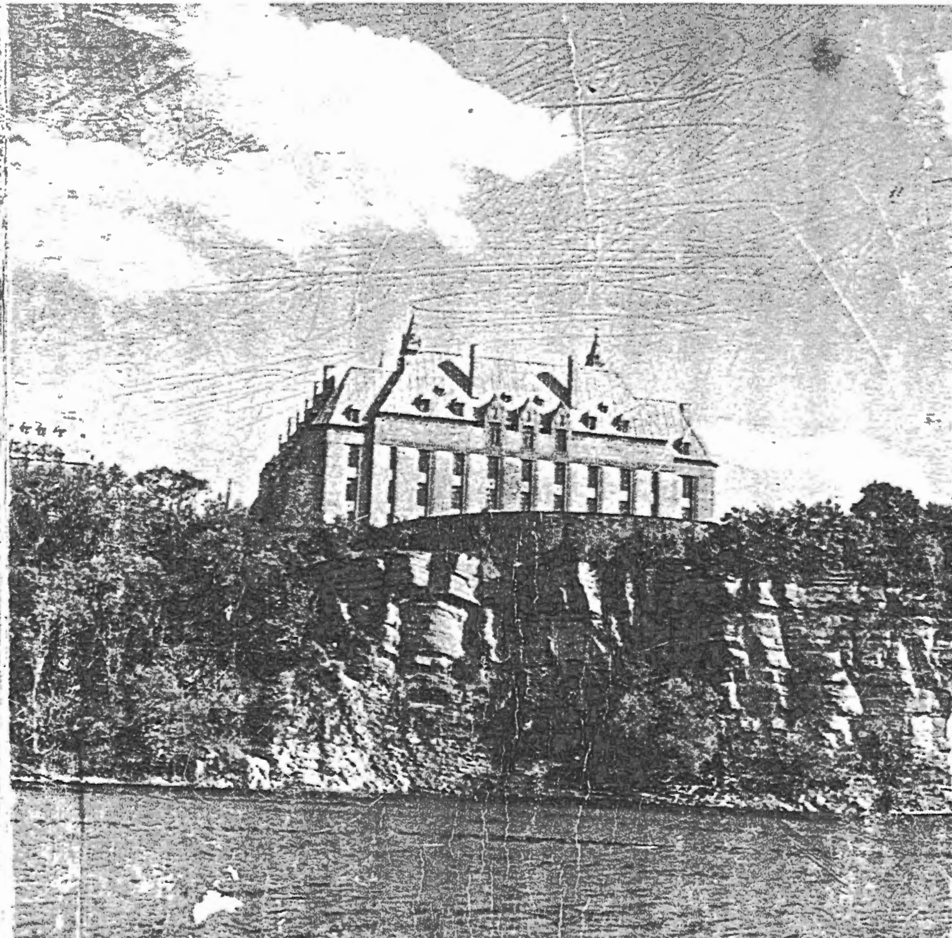
Geological Survey of Canada
Miscellaneous Report 15

DEPARTMENT OF ENERGY, MINES AND RESOURCES
Ottawa, Canada

Geology and Scenery of the NATIONAL CAPITAL AREA • D. M. Baird

Guide to the Geology and Scenery of the NATIONAL CAPITAL AREA

D. M. Baird



Cover—

The Supreme Court Building and cliffs of Ottawa limestone bathed in late afternoon sun, seen from the Ottawa River.

All photographs • D. M. Baird

Maps and diagrams • Cartography Unit, Geological Survey of Canada

Editing, layout and design • V. McBride, Public Relations and Information Services, Department of Energy, Mines and Resources

Technical editing • R. G. Blackadar, Geological Survey of Canada

Printing • Northern Miner Press Limited, Toronto for the Queen's Printer, Ottawa

Guide to the Geology and Scenery of the NATIONAL CAPITAL AREA

David M. Baird

MISCELLANEOUS REPORT 15
Issued by
THE GEOLOGICAL SURVEY OF CANADA
Department of Energy, Mines and Resources, Ottawa

Available by mail from the Queen's Printer, Ottawa, the Geological Survey of Canada, 601 Booth St., Ottawa and at the following Canadian Government bookshops:

HALIFAX
1735 Barrington Street

MONTREAL
Æterna-Vie Building, 1182 St. Catherine Street West

OTTAWA
Daly Building, Corner Mackenzie and Rideau

TORONTO
221 Yonge Street

WINNIPEG
Mall Center Building, 499 Portage Avenue

VANCOUVER
657 Granville Street

or through your bookseller

Price $2.50 Catalogue No. M41-8/15

Price subject to change without notice

ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1968

Page

This book is offered as a tribute to the pioneers of geology who, often in obscurity but always with courage, laid the foundations of our knowledge of the geology of Canada, and above all to Dr. ALICE E. WILSON who spent so much of her life working on the Ordovician rocks and fossils of the Ottawa valley and in explaining them to the ordinary man.

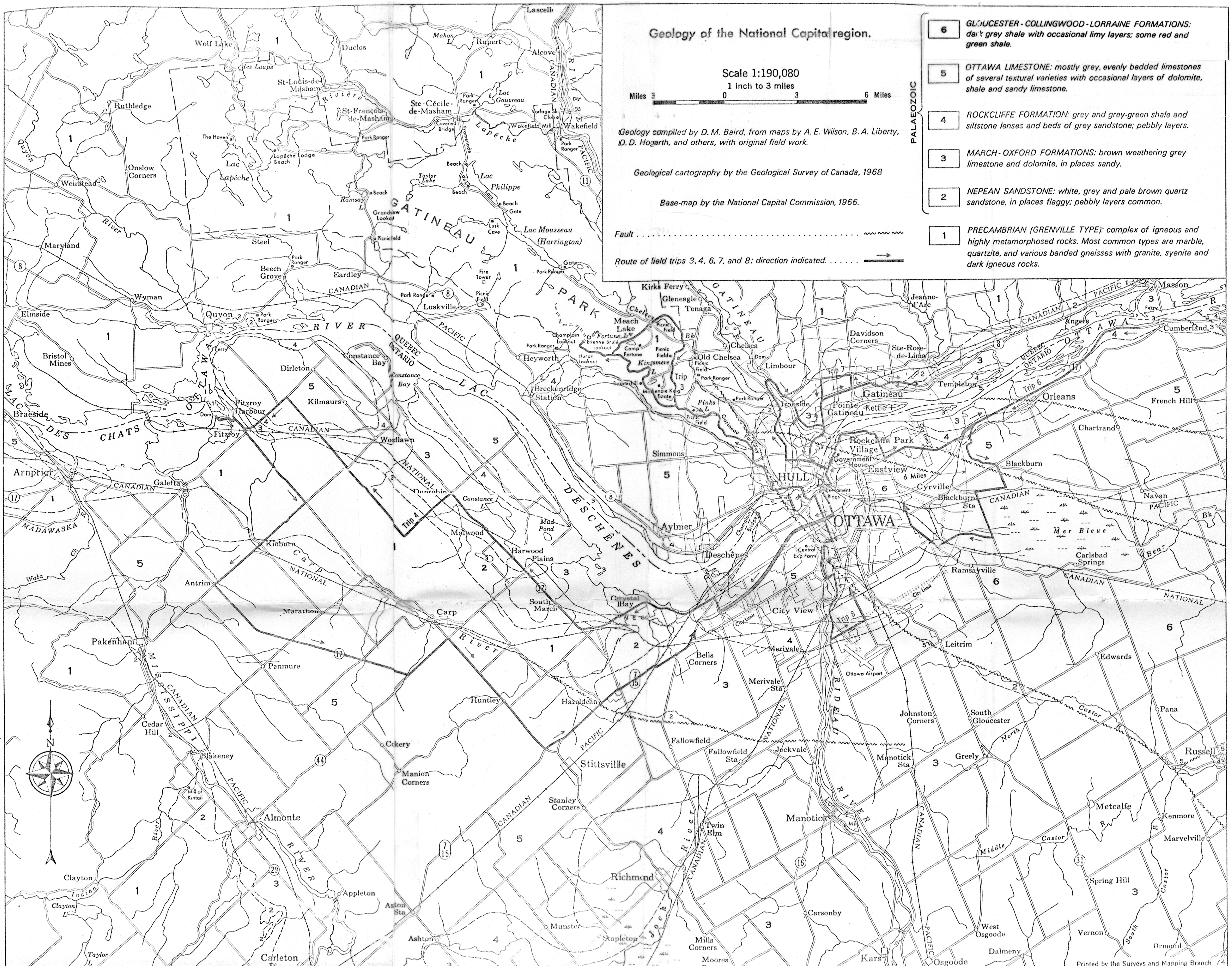
THE AUTHOR

Dr. David Baird was born in Fredericton, New Brunswick, in 1920. He spent the first five years of his life in China where his parents were missionaries, returning to Canada to receive his early education in Canning, Nova Scotia, and Saint John, New Brunswick.

In 1941 Dr. Baird graduated from the University of New Brunswick, achieving his B.Sc. degree in geology with first class honours. He later won his M.Sc. degree at the University of Rochester and in 1947, his Ph.D. in geology at McGill University.

Prior to his appointment as Provincial Geologist of Newfoundland, where he served from 1952-1958, Dr. Baird taught at Mount Allison University and the University of New Brunswick and later, during part of his term as Provincial Geologist, at Memorial University of Newfoundland. From 1958 to 1966 he held the post of Chairman of the Department of Geology at the University of Ottawa. In September 1966 he became Director of the National Museum of Science and Technology.

Dr. Baird has done field work in many parts of Canada and has spent several summers in the Geological Survey of Canada. He has appeared on CBC television and radio on such programs as *Critically Speaking*, *University of the Air* and *Live and Learn*, a science series. He has written more than fifty publications, including a series of guidebooks about the geology and scenery of Canada's National Parks.


Geology of the National Capital region.
Scale 1:190,080
1 inch to 3 miles
Miles 3 0 3 6 Miles
Geology compiled by D. M. Baird, from maps by A. E. Wilson, B. A. Liberty, D. D. Hogarth, and others, with original field work.
Geological cartography by the Geological Survey of Canada, 1968
Base-map by the National Capital Commission, 1966.
Fault
Route of field trips 3, 4, 6, 7, and 8; direction indicated.
PALAEOZOIC
6 GLOUCESTER - COLLINGWOOD - LORRAINE FORMATIONS: dark grey shale with occasional limy layers; some red and green shale.
5 OTTAWA LIMESTONE: mostly grey, evenly bedded limestones of several textural varieties with occasional layers of dolomite, shale and sandy limestone.
4 ROCKCLIFFE FORMATION: grey and grey-green shale and siltstone lenses and beds of grey sandstone; pebbly layers.
3 MARCH - OXFORD FORMATIONS: brown weathering grey limestone and dolomite, in places sandy.
2 NEPEAN SANDSTONE: white, grey and pale brown quartz sandstone, in places flaggy; pebbly layers common.
1 PRECAMBRIAN (GRENVILLE TYPE): complex of igneous and highly metamorphosed rocks. Most common types are marble, quartzite, and various banded gneisses with granite, syenite and dark igneous rocks.
OTTAWA
HULL
GATINEAU PARK
OTTAWA RIVER
LAC DES CHATS
LAC DESCHÊNES
RIDEAU RIVER
Printed by the Surveys and Mapping Branch

INTRODUCTION

In the years prior to 1857, when this country was divided into *Upper Canada* and *Lower Canada,* the capital changed back and forth between towns in these two regions. The situation eventually became intolerable and a petition was sent to Queen Victoria asking her to pick a suitable and permanent site. The Queen and her advisers made known on December 31, 1857, that they had chosen Ottawa, a village of less than 10,000 people near the junction of the Gatineau River, the Rideau River and the mighty Ottawa just below the Chaudière Falls. At that time this was a wild, untramelled, but beautiful site; its wooded bluffs overlooked the rivers, and the distant Gatineau Hills to the north, and forests stretched off for hundreds of miles in all directions. It was an ideal picturesque spot for a National Capital, and its beauty has endured, despite man's activities in some cases and even because of them in others. The grea forests have mostly been cut away, the waterfalls are now carefully controlled, the rivers are no longer crystal clear, yet the capital area offers many exquisite views and, in many places where man has taken away the natural beauty he has substituted lovely gardens, canals and green areas.

Behind any natural scene on the face of the earth there lies a long history of development, often going back hundreds of millions of years. At Ottawa, rocks that took their present form a thousand million years ago were thrust up to form the hills to the north. The horizontally layered limestone in the cliffs along the Ottawa River and at the falls of the Chaudière have been part of the history of the region for four hundred million years or more. The mighty Ottawa River, pushed out of its course here and there by the glaciers in the last million years, had its ancestry in rivers that have flowed for tens of millions of years along the edge of the Canadian Shield — a vast area of ancient rocks extending roughly from the Labrador coast westward to the line of Lake Winnipeg and Great Slave Lake, and northward from the Great Lakes and the St. Lawrence to the Arctic Ocean.

The feeling for the natural scene is enhanced for the viewer when he realizes that during his lifetime he sees only a very

brief glimpse of the evolution of the earth. Its history has already spanned thousands of millions of years and, when we are gone, it will probably continue for millions of years more. Thus, when you visit Canada's capital and drive through the flat lands to the south, or stand on the bluffs at the Parliament Buildings and look to the west and north toward the sunset or the distant hills, or drive in the Gatineau Park on the edge of the Canadian Shield, enjoy the beauty in the realization that you are part of the grand story of the evolution of the earth and its living things.

The purpose of this book is to provide a general guide to the rocks and scenery of the National Capital area, supplemented by a background of the basic principles of geology. The first section deals with the main ideas of geology and how they apply in the National Capital area. For those not trained in the geological sciences this information is essential to a clearer appreciation of what we see around us. Succeeding sections describe the geological events that have led to the present pattern of rocks and scenery. The last part of the book outlines a series of field trips and excursions to places where we can get a good close look at the rocks and scenery of the National Capital area, with particular purposes in mind — to see the surface features, to see the building stones used in the area, to see the ancient Precambrian rocks, to see the later limestones, and so on.

