 51,101,115
Waterdown Creek 101
Waterdown Moraines 28,48,51
Waterford 63,65,156
Waterloo 98,129,137
Waterloo, R.M. of 81,136,137
Waterloo County 137,219
Waterloo hills 10,26,44,136
  Location; figure 113
Waterloo Moraine 13,26,27,44
  Location; figure 29
Waterloo sandy loam:
  Soil profile; table 137
Waterloo soil series 127,134
Watford 45,63
Watrin soils 147
Waubaushene 184
Waverley 76
  Algonquin bluff:
  Photo 76
Wawanosh, Lake 70
Wawanosh Moraine 27,45,47-48,127
Wayne, Lake 24
Webster's Falls 101
  Photo 102
Welland 66,99,157,158
Welland Canal 52,98,99,101,120,158
Welland clay 157
Welland County 6
Welland Junction 158
Wellandport 158
Welland River 52,99,120,157
Wellington 189
Wellington County 130,131,137,139
Wellington Grey and Bruce Railway 160
Wendigo Lake 61
West Bay 77,164
Western Ontario, University of 62
West Gwillimbury Tp. 177
West Huntingdon 79,170
West Lake 188,189
West Lorne 64
West Luther Tp. 130

Westmeath 208
Westmeath Tp. 206,208
Westminster Moraine 27,47
West Montrose 138
West Montrose Esker 58
Weston 103
West Osgoode 60
Westover 23
West Wawanosh Tp. 47,128
Westwood 59
Wexford 56
Wheatley 44,67
Whirlpool, The 99
Whirlpool Formation 121
Whiskyjack Lake 61
Whitby 174,176,194
Whitchurch-Stouffville, Town of 168
White 84
White Cloud Island 118
White Lake 105,108
Whitfield 50
Whitney 61
Whittaker Lake 145
Whittlesey, Lake 27,28,47,48,50,56, 61,62-63,146,147,149
  Beach 23,44
  Delta 127
  Figure 33
  Warped shoreline:
    Figure 62
Wiarton 24,51,70,121,161,163
  Harbour 118
Widder Formation 92
Wilberforce 213
Wilcox Lake 168
Wilfrid 76
Wilkes Lake 110
Wilkesport 92
Williamsford 49,88
Williams Lake 88
Williamsport 85
Williamstown 106
Williscroft Moraine 51
Willow Brook 95
Willow Creek 64,86
Wilmot Creek 102
Wilson Falls:
  Power plant 85
Winchester 204
Winchester clay plain 107,203
  Location; figure 113
Winchester peat bog 107
Winchester Tp. 204,205,219
Windham Centre 63
Windsor 2,67,68,149
Wingfield Basin 119
Wingham 47,81,91,139,140
Winifred Lake 85
Wisconsinan:
  Glacial lakes 61
  Glaciation 9,10
  Glacier 25,26,54,217,218
    Recession; figure 29
Woburn loam 174
Wodehouse 88
Wodehouse Creek 88
Wolfe Island 186,187,196
Wolfe Mountain 167
Wolford Tp. 197
Wolsey, Lake 77,165
Wolverton 98
Woodbridge 10,103,176
Woodford:
  Drumlins 57
Woodham 45
Woodland Beach 180,181
Woodstock 16,27,46,93,94,95,143,144,145,219
Woodstock drumlins 27,44,55,56,81
Woolwich Tp. 219
Wroxeter 91,141
Wyecombe 65
Wye River 86,180
Wyevale 54,180
Wylie 83
Wymbolwood Beach 180
Wyoming 48,64
Wyoming Moraine 27,28,47,48,64,91,92
  Hensall:
    Photo 48

Yachting centres:
  Little Current 166
  Tobermory 163
Yarker 106,187
Yarmouth Centre 63
Yonge Street (Toronto) 79
York, R.M. of 24,67,81,173,174
York River 108,109
  Power plant 109

Zephyr Creek 181
Zinc 213
Zorra Tp. 46
Zurich 48,161

NOTES:

NOTES:

6967
(5k P.R., 84 11 01)
ISBN 0-7743-9422-6

ONTARIO GEOLOGICAL SURVEY
Map P.2715
PHYSIOGRAPHY OF SOUTHERN ONTARIO

To accompany "THE PHYSIOGRAPHY OF SOUTHERN ONTARIO, THIRD EDITION"
By L.J. CHAPMAN and D.F. PUTNAM
ONTARIO GEOLOGICAL SURVEY, SPECIAL VOLUME 2, Published 1984.

Ministry of Natural Resources
Ontario
Hon. Alan W. Pope
Minister
John R. Sloan
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

MAP P.2715

PHYSIOGRAPHY OF SOUTHERN ONTARIO

To accompany: "THE PHYSIOGRAPHY OF SOUTHERN ONTARIO, THIRD EDITION"
by L.J. Chapman and D.F. Putnam

Scale 1:600 000

Miles 10 0 10 20 30 40 Miles
Kilometres 10 0 10 20 30 40 50 60 Kilometres

LEGEND

- Till Moraine
- Kame Moraine
- Till Plain (drumlinized)
- Drumlins
- Till Plain (undrumlinized)
- Bevelled Till Plain
- Shallow Till and Rock Ridges
- Bare Rock Ridges and Shallow Till
- Clay Plain
- Sand Plain
- Esker
- Spillway
- Beaches and Shorecliffs
- Escarpment
- Limestone Plain
- Shale Plain
- Peat and Muck
- International Boundary
- Interprovincial Boundary
- County, District, Regional or District Municipal Boundary
- Township Boundary, surveyed
- Township Boundary, unsurveyed
- Multilane Highway
- King's Highway
- Secondary Highway

SOURCES OF INFORMATION

Map Series: Physiographical Series, Ontario Department of Mines and Northern Affairs, Ontario Research Foundation, Maps 2224-2227. Physiographic Series, Ministry of Natural Resources, Ontario Research Foundation, Map 2228.

Base map: modified from Ontario Ministry of Natural Resources, Map 21-6, Southern Ontario, 1980. Scale 1:600 000.

CREDITS

Physiography by L.J. Chapman and D.F. Putnam. Editing by L.J. Chapman.

Cartography and design by R. Balgalvis, R. Rennick, and L. Hunt.

Issued 1984.

Parts of this publication may be quoted if credit is given. It is recommended that reference to this map be made in the following form:

Chapman, L.J., and Putnam, D.F.
1984: Physiography of Southern Ontario; Ontario Geological Survey, Map P.2715 (coloured). Scale 1:600 000.

BICENTENARY OF THE PROVINCE OF ONTARIO

The Ontario Geological Survey, as part of the celebrations for the Bicentenary of the Province of Ontario in 1984, has produced this map to give recognition to the importance of physiographic features to the resource development of Southern Ontario. The map should be used in conjunction with Special Volume 2, also published by the Ontario Geological Survey.

©Ontario Ministry of Natural Resources