THE MAIN IDEAS OF GEOLOGY AND HOW THEY APPLY IN THE NATIONAL CAPITAL AREA

To understand the story behind the shaping of the rocks and scenery of today we must first examine the fundamental

Students examine jointed, horizontally bedded or layered limestones of the Ottawa Formation at Chaudière Falls.

ideas of geology to find out something about the manner of thinking of the distant past.

Time and Its Vastness

As late as the eighteen hundreds, most people, even those working in the sciences, did not enquire very carefully into the history of things beyond a few thousand years — the time encompassed by recorded human affairs. When inquisitive minds began to look into what happened before that, and before that, and even before that, it was gradually realized that the rocks and surface features of the earth were very old in terms of the span of human life. Workers began to understand the enormity of geological time when they got the idea of measuring the amount of silt brought down by the Nile River each year and dividing this into the total volume of its delta.

It was ultimately observed that rivers that drain the land carry with them salts that end up in the sea after the water evaporates and goes back onto the land again as rain and snow. Then someone figured out how much salt is carried to the sea each year. It was natural, then, to wonder how long ago the oceans started off as fresh water, so someone divided the annual addition of salt into the total amount and came up with an answer of many millions of years. When it was realized that some rocks were once sands, gravels and muds in the bottom of the sea — rocks which we now call *sedimentary rocks* — it was logical to start thinking in terms of the rate of accumulation of these rocks in present river deltas and seas. When we see here and there on the surface of the earth vast thicknesses of sedimentary rocks like those exposed in the sides of the Grand Canyon of the Colorado River, and we can calculate an annual rate of accumulation, then once again by dividing we should get some idea of the time involved. And once again this comes to millions of years.

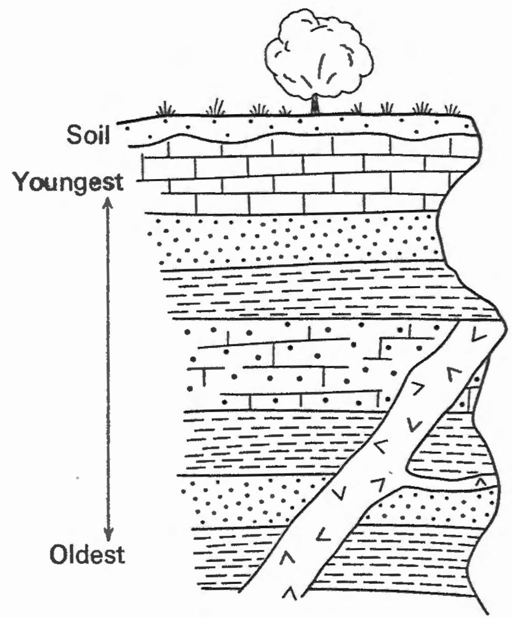
In recent years more sophisticated methods have been developed for telling the ages of earth features. Most of these centre around the fact that radioactive disintegration proceeds in an orderly and very regular fashion. Some elements that occur commonly enough in rocks to be useful produce identifiable by-products during their radioactive disintegration. If the rate of disintegration is known and if the amount of by-product can be measured, then a method of dating the containing rocks is at hand. In this manner the disintegration of radioactive uranium produces a particular kind of lead, the disintegration of radioactive potassium produces a particular kind of argon and the disintegration of a certain kind of carbon produces another recognizable type of carbon. These have all led to what have been called 'geological clocks'.

With all these methods, and others known to astronomers and physicists, it is evident that the earth started its history in a period of time about 5,000 million years ago. The rocks in the Gatineau Hills just north of Ottawa give measurements that show they were formed about 1,000 million years ago. The limestones that underlie the flat land to the south appear to be about 450 million years old. This means that if we are not used to thinking of enormous periods of time but only in terms of five or ten thousand years of recorded human history we must adjust our thinking greatly to comprehend

the long, slow evolution of landscapes and the formation of rocks. With this understanding we can peer down the vast corridors of geological time through the hundreds of millions of years to the very beginning of the earth itself.

Time Sequences

The second major idea is that of relative time and time sequences, the technique of working out sequences of events. One of the most fundamental concepts is the 'law of superposition' which says quite simply that in any sequence of



layered sedimentary rocks the youngest rocks lie on top and the oldest ones below. You can easily see why this usually applies by thinking of how these rocks originate — by the accumulation of layers, one after another, as sand, silt, mud and gravel in the bottom of the sea. When, for example, a road is built, a layer of coarse gravel may come first, followed by fine sand, then crushed stone, then coarse asphalt and finally fine asphalt to finish off on top. If you were to cut a cross-section down through the road you could see this layering at once and it would be obvious that the 'youngest layer' is the top coat of fine asphalt and that the first layer put down, the 'oldest', is the coarse gravel on the very bottom. Thus, when we look at a cliff of layered rocks we may assume, following the law of superposition, that the rocks on top were laid down after those on the bottom, and are therefore younger.

When *igneous rocks* — rocks which were at one time molten because the temperature and pressure were very high — invade surrounding rocks, some of the liquid rock may cut across the structures of the invaded rocks, following breaks in them. Millions of years later you could tell the sequence of events by finding out which rock seems to cut across the structures. The resultant rock would look very different from that formed where sand and gravel were laid down on top of an eroded surface of igneous rock.

Having many methods of working out time sequences, geologists were able to figure out the histories of regions long before any absolute radioactive clocks had been invented and they still use methods of working out sequences of events more than any other in unravelling the story of the past.

Processes are the Same through Time

In the early days of geological enquiry, great river valleys were often ascribed to sudden cataclysms in which the surface of the earth was ruptured and pulled apart. Similarly, mountains were attributed to enormous convulsions in which large parts of the earth's crust were very suddenly thrust upward for thousands of feet. People who believed in this kind of origin of earth features were known as *catastrophists*.

In the late seventeen hundreds a Scotsman, James Hutton, and his friend and successor, John Playfair, were largely responsible for the realization that features of the earth's surface and those in the rocks themselves could be accounted for by looking to processes which are going on all the time. They showed that river valleys were not opened up suddenly but instead were carved by the slow erosive action of the rivers themselves in processes we can actually observe right now. Mountains were not suddenly thrust up but instead rose very slowly over millions of years. These workers and those who have followed them are known as *uniformitarians* because they believed that the processes in ancient times were the same as those of the present, even though some of the conditions under which the processes operated were slightly different. Thus when we travel around the capital of Canada now we can actually observe erosion of rocks by streams, and frost action splitting boulders apart and comminuting the soil in ways it always has. To discover the reasons for certain deposits of coarse boulders and clay we have only to go to modern glaciers and watch what is going on there.

A natural corollary of the idea of uniformitarianism — that to understand how ancient things were made we have only to look to processes operative now — is the idea that landscapes gradually change through an orderly sequence of evolution. Investigations all over the world show that rivers and seacoasts, mountains, glaciers and desert hills, each seem to have orderly patterns of development. This has been discovered in an interesting variation of the scientific method which has fairly widespread application in the geological sciences.

When geologists wish to study what happens in the erosion of river bends, for example, they obviously cannot stay around for a million years to watch. But by using sequence arrangements they can see how processes operate through long periods of time. If we have a hundred river bends to look at in different stages of development it makes sense to think that if we arrange them all in a series, with the most advanced one at one end and the least advanced at the other, then all stages in the development of any single river bend should be represented. To see what will happen to any one river bend then we have only to look in the series to find out what seems to be next. This method was the one that Charles Darwin, the great evolutionist, used long ago to discover the origin of coral atolls, those nearly circular islands of coral in the warm oceans of the world. He found that by arranging all the varieties of coral islands in a series according to their shapes he also had a series showing their origin. Thus he explained the atoll, the last in the series, on the basis of what he saw in other places.

To further explain this way of thinking, one might imagine taking a tour, say, through a brush factory, on a day when all the workers are on holiday. By getting samples of all the different stages of the building of a brush and laying them out in a line — the finished brush at one end and the raw materials at the other, with partly finished brushes in between — it would not be difficult to figure out how brushes are actually made. The real test of your conclusions would be to visit the factory the next day when all the machines are humming and the workers are busily making brushes. If you were to see each step in the manufacture of the brush at each machine you could conclude once again that the brushes were made by starting with the raw material you saw the day before and ending up with the finished product.

This is different from a test in which you would go to watch a particular brush being made through all the stages. This would probably take much longer but your conclusion would be the same. In this way you could test successfully your sequential arrangement of the steps which you first thought must occur. Similarly the geologist looks at the river bend to see what small changes there are. If all of the changes observable in a short period are in the direction of the sequential arrangement made from all the river bends that he could find, then he is probably correct in assuming that this is the manner of evolution of river bends.

When we look over the hills of the National Capital area we can thus recognize that everything before us — the Ottawa and Gatineau Rivers, the eroding hills, the boulders decaying in the fields — is in some stage of evolution.

Evenly bedded or layered limestones of the Ottawa Formation above the Chaudière Bridge, below the falls.

When living things die their bodies generally disappear through decomposition, returning to the great economy of nature the substances which they had used temporarily. Sometimes, however, when the dead plant or animal falls into a particularly favourable environment it may be preserved almost indefinitely in part or in whole. Hard parts, like bones, teeth and shells which are largely mineral matter, may fall to the ocean floor and be buried in muds there and thus be preserved from further decomposition or breakage. Sometimes soft fleshy parts of animals may drop into a particular kind of mud where their decay is stopped when it is only partially completed, so that a carbonaceous residue is preserved. Sometimes footprints or crawling tracks or imprints of a plant or animal are made on the surfaces of layers of mud or silt and are preserved when these are buried. All these indications of ancient life are called fossils. In earlier times there were all sorts of fantastic ideas as to how fossils got into the rocks. Although a few astute philosophers in ancient times suspected that fossils were the remains of very ancient life it was not until two or three hundred years ago that they began to be studied for what they are.

About 1800, William Smith, a canal surveyor in England, discovered that in the rock-cuts of the canal system, then being built, certain rock layers had in them certain fossils that were different from those in other rock layers. This notion, put together with the law of superposition, soon led people to realize that life must have been different in different parts of the geological past. It remained for Charles Darwin, the possessor of one of the greatest scientific minds of all

Large algal head weathering out of limestone above the Orleans quarry, east of Ottawa.

time, to synthesize a great mass of evidence and to provide an understandable mechanism in his theory of organic evolution. We now realize without any doubt that life has changed since its early beginnings on the face of the earth and that it is very different now from what it was a hundred million years ago or even five million years ago. Realizing all this we should be able to conclude that the older the rocks are the more different the living forms should be from those of today. By looking at the rocks and the fossils preserved in them we should be able to work out what the changes have been. It should then be possible to place a rock unit in its proper time position by examining the fossils in it and comparing them to the known evolutionary record.

An understanding of this fundamental idea allows us to appreciate the rocks now found at the surface in the National Capital area. To the north of Ottawa, very ancient rocks have no fossils in them and are thought to pre-date life generally on earth. Much younger, flat-lying limestones in the vicinity of Ottawa itself do contain fossils that represent a period of time when life was still fairly primitive — a time when there were no forests on the land, few fishes in the seas and no land animals as we now know them. This was about 400 to 450 million years ago.

Sands and gravels near the surface have yielded bones of fish, whales, clam shells and the like, which show that they were laid down in the last 15,000 years, and the plants and animals we see today on the surface of the earth will, in their turn, leave fossils to mark what we call the present.

RECENT GEOLOGICAL EVENTS

Every now and then an earthquake will shake the Ottawa Valley or a landslide will occur in the region, emphatic reminders that geological happenings are going on around us now. But on a smaller scale we can see many other processes at work. After a rain the rivulets and brooks scour sand, mud and silt from the land and carry them to the Ottawa River for eventual delivery to the sea far away. In spring and fall the constant freezing and thawing splits boulders apart, wedges rocks up from the solid ledges below, and lifts boulders up through the soil in the fields. The surfaces of fresh rock gradually decay through a combination of physical breakdown and actual chemical decomposition.

All of these processes are changing things very slowly so that this region is not exactly the same as it was when Champlain went by about 350 years ago. In fact it is not exactly the same today as it was yesterday.

Landslides and Quick Clays

From time to time we will hear of a great landslide in some part of the world, and to us in the National Capital area such places and events may seem generally remote. Yet here and there in the valleys of the Ottawa, the Gatineau and the Lièvre Rivers and their smaller tributaries, we see evidence that landslides have taken place in the very recent geological past, and apparently rather frequently.

Now when we look at the causes of landslides on the world-wide scale we soon see that the fundamental reason for them every time is a condition of instability where a mass of rock, mud, soil, or sand is no longer able to support itself and moves or falls swiftly downhill. Waves may undercut a cliff to produce a landslide or a river may cut into its bank, making it too steep so that the bank collapses. Glaciers, now or in the recent past, may cut into the walls of their valleys and steepen them beyond their capacity to support themselves. Sometimes the equilibrium on a hillside is disturbed when excessive rains over a period of time saturate the upper layers of loose material or even solid rock. The weight on the slope is so much increased that the whole thing becomes unstable and suddenly lets go to slide downhill. In some instances it has been shown that rain provided only lubrication on a surface which otherwise would have had enough resistance to hold the mass of rock or soil.

It has often been realized that the actual trigger for a landslide is an earthquake. You can easily see how a quivering in the ground would set a mass of rock and rubble in motion where a condition of instability existed, say in the mountains

A beautiful example of a landslide in the clays of the Ottawa region at the east end of the city. The Montreal Road crosses the photograph near the lower margin and its intersection with the Queensway is at the lower right corner. The conspicuous terrace, out of which the clay has flowed out over the flats below, crosses the photograph diagonally. Note the pools and wet places in the toe of the landslide, showing that its surface is irregular by contrast with the very flat fields elsewhere.

or along the steepened banks of rivers. The Montana earthquake of 1959 with the great landslide in the side of the Madison River valley is a case in point.

In the Ottawa-St. Lawrence Lowland area an unusual cause of instability leads to landslides. In the very recent geological past the area of this lowland was invaded by a shallow sea, into which masses of fine sediments were being poured.

A landslide in Leda clay has dammed the stream on the lower right foreground, approximately two miles east of Breckenridge Station (west of Aylmer).

These settled to the bottom to form a clay. Since then the land has been uplifted and this clay now occurs in banks and terraces along the sides of the river valleys. This is an unusual clay — a *quick clay*.

Most people are familiar with what happens on a water-saturated beach when they move their feet up and down. They will gradually sink as the water oozes from the sand and turns it into a much more liquid mass. Tales and legends are full of adventures involving quicksands and people being suddenly trapped. These are nothing compared to quick clays which, when jarred or stirred, have the capacity to turn into a liquid much more fluid than any quicksand. Quick clay can be changed from an apparent solid, able to sustain quite a load, into a flowing liquid by an earthquake, an explosion, the jar of a pile driver, or the vibrations set up by heavy traffic on a nearby road. Once the clay becomes liquid it will flow rapidly along almost any slope or, if it is in a terrace, it will flow over the flats below it for some distance. Trees, buildings or almost anything on it might be rafted along for considerable distances.

The reason for this peculiar behaviour seems to lie in the composition and structure of the clay itself. To become a quick clay it must have a layered, extremely fine structure; a very high proportion of particles of less than two microns in diameter (that is .002 of a millimetre); and a very high content of water. It seems that the tiny, flat particles of mineral matter making up the bulk of the clay are stacked like a house of cards at irregular angles but holding each other up with spaces between. Some think that a certain amount of salt is necessary to keep this structure stable, acting as a sort of stabilizing glue. When the salt is removed by leaching and when the water content is increased the house of cards seems to collapse so that the millions of tiny flat particles now lie more or less parallel and are lubricated with the water so the whole mass flows like a liquid.

Clays of this kind are found in Scandinavia, Canada and, to a small extent, in the New England States, and these places are exactly where quick-clay landslides are to be found. After a heavy rain or disturbance of the natural drainage by man's activities the clay becomes saturated with water and is ready for some triggering action to turn it into a flowing, quick clay. It seems that when conditions are ideal it takes only a very small amount of motion to turn a large mass of this kind of clay into a highly mobile fluid.

A trip up any of the river valleys in the National Capital area will show old landslide sc›rs of this kind. The photograph on pages 18-19 shows the naracteristic shape of one of these that must have taken place several hundred years ago in the east end of Ottawa. Here, on the edge of a terrace, an area of several acres underlain by such quick clay sagged and flowed out over the flat below, engulfing the forest that lay there at that time and leaving a great scar on the hillside. The photograph on page 20 shows a smaller landslide that took place in 1964 in the same kind of quick clays near Breckenridge Station north of the Ottawa River. This one was only noticed when the power lines that cross the area were broken. Here the clay has oozed down into the valley of a brook and has dammed it to form a temporary dam and waterfall. Aerial photographs and studies on the ground show dozens of similar landslides (or *landslips* as they are

sometimes called when they are smaller) in the National Capital area. A very large one occurred in the Lièvre River in 1908, partially destroying the village of Notre-Dame-de-la-Salette and partially damming up the main river.

The spread of Ottawa and adjacent communities farther afield into the areas underlain by the clays which have these 'quick' possibilities could be laying the ground work for trouble one day, should there occur the coincidence of the several conditions — the right kind of clay, the right kind of structure in it, saturation with rain or other water and some vibration or motion, either natural or man-made.

Earthquakes

Maps published by the Dominion Observatory showing the locations of earthquakes in North America since records were first kept indicate that the Ottawa-St. Lawrence valley system has a higher incidence of earthquakes than any other areas in eastern Canada. The records, in fact, show that earthquakes of considerable severity have occurred in this region in the last 300 years. And, if quakes of equal severity were to happen now, directly under major cities like Ottawa and Montreal, damage and loss of life would likely be stupendous. In terms of probabilities of earthquakes happening in the future, the Ottawa-St. Lawrence Lowland and the coast of British Columbia share the dubious honour of being areas of possible major damage.

From time to time sensitive instruments record movements in the earth of local origin in the Ottawa region. Some of these movements seem to originate along major *faults* or breaks through the centre of the city and off to the southeast. Others seem to be related to the edge of the Canadian Shield, but most seem to lie inside the margin of the Shield to the north of the National Capital area.

One of the features of earthquakes and earthquake damage is the very great difference between the movement of earthquake shocks in solid rock and their movement in unconsolidated materials such as sand, gravel and clay. This means that in the National Capital district, areas underlain by thick masses of glacial deposits or marine clays are particularly susceptible to earthquake damage. Combine this with the flowing characteristics of the quick clays and we get a rather grim picture of what could happen in some of the areas in the National Capital district where large buildings or extensive housing developments are situated. Looking over the tranquil Ottawa valley on a summer's day it is hard to imagine that at any moment the ground here may shake severely.

Drainage of the Ottawa River Region

A view of the area to the southeast of the city, in the region of the Mer Bleue (a large peat bog just east of Ottawa), shows conspicuous raised areas that look exactly like islands except that they are now far from any river, high and dry in some places and bounded by bogs in others (see photo on page 27). To the north and south of these 'islands', across relatively flat-bottomed valleys, scarps rise to the level of the country beyond. More scarps that look like former river banks are clearly visible and apparently outline old channels to the east toward Bearbrook and beyond. Long

scarps occur north of the present Ottawa River and north of Route 8 between Templeton and Masson. Similar features are to be seen on Highway 17 from Orleans to Cumberland and beyond. Between these former shorelines the Ottawa River flows eastward in its present valley, its relatively flat gradient interrupted in the capital area by rocky Chaudière Falls. All these features are part of a history of river drainage that is marked by many changes.

It had its beginnings a few million years ago in a river system that became established along the front of the Precambrian Shield that lies to the north of the present river. When the glacial age came, perhaps a million years ago, the old valley may have been scoured and filled, occupied and abandoned repeatedly, with the river flowing in different places between glacial stages.

The melting of the last ice sheet in this area uncovered the irregular land surface about 12,000 years ago and once again it was possible for the drainage of a large area to the northwest and west of Ottawa to return to the site of the old valley system. But the situation had changed. For one thing the great mass of melting ice to the north poured unusually large quantities of water into the old Ottawa River. Further, glacial debris had choked the old valley in many places so that the river had to find ways around these new dams and back into the old valley.

The weight of the great mass of glacial ice had depressed the land generally, so that when the ice melted and the water ran back into the sea, sea-level rose and the valley was flooded with marine waters well beyond the present site of Ottawa. Drainage from the newly uncovered Great Lakes came into the Ottawa system first through the Fossmill Channel terminating at Petawawa, Ontario, and then for a time through a depression between North Bay and Mattawa. Sea-level changed through the centuries as the land gradually rebounded, altering the gradient of the river and forcing it to change channels from time to time. To complicate matters further, downward erosion of the river uncovered ledges of solid rock beneath the clays and sands, also forcing the river to divert its course.

It seems clear to those who have studied the old courses of the river that the Ottawa at one stage flowed across what is now the city of Ottawa and eastward through the Mer Bleue region, past Bearbrook and beyond to join its present main valley at another low swampy area similar to Mer Bleue, at Alfred, Ontario. As the land continued to rise, part of the waters of the ancestral Ottawa were diverted northward into the main valley and, ultimately, the whole of its drainage was captured by the present valley and the present shape established. Many terraces were cut into the sides of the valley at different levels as water flowed toward the receding shore of the sea. The flat tops of the terraces we see now were the shallow near-shore areas, with beaches, spits, sand-bars and deltas near the foot of the next steep slope landward.

When the river abandoned its channels in the Mer Bleue area the old valley held water as a shallow lake for a while, then became choked with a variety of plants which accumulated slowly to form peat. Now the peat is as much as 14 feet thick and is still accumulating in some places. Radioactive datings (using the carbon 14 method) of partly decomposed organic matter recovered from cores of the Mer

Aerial mosaic shows the Mer Bleue, southeast of Ottawa, as a dark swampy area to the right of centre. The two streamlined shapes to the left were once islands in the ancestral Ottawa River which flowed across this area. Terraces visible in the lower left corner and just to the north of the boggy area of the Mer Bleue mark the old river banks.

Bleue bogs show that the river channels there may have been active some 7,000 years ago.

The Ottawa River, with all its changes, was the master stream controlling the development of the Rideau and the Gatineau Rivers. Thus terraces comparable and related to those of the Ottawa River extend up the Gatineau River valley for several miles. The lowermost end of the Rideau River had to wait for the later stages of the present Ottawa River to develop before it was able to penetrate as far north as the site of the present Rideau Falls, on the limestone cliffs on the very edge of the present Ottawa itself. It is thus interesting to note that the lower end of the Rideau River is more recent and younger than the upper part.

THREE KINDS OF ROCKS

Volcanoes in many parts of the world spew out masses of melted rock which spread out over the country as lava flows, then cool and solidify to become *igneous rocks*. People can actually watch the molten material cool and solidify in the case of lava flows in regions of active volcanism such as Japan, Central America and the West Indies, Italy and Indonesia. Other rocks, however, give all the appearances of having been molten at one time and yet were not spewed out on the surface as lava flows. These rocks, the most common of which is granite, seem to have been made molten deep within the earth and to have pushed their way into the surrounding rocks, to cool and solidify there, still deep beneath the surface. Their general coarse grain results from their having cooled very slowly, and they are more apt to be homogeneous than are lava flows which may be

poured out on the surface, layer upon layer. These coarser-grained, deep-seated igneous rocks often occur in enormous masses. When they are exposed by deep erosion over a long period of time the granite or syenite or gabbro in them may cover many square miles of the country and form the bulk of very large systems of mountains like the Coast Range in British Columbia.

A second, altogether different kind of rock originates when sediments like sand, gravel, mud, silt and limy muds solidify gradually over a long period of time to form solid rock. The original materials, which may have come from the erosion of earlier igneous rocks by physical and chemical breakdown, were transported by rivers, ocean currents, glaciers, wind or waves. Then they were deposited in deep quiet water offshore in the ocean, in river deltas, in deserts, or in river valleys. After these sediments were buried by hundreds or even thousands of feet of later sediments they hardened or were cemented together in their pore spaces to become solid. These are the *sedimentary rocks*.

If lava flows, granite, or sedimentary rocks become heated by contact with great quantities of hot molten granites from somewhere down below or if they are squeezed severely during movement of the outer layers of the earth's crust their mineral makeup and appearance may change quite drastically. Rocks altered by heat and pressure in this manner are called *metamorphic rocks*. Slates and marbles are two well-known examples. In many places metamorphic rocks called *gneisses* and *schists* show intricate fold and flowage structures which give some idea of the contortions they must have gone through during some ancient part of their past history.

Boudinage or sausage-like structures made of white aplite in dark gneisses, below the power dam at Fitzroy Harbour (west of Ottawa).

In the National Capital district, examples of all three kinds of rocks are abundant. Thus the geologist looking at the cliffs of grey limestone behind the Parliament Buildings or along the Ottawa River thinks to himself of this area having once been covered by an ancient sea in which limy (calcium carbonate) muds and sands were being deposited. Once in a while a great storm would disturb the bottom and change the kinds of sediments which were being deposited there. Quiet seasons would be marked by homogeneous deposits of a different kind. When living things died their shells fell into the limy mud and were preserved. When the observer sees the ancient metamorphic rocks in the Gatineau Hills he sees that they are a record of mountains being constructed and eroded away so that only their roots, made of highly metamorphosed rocks, are left now. In these hills too, he may see masses of granite and pink syenite which show where large volumes of rocks were at one time molten and squeezed into the surrounding rocks. He also can see thin sheets of a dark or light igneous rock which must have squeezed up cracks in the earth's crust to form what we now call *dykes*. Thus an understanding of the origin of the three kinds of rocks leads us a long way toward understanding the geological history of the region.

THE MOST ANCIENT ROCKS

The oldest rocks in the National Capital area occupy its northern part and are to be found all through the Gatineau Hills. Patches of them occur here and there in the lowlands to the southwest as well. All are part of an area of ancient (Precambrian) rocks that covers more than one third of all of Canada and extends from the Labrador coast, on the east, westward to the line of Lake Winnipeg and Great Slave Lake and from the Great Lakes-St. Lawrence-Ottawa area, on the south, northward to the Arctic Ocean. This is the *Canadian Shield*.

Within such an enormous area of ancient rocks as the Canadian Shield it would be reasonable to suspect that some would be of different age from others. The part that we see north of the National Capital area belongs to what is known as the *Grenville province*. Radioactive methods show that the principal igneous and metamorphic events took place in this mass of rocks about 1,000 million years ago. It seems likely that great mountains were built at about that time with intense metamorphism of even earlier rocks and the injection of masses of igneous rocks into the cores of the ancient mountains.

Even earlier than the metamorphism and the mountain building, however, must have been the making of the rocks that were folded, faulted and changed during this chapter of the earth's history. It seems from the occurrence of marble — a metamorphic rock that always comes from sedimentary limestone — that at one time in the remote past, ancient seas must have covered the area where the Gatineau Hills now stand. Certain of the other layered rocks show also that they must have come from sedimentary ancestors, even though they are not now recognizable directly as sedimentary rocks because of the many changes that have taken place in their mineral makeup and in their physical appearances since they were first laid down. Here and there in the gneisses and schists, the layered metamorphic rocks in the Gatineau, other

evidence suggests that there must have been some igneous activity too. Certain dark layers indicate from their chemistry that they were probably either lava flows or dykes that were interspersed with the ancient sedimentary rocks.

Experience in other places in the world shows that large mountain ranges always seem to have the same general sort of history. The first stage in mountain development consists of the accumulation of extensive masses of sedimentary rocks

Contorted Precambrian gneisses are exposed below the sands and gravels in a large pit off the highway between Cantley and Wilsons Corners, north of Hull.

in large downwarps of the earth's surface. This is followed by a second stage in which the mass of accumulated sedimentary materials is partly uplifted and eroded. Meanwhile volcanic activity often adds lava flows to intermingle with accumulating sediments in remnants of the old seas, and general unrest follows. A third stage sees mighty compressive and shearing forces wrinkle and break the accumulated rocks and thrust them up into high mountains. The fourth stage, which may be more or less simultaneous with the third, calls for the injection into the cores of the mountains of great masses of igneous rocks which solidify, eventually, to form granite and smaller masses of other kinds. Long continued erosion features the fifth stage, cutting deeply into the complex mass of rocks produced in the first four. A sixth stage may see renewed uplift and renewed erosion after a long period in which the original mountains are nearly flattened by the wearing action of rivers, glaciers, wind and so on.

Geologists have come to recognize the various characteristics of each one of these stages of development in different parts of the world and, from many examples in the different stages of development, to synthesize the general history. Thus, when we see in any one area a group of these characteristics we can generally place the region in a particular stage of mountain development.

The Gatineau Hills and the southern part of the Canadian Shield north of the National Capital area show very clearly that we are looking at the eroded roots of a once massive mountain range, now dead and completely eroded away.

The remnants of the sedimentary rocks and the high degree of metamorphism that they show, the masses of granite, syenite and other intrusive igneous rocks, and the general inactivity there now all show that this is the stage in which the area belongs. Furthermore, radioactive dating, developed by scientists only in the last couple of decades, shows conclusively that the intensive stage of mountain-building activity took place here about 1,000 million years ago, in a stage called the *Grenville mountain-building episode*. At that time a series of lofty mountain ranges extended across what is now the southern part of the Canadian Shield, and for the next several tens of millions of years they dominated the scenery to the north of Ottawa. Deep drilling shows that these same rocks extend far to the south of the Ottawa River underneath the cover of sands, gravels and younger rocks.

From the rock record we can tell that the mountain-building episode with all its individual chapters and happenings was followed by a very long period of erosion. This we know from two dates — the first being the age of the mountain building itself, placed at 1,000 million years ago. The second is the age of younger rocks that lie on top of the eroded roots of the mountains. These are limestone, shale and sandstone which we know to be about 450 million years old. It is clear from the study of the National Capital area — indeed of the whole southern rim of the Canadian Shield from Quebec City westerly to Montreal, Ottawa, Georgian Bay and on to Sault Ste. Marie — that the mountains built in Grenville time had been eroded to a flat, nearly featureless plain by the time living things first began to populate the earth in large numbers, about 600 million years ago.

YOUNGER ROCKS LIE ON TOP OF THE ANCIENT ONES

The first sedimentary rock, which lies on top of the eroded mountain roots in the Ottawa area, is almost everywhere a sandstone. Occurring in the sandstone are ripple marks, worm trails and occasional pebbles and streaks of pebbles, testimony that this rock is a beach and shallow-water deposit. It seems likely that the flat plain marking the stumps of where the mountains used to be was gradually depressed beneath the surface of an ancient sea. As the sea moved in over the land so did the zone of the beach. Sluggish rivers coming off the subdued landscape and the action of the waves along the shore produced sands that were distributed along the advancing beach that gradually covered the old landscape as it was submerged. Here and there, gentle rolling hills stood out as islands for a short period as the sea gradually encroached upon the land. The beach and shallow-water deposits filled in around the old hills and, as the water got deeper, eventually covered the hilltops themselves.

Now, thousands of millions of years later, we can see the evidence of these happenings in the yellowish white *Nepean sandstone* — the stone that has been widely used to build walls, flagstone paths, and many of the major buildings in the National Capital area, including the Parliament Buildings. This dense, tough, white or yellowish grey sandstone resists weathering very well and is fairly easily worked.

When we study the occurrence of Nepean sandstone, both as it outcrops in the valley of the Ottawa River and in subsurface wells that penetrate through overlying younger rocks,

Removing flagstone and building stone from the Nepean sandstone outcrops at the old Campbell's quarry, west of Bells Corners.

it is clear that it thickens and thins from place to place. The thin parts occur above ancient rocks that once formed hills and consequently stuck up higher than the rest of the old landscape; the thicker parts are found where minor valleys and depressions used to be.

Outcroppings of Nepean sandstone have been mapped all along the southern edge of the Canadian Shield in the Ottawa-

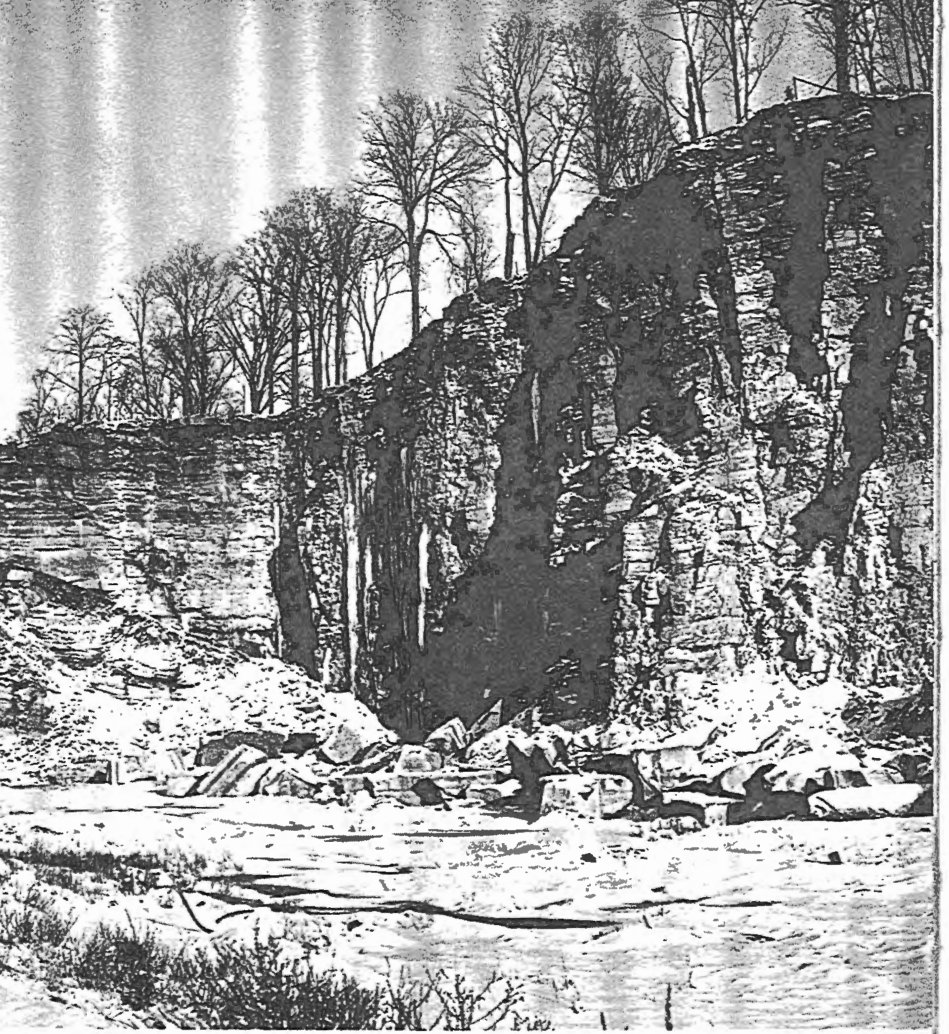
Montreal area. An examination of a map of this region will show that this basal, beach-type sandstone does not occur to the north of the southern margin of the Gatineau Hills, which would seem to indicate two possibilities -- either that the sandstone was at one time deposited on top of what is now the Gatineau Hills and that it has since been eroded away, or that it was never deposited to the north of the edge of the Canadian Shield at all. Which of these possibilities was the actual case we do not know for certain but it would seem from the available evidence that the ancient shoreline was not very far away from the present edge of the Canadian Shield itself.

If the law of superposition is to be believed and followed we should find a record of the next event in this area in the rocks that immediately overlie the basal Nepean sandstone. In localities where the next rocks lie directly in contact with the Nepean sandstone we find a very sandy dolomite, several tens of feet thick. This seems to be a transitional rock unit, because down below lie the beach-type sandstones and above lie the limestones and dolomites of still later times. It would be reasonable to suspect that the time in between these two rather different chapters in the earth's history would be represented by a mixture of the two different environments. Thus it seems that sand was still being produced, perhaps on a distant beach with back currents bringing the sand grains out into the deeper water where, by this time, muds rich in calcium carbonate and magnesium carbonate were being deposited from the sea itself. Rocks of this particular age have been referred to as the *March-Oxford Formation*. They show a gradual lessening of the sandstone through a mixture

of sandstone and dolomite into a more or less massive dolomite (calcium-magnesium carbonate). This indicates a gradual deepening of the sea over the area. If you think of this for a while you will soon come to realize that sandstone was probably being deposited on a beach in one part of the sea while sandy limestone and dolomite were being deposited in the middle depths near shore and pure limestone and dolomite farther offshore, away from the influence of the shore waves. Thus we have one kind of rock of the same age as another kind of rock in a different area.

If we look at a place where a thick rock section is preserved we will see that above the rocks of the March-Oxford Formation, quite thick shales and sandstones were laid down. Along the front of the Ottawa River, below the village of Rockcliffe Park and in the river banks at Rockcliffe Park, we can see exposed many tens of feet of shales with sandy layers and lenses in them. From studies of the geology of the whole of the St. Lawrence-Ottawa River lowlands we know that while the shales and sandstones were being deposited in the Ottawa region, thick limestones were being deposited in the region of Montreal and farther east. From this and other considerations we conclude that these shales and sandstones represent the shoreward phase of marine deposition which was rather widespread to the east, with a shoreline somewhere not far to the west.

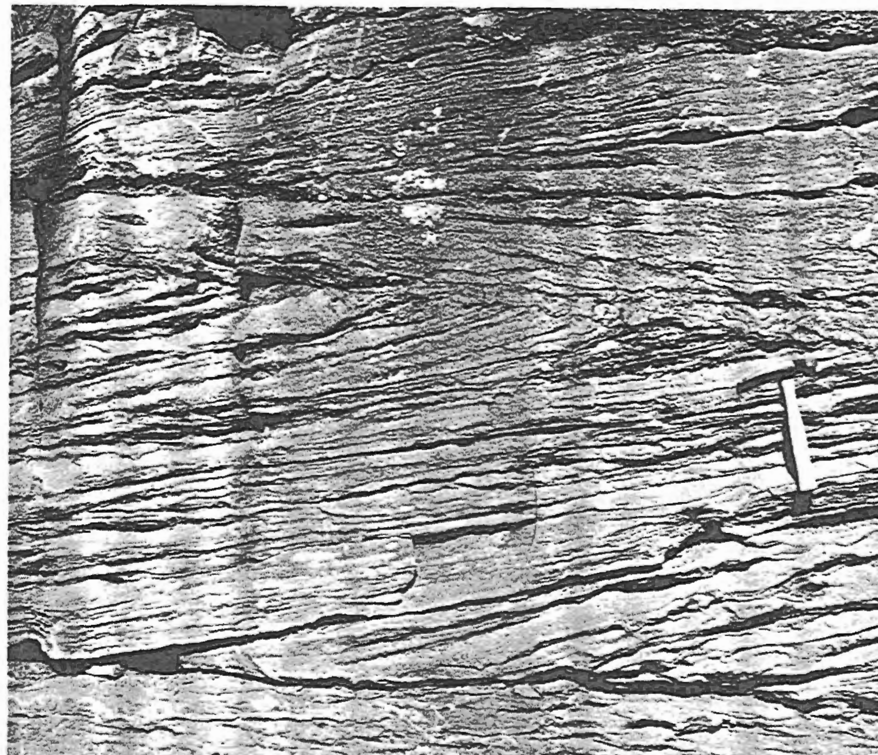
In these rocks, called the *Rockcliffe Formation,* you can see channeling and other indications of a fairly active environment. At the bottom of the Rockcliffe Formation, furthermore, you can see that the underlying March-Oxford Forma-



The Rockcliffe Formation in this quarry beside Highway 17 between Orleans and Cumberland shows fairly massive, sandy beds. Large blocks of sandstone are left on the quarry floor after the more shaly fraction is taken away for fill and road construction.

tion was eroded a little bit before the first *beds* or layers of shale and sandstone were laid down. Some people interpret this to mean that the earlier dolomites were actually exposed at the surface and eroded before the next formation was laid down on top of them. The idea is strengthened by the fact that limestones were deposited in the Montreal area in the time between the deposition of the March-Oxford and the Rockcliffe Formations in the Ottawa area.

Limestones of the Ottawa Formation sometimes show conspicuous cross-laminations as does this outcrop in the Hawkesbury area, east of the National Capital area, indicating that some of the limestones accumulated in areas of considerable current activity.



The next stage in the development of the National Capital area consisted of a marine invasion in which hundreds of feet of fine-grained, grey limestone were laid down. Over the thousands of years in which this thick limestone group was being deposited, a situation existed that was not unlike that prevailing in the present-day Bahamas Banks. In fact, studies of the internal structures of the limestones of the Ottawa area and those of the modern limy sands and muds being deposited on the Bahamas Banks show a remarkable similarity of types.

During all this time, living things were abundant in the area, and as they died their shells dropped into the limy muds in great numbers, contributing in some places very heavily to the total bulk of carbonate in the limestones. Here and there we find scoured channels, peculiar cross structures known as *crossbedding,* angular grains and peculiar little concentric shelled grains which show that conditions varied from time to time. In the quiet, tranquil depths, only chemically precipitated lime was accumulating, whereas in other places, banks and mounds of limy sand with strong currents washing them were being built. Some geologists subdivide this several hundred feet of limestone into numerous smaller units with local names but for our purposes we will call the whole group the *Ottawa limestone.*

The next several hundred feet of the rock record shows that markedly different conditions prevailed in the marine basin which covered the present National Capital area. Instead of almost pure calcium and magnesium carbonates, the accumulating sediments were very fine grained mud that must have come from the erosion of a land mass somewhere else.

Jointed limestone of the Hull member of the Ottawa Formation shows weather staining near the old surface, in a road-cut just west of the Canada Cement plant quarry in Hull.

This we know because the mud is made of the products of weathering and erosion of a variety of rocks and contains only a little calcium carbonate from the sea. This ancient mud is now to be found in the form of fine-grained, easily splitting shales, called the *Gloucester-Collingwood Formation*. They are mostly dark grey but vary in some places to nearly black, and in some other places to very light grey.

They are found very extensively to the south and east of the Ottawa area and in smaller patches in the rest of the district. Here and there in the shales, masses of fossils show that large numbers of creatures apparently died suddenly so that their hard parts and shells accumulated in considerable quantities at particular times. Thus every now and again during excavations in the city of Ottawa, patches of the highly fossiliferous black shales are encountered and laid open to the air, an ancient cemetery disturbed.

Within the thickness of dark shales there are surfaces which indicate that the land stood close to sea-level, in fact it may very well have been exposed for short periods so that some small amounts of erosion took place before minor subsidence was followed by deepening of the sea and deposition of more dark muds.

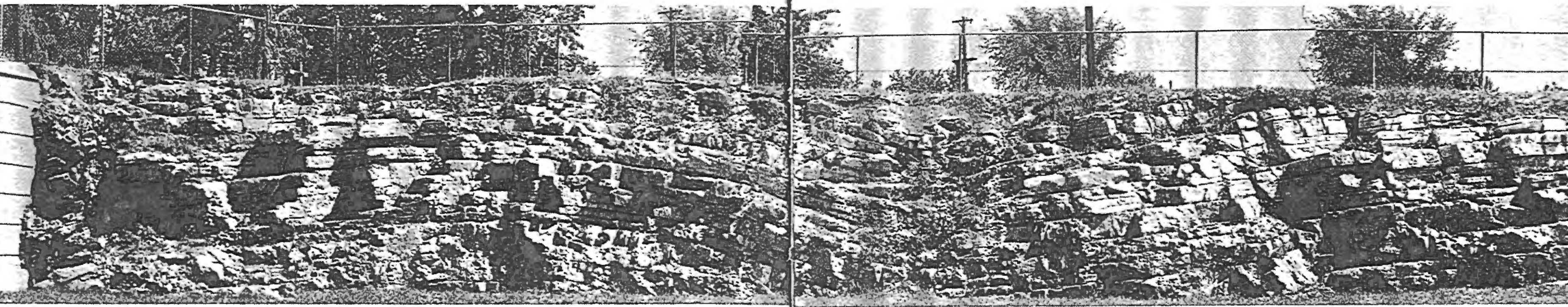
At the top of the dark shale section some localities show a reddish shale interspersed with a few green layers. This rock seems to correlate with an extensive area of similar rocks farther to the south. It has been called the *Queenston shale* because it outcrops at the bottom of the scarp at Queenston, Ontario. Some geologists believe that this is a part of an enormous delta from a river which 400 million years ago

built a mighty deposit of sediments covering many hundreds of square miles in what is now southern Ontario, Quebec and northern New York.

In the National Capital area there is no further evidence bearing on events of this ancient time because rocks of this age are directly overlain by much more modern sands, gravels and clays which we know are the result of events that took place within the last million years. What happened, then, during this long interval extending over nearly 400 million years?

In other places the rock section is more complete so that a continuous recording of events is available for study. There we can see clearly the evidence of a 400-million-year history of seas spreading over the land and retreating again, mountains rising and waning, great igneous events, and a whole succession of living forms, leading from the primitive life of ancient times to the complex of living things we see around us now.

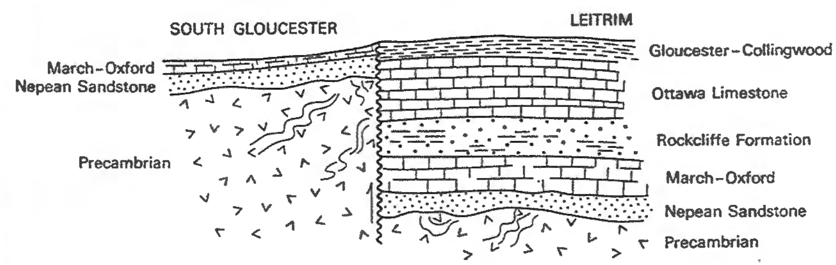
If no other physical events had affected the National Capital area then to this day we should expect to find layer upon layer of rocks everywhere with a series of old beach deposits where the ancient seas ended against the landscape somewhere to the north. Such is not the case. A study of the geological map of the area shows that the surface of the earth has been broken up into a series of blocks, some of which are pushed up and others depressed. Later erosion has smoothed off the landscape so that now it is not uncommon to cross directly from one rock unit onto another while travelling on a horizontal surface. This situation was produced by *faulting* or breakage of the earth's crust.



The youngest rocks affected by this breakage of the surface rocks into slices and blocks must have become solid before breakage took place. This reasoning means that the faulting did not occur before about 400 million years ago. We know that erosion has had a long period in which to flatten the broken surface again, so the time of faulting was not within the last few million years.

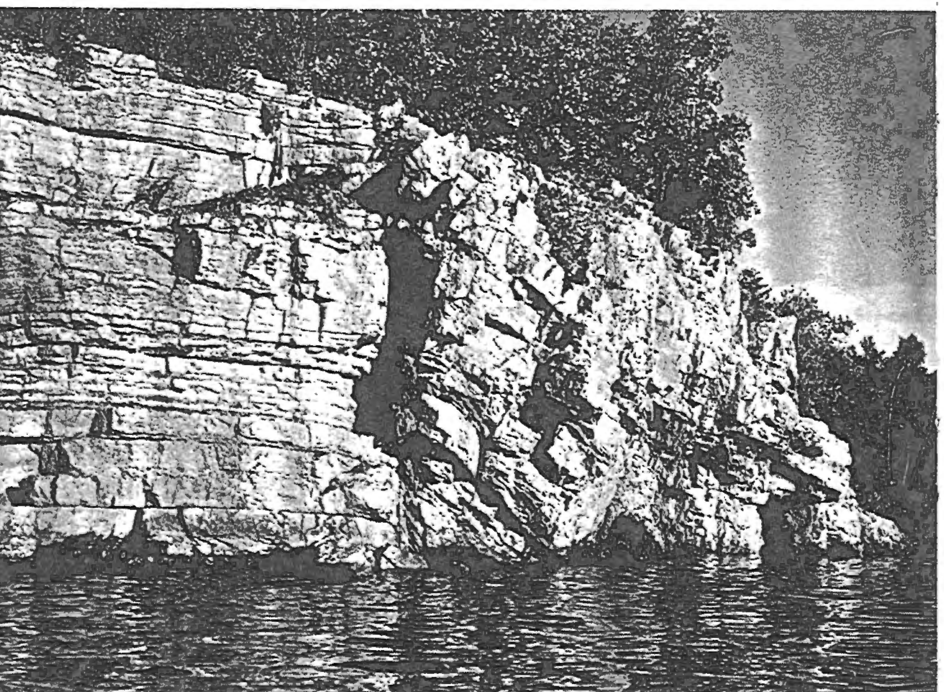
In other areas, notably to the southeast in the Appalachians, we see rocks that record a great mountain-building episode, an event that changed things drastically there between about 300 million and 200 million years ago. Perhaps it was then that the faulting in the Ottawa area took place, because fairly stable conditions prevailed thereafter. Studies of the

Long, low outcrops of Ottawa limestone along the Queensway near the Parkdale intersection show gentle folding, jointing and, at the left margin near the concrete wall, a sharply disturbed zone marking a fault.



surface features along the southern edge of the Canadian Shield suggest that parts of it have been uplifted in the last 50 million years or so. Perhaps it was then that the breakage took place. Minor earthquakes seem to be located along some of the faults so it may even be that some movement is still going on.

The bank of the Ottawa River below the lookout at Rockcliffe Park shows clearly where a fault cuts the limestones.



GLACIATION

Scratches on the surfaces of bedrock, piles of sand and boulders, disrupted river systems, erratic boulders on the hilltops — all these features of our landscape were puzzling to early observers in eastern Canada and New England. It was, in fact, a scientist from Switzerland, visiting in New England in the 19th century, who first assessed the real significance of these features. He was impressed with their similarity to features he had seen in Europe in regions of former glaciers, since melted away, and so proposed that glacial ice had once covered parts of North America.

A hundred years of investigation have made us certain that nearly all of what is Canada and a fringe along the northern United States were covered with a great ice sheet that must have been similar in many ways to the one now on Antarctica. The glaciers in the high mountains of Canada, on the Arctic Islands, and the icecap on Greenland are the last remnants of it. Signs of its presence and its passing in the National Capital area are abundant: to the glaciation we may attribute many of the features of the present river courses with their lakes and waterfalls; most of the surface deposits of sand, clay and gravel; the occurrence of some peat bogs and bare, rocky hills; and the terraces along the Ottawa River and the boulders in the fields. How did it all come about?

About a million years ago the climate in a large part of the world, including all of northern North America, began to get cooler very gradually. Winters became a little longer and summers became progressively less warm. This meant that winter's snow came a little earlier each year and stayed on the ground longer and longer each spring. The climate continued to get colder until eventually the snow stayed all year round in sheltered spots and on the sides of valleys or on the north slopes of hills away from the sun. Finally, as snow continued to accumulate in quantities greater than those melted away each summer, it stayed on the ground all year. And as the years went by the snow continued to get deeper, at first tens of feet, then hundreds and even thousands of feet. As it got thicker the weight of the upper layers of snow caused the lower layers to change to ice in somewhat the same way that snowballs are made by squeezing loose snow. With this great blanket of snow increasing to thousands of feet in thickness, the enormous weight of the upper layers squeezed the bottom ice layers so much that they became plastic and began to flow from the highest parts of the land, or where accumulation was the greatest, outward towards the edges. Some ice ultimately reached the sea. In addition to this actual movement of ice from the centres of greatest accumulation, the ice sheet expanded because the snow fell and piled up in the marginal areas as well, adding to the ice accumulations there.

Finally, then, most of northern North America was covered with a great complex ice sheet, and for many thousands of years later the unbroken wintery scene was very much like the one we see so often pictured in Antarctica or in Greenland today. However, the cycle of climatic change, which brought the cold in the first place, eventually brought new conditions, and, almost imperceptibly, the climate began to get a little warmer.

Over the centuries the ice sheet began to shrink, losing a little more of its volume by summer's melting than it gained

by fresh snowfalls in winter. At first a small part of the country, then more and more of what was originally covered, was bared, showing masses of sand and boulders and loose rocks that the moving ice had pushed or carried. This process continued over a very long period until, as now, only small remnants of the ice were left in the highest parts of the mountains and in the most northern areas.

The great mass of ice pushing over the surface of the land scraped everything that was loose in its path. Soils were torn up and carried away and great blocks of solid rock were engulfed in the ice and carried off, some of them for many miles. The bedrock was scraped and in places striated and polished by both the moving ice and the boulders and solid debris frozen into it. Hills were rounded off and old river valleys were scoured out and their walls steepened.

The melting ice left its rock burden scattered all over the country. Big boulders were stranded on the hilltops or mixed with piles of fine clays and sands. Mounds of ground-up rocks and old soil were dumped here and there. Some of the debris was left to block old river valleys, and rocky hills were often left bare.

The removal of enormous quantities of water from the ocean to supply the substance of the ice sheet lowered the world-wide sea-level. By calculating the areas and volumes involved, it has been estimated that the sea-level was lowered by at least two hundred feet and perhaps as much as four hundred feet. The weight of the tremendous mass of ice — thousands of feet thick over hundreds of thousands of square miles — actually depressed the land on which it lay. When

The Rideau Falls seen here on a very cold day in winter. The falls were formed where the Rideau River, coming in from the south, fell over the cliffs of the south shore of the Ottawa River.

In springtime, Green Creek between the old Montreal Highway and the Queensway is filled with large cakes of ice which have been pushed out onto the surrounding flats at the time of higher water.

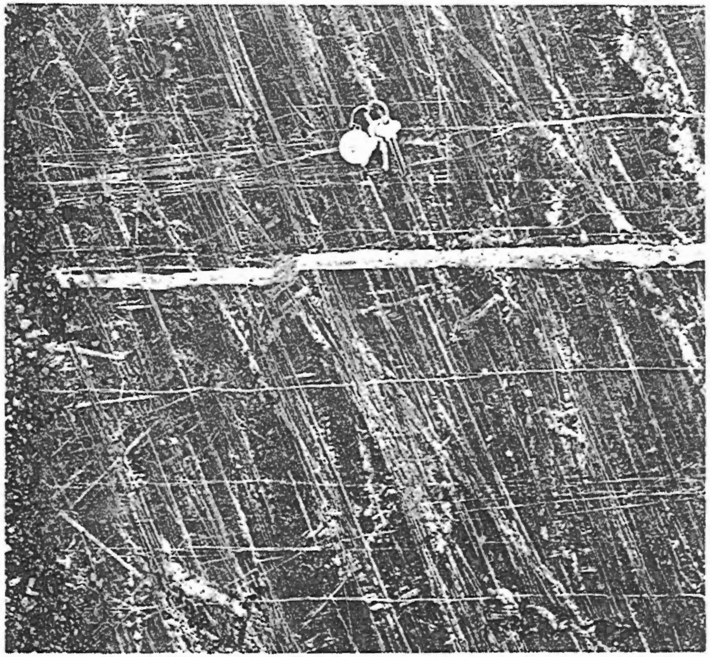
the ice melted and the great weight was removed, the land slowly rebounded. This depression and rebound action of the land occurred, of course, very slowly, rather like what happens when you press your finger into a piece of solid-looking tar for several minutes and then release it. The resulting dent in the tar will eventually fill in, but ever so slowly.

The water, tied up in the ice sheet for so long, returned to the ocean as soon as the ice melted. Thus in the depressed parts of the world such as Scandinavia and eastern Canada the sea encroached rapidly on the landscape. At the same

time, melting of the ice masses removed a great weight from the land surface so that land previously depressed began to rebound slowly and to rise again above sea-level. From our position, however, we often think of the sea withdrawing from the land. In this process, marks of the older water level have been left high and dry as abandoned beaches, terraces and deposits of several kinds.

Now let us see how this world-wide refrigeration of climate, the resulting glaciation and accompanying sea-level changes have affected the National Capital area. We can logically divide all this into three parts: the coming of the ice and its stay on the land, the melting or waning of the ice sheet, and the after effects — the depression of the land, the flooding of the landscape, and its rebound since then.

The hilly country in the Gatineau area to the north of Ottawa shows numerous examples of glacial erosional features. Fresh, hard, igneous and metamorphic rocks rise very close to the surface or are actually at the surface over large areas, suggesting that preglacial soils have been removed. Glacial *striations* or scratches and plucked knolls (called *roches moutonnées*) are common. On the limestones and shales south of the Gatineau Hills, that is, in the softer sedimentary rocks that presumably were deeply striated, grooved and channeled by glacial erosion, the phenomena of glacial abrasion is preserved only here and there, where the surfaces have been protected by a mantle of glacial debris. Quite spectacular displays of glacial features are to be found when the cover is freshly stripped off. This may happen where a brook is changing its course or where quarrying or building operations require the removal of those materials on top.



Dark limestone with a thin vein of calcite criss-crossed by glacial scratches, at the Orleans quarry, east of Ottawa.

The melting of the great ice sheet resulted in the release of whatever was being carried, and this material would often be reworked, sifted and mixed by the rushing meltwater streams. Where meltwater streams tumbled off the edges of the ice, heaps of gravel and sand were accumulated as cones and some of them now stand as hills called *kames*. These contain stratified or layered sand and gravel similar to river

gravel because they were laid down in running water. Hills called *drumlins,* which are partly streamlined masses of glacial debris, are produced by the movement of the ice over a mass of material deposited earlier. These sometimes result in very beautifully developed, half-teardrop shapes such as those seen in the Peterborough district, 150 miles to the southwest of the Capital area. Meltwater streams occupying crevasses in the ice or subglacial courses would occasionally deposit long sinuous masses of sand and gravel called *eskers.* Some of these occur near the road between Luskville and Lac La Pêche.

Sometimes the meltwater streams would deposit partly washed sand and gravel along the sides of valleys still partly occupied by ice in the middle, or on flat areas beyond the edge of the ice itself. Deposits of this kind may be seen along the margins of the Gatineau Hills and here and there on the flat lands to the south. Boulders, sometimes very large, were carried both in and on top of the ice so that when melting overtook the ice they were deposited wherever they happened to come down. Thus such boulders were sometimes left sitting on hilltops or on rocks from which they clearly could not be derived.

Following the melting of the last ice sheet in the region, flooding of eastern North America reached the National Capital area as Atlantic Ocean waters flooded the valleys of the Ottawa River and its tributaries, lapped onto the Gatineau Hills, and covered all of the flat area as far south as Malone, New York. Along the shorelines of this *Champlain Sea,* waves eroded the recently deposited glacial debris to make beaches and terraces. In places the glacial deposits were

Green Creek wiggles across the country to join the dark Ottawa River at the top edge of this photograph. The old Montreal Road, and the road to Orleans with branch roads, are conspicuous in the lower half of the picture. The Queensway, under construction when this photograph was taken, comes in from just below the middle of the left margin. You may note the three terraces in the lower half of the picture, with rocks of the Rockcliffe Formation outcropping on the lower one near the old Montreal Road and limestones of the Ottawa Formation in the upper two. The large scar along the lower left margin is the Orleans quarry.

reworked by waves and currents to produce well-sorted, clean sands. A glacial *moraine* that forms the core of the hill on which the Ottawa International Airport stands was reworked in this manner. Shore currents carried large quantities of material that show conspicuous current features such as those now visible in a series of sand pits west of the airport. Similar shore deposits occur also at the foot of the Gatineau Hills along the Mountain Road. In the deeper parts of the sea and what are now the river valleys, quantities of fine clays were being deposited.

Along the shores and in the sea bottom of the time, organisms lived and died and their shells and bones became part of the deposits. Thus countless small creatures, such as clams and barnacles, left their shells in the Uplands sand pits where today you can collect them easily, and in great numbers. Two, more or less complete skeletons of a species of small whale (Beluga) were even found there some years ago.

The National Capital area contains large areas of sand and silt that when dry or unprotected by vegetation are subject to wind erosion and the formation of sand dunes. Such wind-blown sands are to be found in several places in the southern parts of the area. Some of these sandy areas may have been formed along the shores of the receding sea just after the melting of the ice, because we now see them overgrown by soils and stabilized by vegetation. The low mounds of these dunes can be seen on the road to the airport at Uplands and also in the Blossom Park-Hawthorne area.

During the period of post-glacial uplift of the land, waves on the inland sea cut terraces at several levels but few of these features are well developed in the Ottawa area. The most

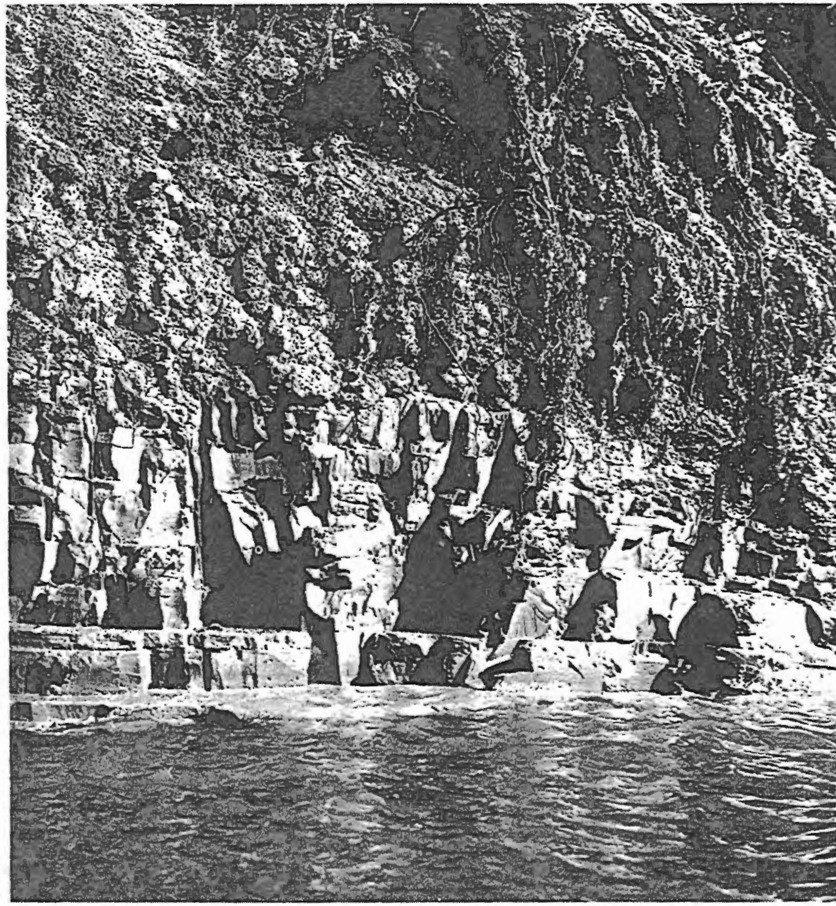
Terraces that show the once higher level of the waters of the Ottawa River and embayments that followed its valley are conspicuous near Breckenridge Station (west of Aylmer) and along Highway 8 to the northwest.

prominent is the one to be seen from the access road of the airport where the road curves westward and passes under a taxi strip. The higher part of the airport property is an 'island' ringed by what may be the lowest truly marine shoreline in the area. As sea-level fell below this terrace, river currents developed over a wide area and the system quickly changed to one of fresh water. Many terraces were then formed by the action of the river currents. Brooks cut valleys in the freshly exposed banks to build deltas at the new sea-level. These terraces and gullies, with complementary deltas and other shoreline features, can be seen very clearly at many places. A series of terraces is visible from the highway near Templeton, east of Hull; at Cumberland, Orleans and Rockcliffe, all east of Ottawa, on the south side of the Ottawa River; and in the valleys of the Gatineau and Lièvre Rivers.

Thus, the drainage system was not always exactly as we know it now. In early times the Ottawa River in the vicinity of what is now the National Capital must have carried a very large volume of water indeed, as it was fed great quantities of meltwater and later carried some of the drainage from the Great Lakes. That it changed its course several times is clearly evident in old river channels in such places as the Mer Bleue at the southeast end of Ottawa where the old channel, complete with islands and tributary valleys, is still clearly visible on the land.

When the Ottawa River finally established its present channel it was not in the old, through-going, preglacial river valley, because that had been partially filled with glacial and meltwater deposits. Where it had been forced out of its old channel it flowed out over the lowest part of the country and started cutting down into the deposits underneath. Where rock barriers were met, waterfalls were formed. And this is how Chaudière Falls and the lake-like expansion just above the city of Ottawa originated.

One of the important features of post-glacial erosional history of this region is related to the fine clays laid down in the late-glacial Champlain Sea. Because of the occurrence of small clams called *Leda* in these clays it is often called the *Leda Clay*. In places these clays are as much as 100 feet thick. In many places this is a quick clay of the unusual properties described on pages 19 to 23 and is subject to mud-flow type



Freshly eroded Leda clay shows a blocky structure and fairly well marked bedding planes, just below the parking lots on the Rockcliffe Parkway.

of landslide. When the rivers of the area — the Ottawa, the Gatineau, the Lièvre, the Rideau and their tributaries — cut into the landscape they often reveal these old marine clays, and their banks are marked by amphitheatre-shaped landslide scars in many places. On the flat terraces and in other places where these clays are found, the forests of the last few thousand years have produced a layer of soil that may be from one inch to two feet thick with, below that, the Leda clay for as much as 100 feet, overlying either glacial deposits or the bedrock itself.

Thus you can see that the glaciation, one of the most recent events in the geological history of the National Capital area, has had the greatest effect on the scenery we see. And ever since the glaciers and the seas left the area, and the drainage we know has established itself, erosion and the very recent events described earlier (pages 16 and 35) have been going on, and indeed, are still going on as you read this.

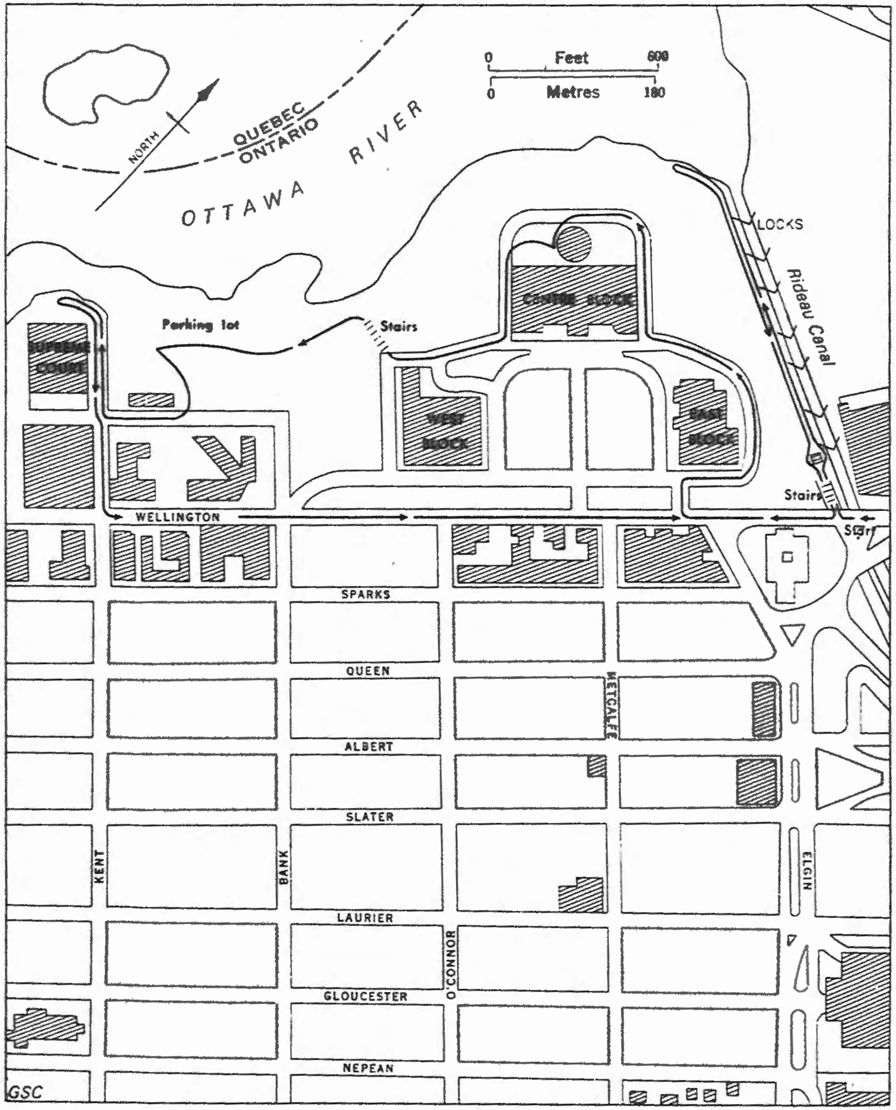
WHERE TO GO AND WHAT TO SEE — FIELD TRIPS

The excursions outlined in this section range from a short walk in the vicinity of the Rideau Canal and the Parliament Buildings to an all-day field trip west of Ottawa. The length of time it takes for any one of these trips will depend, of course, on whether you will want to look painstakingly at one particular item and not at the rest, or perhaps will want to spend the whole day looking at everything carefully.

The time mentioned at the beginning of each description is an average. The descriptions will assume that you have read the book this far. Mileages are given for the long trips, and if you should be driving a car built prior to the late thirties you just wind your trip speedometer to zero and you are all set (although you may have qualms about travelling that far in a car of such vintage). If you should be driving a more recent model, however, you will just have to add whatever it says in the log to whatever is on your meter at the start.

The route of each trip is outlined on either the small road map that appears at the beginning of the description or on the geological map on the inside back cover. Trip 2 has numbered stops that are shown on the map on page 74.

To get the most out of these trips it is worthwhile to have either a National Capital Commission map of the region showing the roads or some of the 1:50,000-scale maps of the National Capital area which are sold by the Map Distribution Office at 615 Booth Street.



Trip 1. A Walk near the Rideau Canal and the Parliament Buildings

This trip, of about two hours duration, includes a close look at the Ottawa limestone, the Rideau Canal, the building stones of Parliament Buildings and vicinity, and a view of the Ottawa River and northward to the Gatineau Hills.

Start: Wellington Street on the north side of Confederation Square opposite the War Memorial — at a point halfway across the bridge over the canal, just up the gentle hill from the Chateau Laurier Hotel.

An interesting view here takes in the several locks of the Rideau Canal and northward over the Ottawa River to the distant Gatineau Hills beyond Hull. The Rideau Canal was built in the late 1820's to provide a protective waterway from the St. Lawrence in the vicinity of Montreal, up the Ottawa River and across through the lakes and rivers to Kingston on Lake Ontario. The flight of eight locks just below you here lifts vessels 79 feet from the Ottawa River to the level of the first long stretch of the canal that extends through the city. You might notice the masonry, now 140 years old, with the original blocks of Ottawa limestone still holding firm in most places.

Walk westward or up the gentle hill toward the Parliament Buildings to the sign indicating the Bytown Museum and the steps leading downward to the right. Down these steps and alongside the locks at the bottom level we see cliffs on both sides of the locks, cut in the Ottawa limestone. The limestone layers here are almost horizontal with a few nearly vertical joints and, here and there, small faults where the rocks are broken and one side has moved past the other a few inches.

From the lowest level walk out along the pathway to the left (as you face the river) for a few hundred feet. At this point you can see the Ottawa limestone sticking out in horizontal ledges on the outside of the curving river bank. Fossils are occasionally found in these limestones, but it is not an abundantly fossiliferous zone for the casual collector.

Turn around and walk back to Wellington Street, perhaps enjoying a look through the Bytown Museum on the way.

Turn right or west on Wellington Street, up the slight incline, and proceed along the parliamentary enclosure to the first gate. Note the several sandstones in the walls and the upright columns, particularly the red sandstone in the rosettes centering each of the upright pillars.

The first gate is more or less opposite the entry to the East Block. At the entry you may note the grey granite curbstone; the new steps of rough-dressed limestone leading into the entry; the Nepean sandstone, now quite darkly weathered on most of the exterior of the building; the very fine grained, khaki sandstone (from Wallace, Nova Scotia) around the door and in the carvings of the building; and the red sandstone in the tops of the gothic arches and the circles above the door.

Turn right or east along the street side of the East Block building and, at the corner, notice the Laurier statue. The base of this statue, as with almost all the others in the Parliament Buildings area, is of grey granite, from Stanstead, Que-

bec. From this elevation the War Memorial shows up quite clearly and in it you may note the great, heavy blocks of rose-grey granite. These come from the Rivière à Pierre district of Quebec.

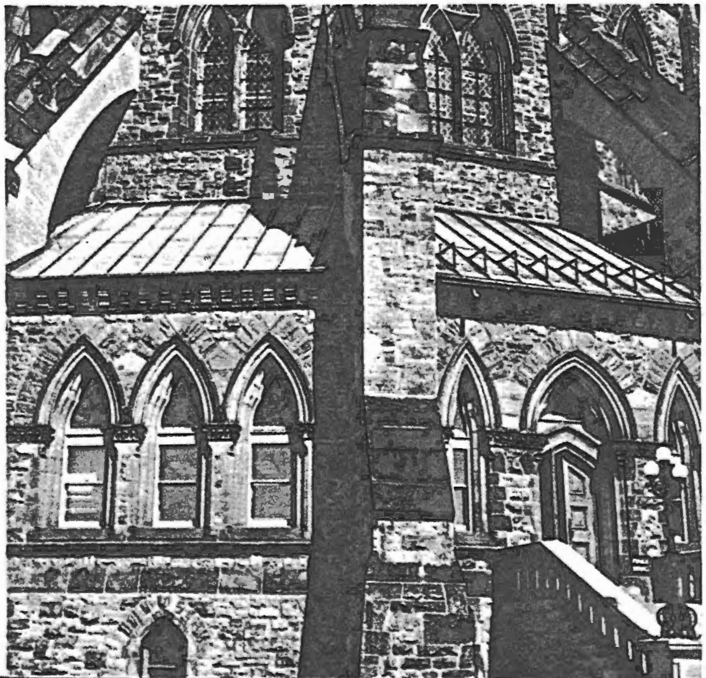
Turn north and walk along the outside walk beside the iron fence. Across the deep gash in which the Rideau Canal flows are the cliffs of Ottawa limestone. Here the limestone is almost perfectly flat and virtually undisturbed. It is important to distinguish between parts of the wall opposite that are built up with large, loose-fitting blocks, and the natural outcroppings, the latter being more prominent in the upper sections.

Continue along the pathway beside the outside iron fence until you reach the Baldwin-Lafontaine statuary. Unlike most of the other bases this one is made of pink marble. If you examine it closely you will see pink calcite crystals in a much whiter, fine-grained matrix or enclosing rock. Here and there in it you can see tiny patterns of lacy appearance and others that have multiple branching in them — these are fossil *bryozoa*, organisms that lived in the bottom of the limy sea at the time the rock was being formed. Note the variation in colour from block to block in the marble and the swirl patterns that were made when the rock was plastic and flowed under very high pressure in the earth. These patterns are most prominent in the block farthest to the left as you stand facing the monument.

From this point you can look across to Nepean Point from which the old Interprovincial Bridge crosses to Quebec and note the bluffs of Ottawa limestone. When you walk around a little farther, still on the outside pathway, you will note the general way the main block of the Parliament Buildings is constructed of Nepean sandstone, with much finer grained, dressed stone over the windows and in the sills. This edifice was built after the central Parliament Buildings burned in 1916; its style is different from that of the original Parliament Buildings. Parts of the original complex still remain in the East and West Blocks and in this old library at the rear of the Centre Block.

The Library is constructed of Nepean sandstone, with a different red sandstone used for trim in the arches over the

The old, original library behind the Centre Block of Parliament is made of local Nepean sandstone with trim in sills and around windows of khaki Wallace sandstone and window arches of red sandstone. The upper parts of the flying buttresses and the steps with balustrades are made of light grey limestone.



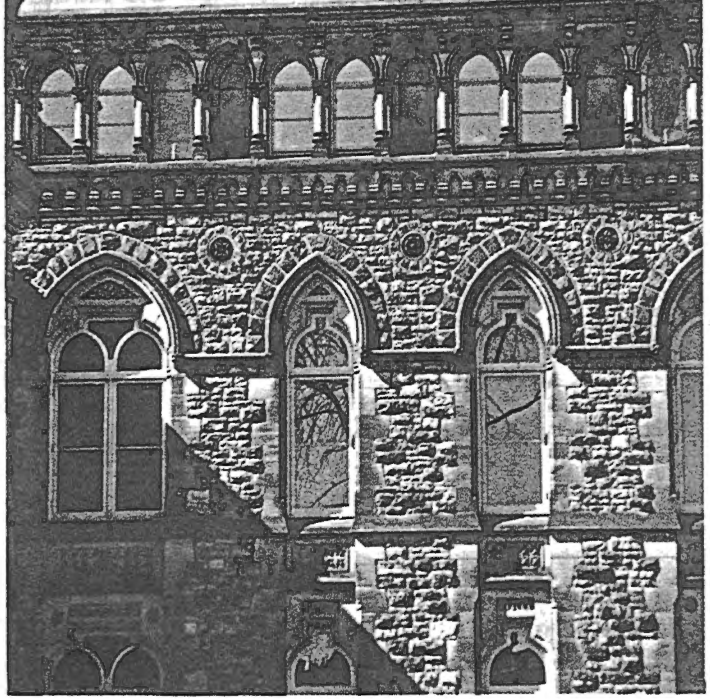
windows. The flying buttresses have a limestone or marble in their undersides which is a conspicuous light grey in the otherwise dark stone building.

Continue on around back of the Library, noting that the McGee and other statues in this area are standing on Stanstead granite bases.

The steps at the west side of the back of the Library are distinctly different from the rest of the stone in the building. The steps themselves are made of granite but the balustrades are made of a very fine grained, almost buff-coloured limestone. If you will look at this limestone very carefully you will find that it is full of tiny fossils. The most beautifully exposed are in the horizontal top piece of the right-hand, bottom pillar (as you face the steps looking at the building) near the beginning of the incline. Some very beautiful lacy patterns (*bryozoans*) are well shown here.

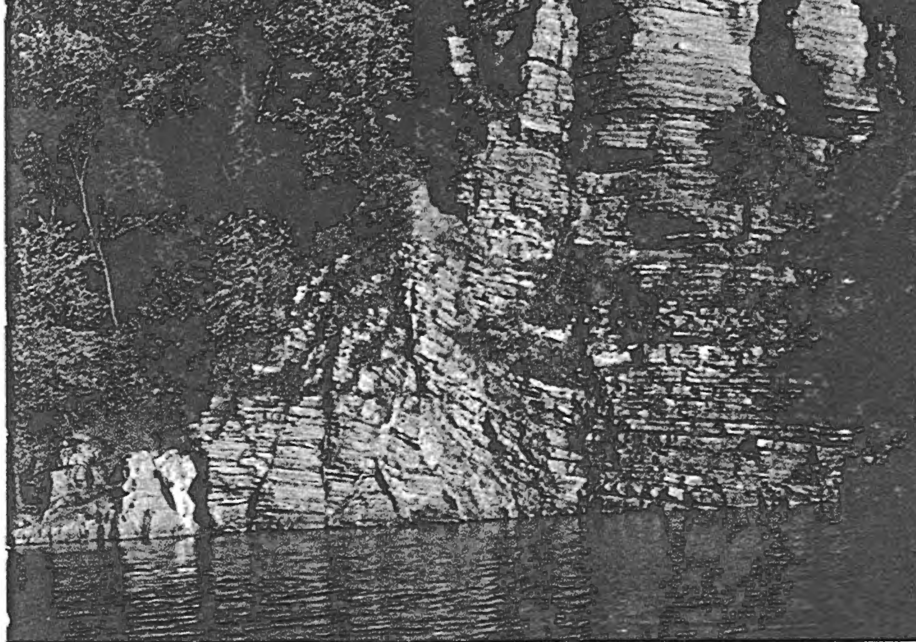
Continue along the outside to the Queen Victoria monument and from here look west up the Ottawa River to the Chaudière Falls, the bluffs of heavy Ottawa limestone below the Supreme Court Building, and nearby, the old West Block with the usual Nepean sandstone in greys and dark browns and the reddish sandstone trim over the windows.

You may end this short tour by walking on around the outside of the West Block to the front of the Parliament Buildings or, if you are feeling ambitious, take the stairs down to the lower parking lot from just below Queen Victoria's statue and walk over to the western end to look at the bluffs of Ottawa limestone at river level. Then, if still feeling ambitious, you can walk up to the Supreme Court Building and



The east-facing wall of the West Block. The main body of the masonry is of Nepean sandstone with window trim in Wallace sandstone and arches and rosettes of red sandstone. The many little pillars between the upper windows are polished granite.

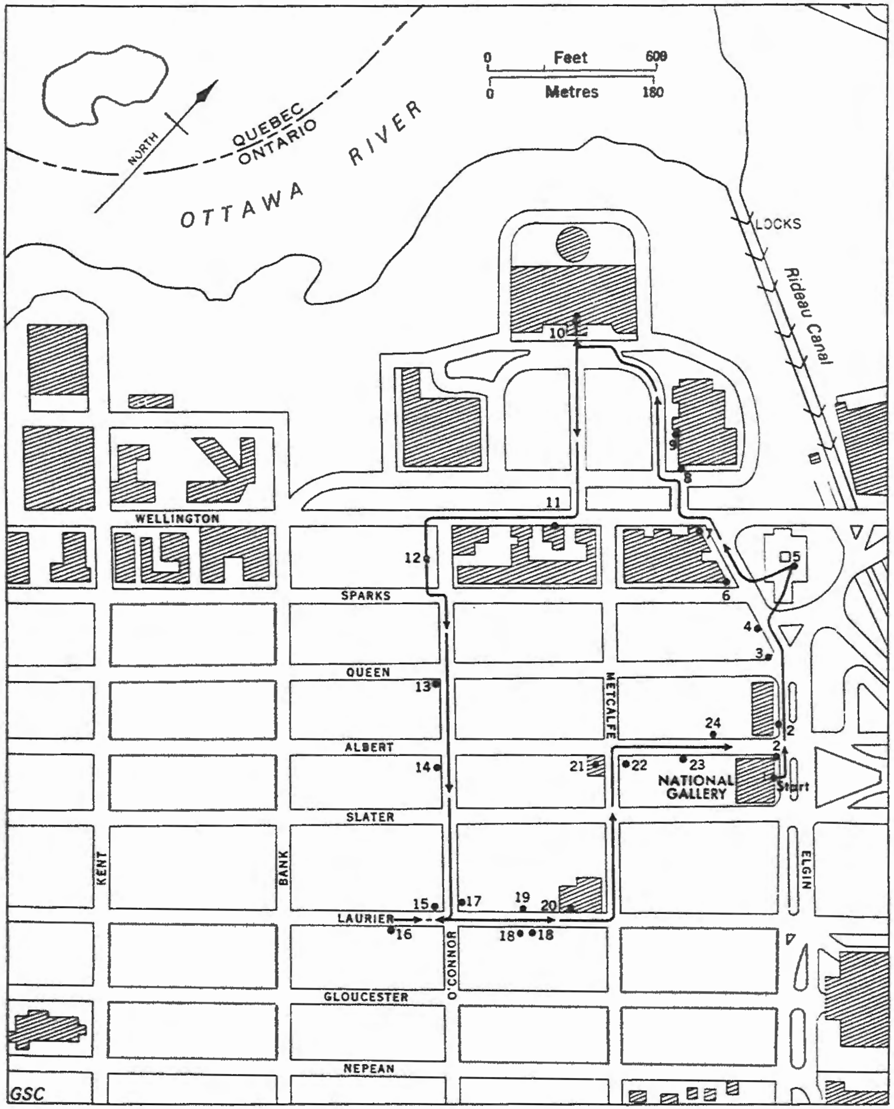
take a close look at the very finely worked grey Stanstead granite out of which it is constructed, and the smooth-surfaced khaki sandstone (from Wallace, Nova Scotia) out of which the outside retaining walls are built. Quite a good view up and down the Ottawa River is to be had from the outside end of the parking lot and the little park immediately behind the Supreme Court Building. Below, and mostly out of sight, are the bluffs of Ottawa limestone as seen in the photo on the cover and in the one on the opposite page.



Flat-lying limestones of the Ottawa Formation to the right are interrupted and broken by a fault which reaches the shore of the Ottawa River here below the Supreme Court Building. Brecciated and fractured limestone and vein calcite several feet thick mark the fault.

As you walk back toward the centre of town along Wellington Street you will pass St. Andrews Church, made of local limestone, and several large buildings made of the pale buff Indiana limestone. Most of the limestone buildings have bases of grey Stanstead granite.

By walking through the Bank of Montreal building on the corner of Wellington and O'Connor Streets you will see some very beautiful building stones. These are described in the tour that follows.



Trip 2. Downtown Ottawa, showing examples of building stone

Trip 2. Building Stones in Downtown Ottawa

This walking tour, which takes about three to four hours, takes you through a few blocks in the centre of Ottawa and points out some of the outstanding building stones in use.

Ever since man first began to put stones together to build houses or fences he has had an eye for special ones that are pretty because of their colour, natural pattern or texture, or their pleasing shapes. Nowadays stones of almost every rock type and from all over the world are to be found in the buildings in any of our large cities. They provide an interesting way of studying rocks.

Route: National Gallery on Elgin Street; north along Elgin Street to the War Memorial; westward via the East Block to the Parliament Buildings; southward, then westward to the Bank of Montreal at the corner of Wellington and O'Connor Streets; south on O'Connor to Laurier Avenue; first west, then east on Laurier to Metcalfe Street; north to Albert Street; and eastward back to the National Gallery.

1. At the National Gallery most of the outside terrace is made of grey granite, with polished and unpolished surfaces. This pleasing grey rock, from Stanstead, Quebec, is very widely used in eastern Canada. If you look carefully at it you will see glassy quartz grains, white and grey feldspar crystals and minute flakes of mica.

   Red 'granite', a very different looking rock, is found in the square pillars both inside and outside the building. It is from Grenville, Quebec, and you may note that on polished surfaces a metallic mineral (magnetite) is easily visible. You will find it difficult to see quartz in this rock because this 'granite' is really a syenite. The outside of the building from the second floor up is made of Queenston limestone. Here and there on the surfaces of the rock you may see marks of fossils.

Pale buff marble around the elevator doors features wavy lines called *stylolites*. These are made apparently by solution within the solid stone. A careful comparison of the material in the black wavy lines with the insoluble residue of the buff marble itself would show that they are identical in composition. The floors inside are made of terrazzo, a hard stone-like mixture of cement and chips of rock. This versatile, man-made 'stone' is used extensively for floors, as you will see on this tour, and it is developed in many variations of colour and texture.

2. After going northward along Elgin Street to the Albert Street corner, look up at the south end of the large building there (the British High Commission Building). The wall is built of slabs of polished Stanstead granite. The swirls in some of them are made visible by lines of dark minerals, and show distinctly the flowage of the rock at some stage in its history. As you walk up to the building notice the dark grey granite in the low walls, in the lower parts of the vertical columns and in the flower boxes and terraces. Great slabs of polished dark rose granite (from the Lac St. Jean region, Quebec) are beautiful between the uprights. On the inside a blue-grey 'granite' from Mount Johnson (or Mount St. Gregoire, Quebec) has fine metallic mineral fragments clearly visible on the polished surfaces. You may note in this building how very different the rock appears according to how it is cut. The inside floor is made of another grey granite with knots and clumps of grey and white feldspar in the dark grey matrix.

3. Proceed north on Elgin to Queen Street to the northwest corner (McIntosh and Watts store). This rather old building has three kinds of rocks worth attention: the rough-cut local limestone with fossils in all the vertical columns from the sidewalk up; the red granite panels in the small pillars around the door marked 'Central Chambers' (a little farther up the street); and, higher up in some of the windows, a coarse-grained, red sandstone.

4. Proceed north on Elgin Street to the Connaught Restaurant. Observe the red and white granite slabs used for trim on this building. Look for quartz. When you have finished your scientific investigations remember the old adage — *beware of imitations* — and see if it fits here. This is really a synthetic stone made of real granite chips in a coloured cement so that it is like terrazzo.

5. Cross to the War Memorial and observe the types of paving stones used; massive grey granite, red granite, and massive rose-grey granite from the Rivière à Pierre district, Quebec. In the last type, note the coarse grain, the large feldspar crystals, and the clumps of large crystals scattered through it. Also note the type of finish on each one of these stones.

6. Cross back to the north side of Sparks Street to the Post Office building. Among the great variety of stones in this building you may note these:

   Fossiliferous limestone — mostly tiny round discs from the stems of marine creatures called *crinoids*. The outside carvings such as the lions are of this rock and where they have weathered you will see the fossils sometimes standing up quite clearly. The smooth walls above seem to be the same type of limestone with a different finish.

   Black, polished igneous rock with very dark minerals and some reddish ones. Note the metallic mineral magnetite and how easily it is seen when the light of the sky reflects on the polished surfaces. This rock is from Quebec.

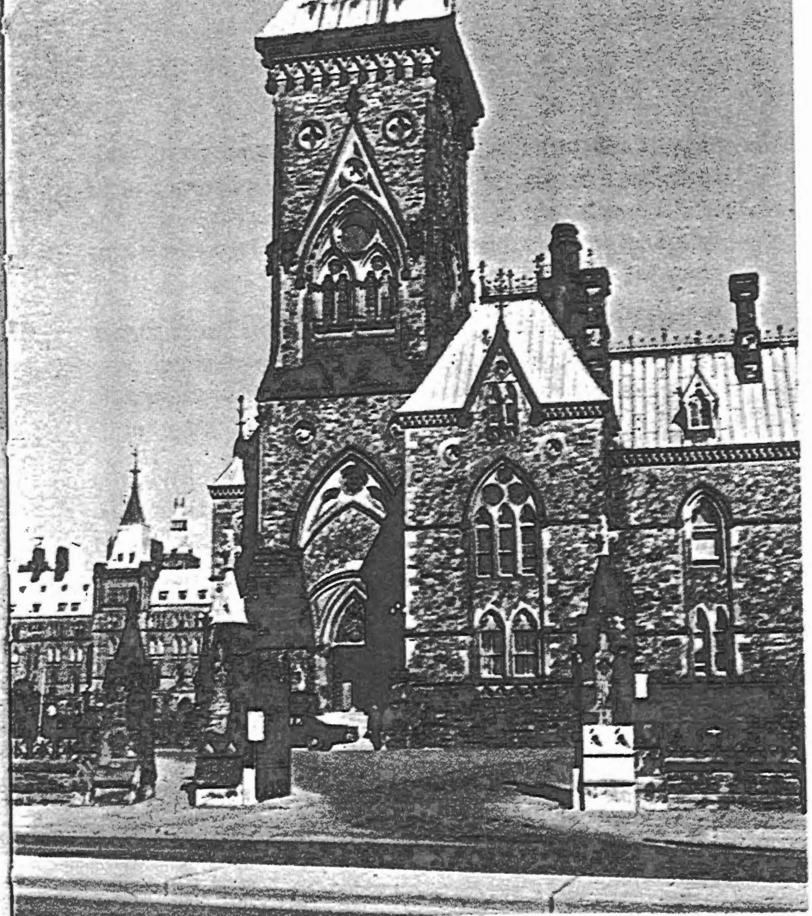
   Tan-coloured marble on inside walls with holes patched with matching artificial material. This is *tufa* from Sicily.

   Black fine-grained marble in the columns and counter tops. Here and there in the rock you may see some fossils.

   Thin, decorative rim of *marble breccia* about six inches above the floor.

   Grey Stanstead granite panels underneath the arches of the windows on the outside.

7. Walk north along the same side of Elgin Street to the Langevin Block, and the main door. This old building



The East Block, part of the original Parliament Buildings built in the 1860's, shows a great variety of different stones on its south face. Nepean sandstone forms most of the walls, with trim in plain and carved blocks of Wallace sandstone (khaki). Red sandstone trim forms the arches and inset rosette with a variety of field stones used in potpourri above the door. The grey steps are limestone.

is built almost entirely of a khaki sandstone from Wallace, Nova Scotia. Note how the rock is deeply eroded in the south side of the entrance where the water has splashed down and how the bedding or layering is emphasized by the weathering.

Walk to the traffic light on the Wellington Street corner and look back at the window on the third floor directly above the door you just left. Note the red granite columns. Are there any quartz grains in the granite?

8. Cross Wellington Street (when the light is green) to the entry of the East Block of the Parliament Buildings. There you see grey granite curbstones, new steps of rough-dressed limestone, Nepean sandstone in most of the exterior walls, very fine grained, khaki sandstone (from Wallace, Nova Scotia) around the door and in carvings, and red sandstone in the top of the gothic arch and in the circles above the door.

9. Proceed northwestward toward the Centre Block, noting as you go along the different colours of weathering in the stones along the west wall of the East Block; and the granite blocks in the walk and the grey sandstone wall.

10. Enter the main door under the Peace Tower. In the rotunda itself there are many noteworthy features including:

    The grey marble steps.

    The mottled limestone from which most of the walls and ceiling are made. This is the famous Tyndall limestone from Manitoba. Look for fossils — (but don't remove any; the security guards take a dim view of this practice). Some good ones are on the east side of the door of room 238S at eye-level, and under the thermostat on the left and south of the information desk. The guards on duty may be able to tell you of others.

    The black marble and green marble inserts in the floor pattern. The green marble is from Vermont; it contains serpentine and calcite veins.

    Green *nordmarkite* pillars which contain *cryptoperthite* (a green, iridescent, sodium-bearing variety of orthoclase feldspar), *microperthite* (an intergrowth of two feldspars) and very small quantities of quartz and dark minerals including magnetite. This is from Megantic, Quebec.

    Other types of light grey marbles from southern Quebec (near Philipsburg).

11. Proceed out the front entrance and down the steps and walk to Wellington Street. Note the old Wallace sandstone gates with the carvings and the patch of cobbles of Nepean sandstone just to the right as you leave. Cross Wellington Street and turn west to the American Embassy. Open the front door and look in at the very beautiful, very white, coarsely crystalline marble. The exterior walls are made of grey Indiana limestone.

12. Walk along Wellington Street to O'Connor Street to the southwest corner of the intersection. The Bank of Montreal Building here has a light Queenston limestone

exterior. Around the front door you may note the carved grey granite. Inside the bank there are many interesting features (besides the money).

These include:

The Italian marble breccia in the counters, and up to hip-level.

The yellow marble in panels around the entrance. Some nice cross-sections of corals are to be seen in the west side at about eye-level.

The beautiful inlaid stone work in the main floor and in the entry way.

Just before reaching the south entrance in the bank, turn left toward the safety deposit box area and note the beautiful stone filled with fossils. Go out the south door and notice the large granite blocks (from Stanstead, Quebec) on the lower levels with Queenston limestone exterior above.

13. Proceed south along the west side of O'Connor Street to the building on the southwest corner of the Queen Street intersection. Here you can see:

Tyndall limestone from Manitoba (the same mottled limestone as in the Centre Block of the Parliament Buildings) now quite badly stained and weathered. The pillars around the front door are of the same material. Blocks of Stanstead grey granite in the lower part of the building.

In the foyer, a black marble floor and pearly-grey marble on the walls.

14. Continue south along O'Connor Street to the south side of the Albert Street intersection. In the Bell Telephone Building note the mixture of polished and unpolished granite blocks that make up the lower part of the building. This rock is the familiar one from Stanstead, Quebec, and in it you will be able to see quartz, mica, black needles of hornblende, light feldspar crystals, and here and there small bits of pyrite. The upper parts of the building are pale yellow limestone.

15. Two blocks south, on the same side of O'Connor Street you come to another Bank of Montreal Building. This is at the intersection with Laurier Avenue. Here you may observe fossil-bearing limestone in the walls and slabs of polished red granite in the lower part of the building. Some of the slabs show a strong gneissic or layered structure and patches where dark minerals are more abundant.

16. Cross Laurier and proceed right or west for 300 feet to the Excelsior Life Building. Observe the same red gneissic granite and fossiliferous limestone as in the previous buildings. In the vertical front panels you can see at least twenty different kinds of rocks. These are split glacial boulders and show a wonderful variety of types of stones, mostly from the Precambrian Shield to the north.

17. Turn back eastward along Laurier Avenue and cross at the intersection to the building on the northeast corner. Note the dark stone with which the lower part of this building is trimmed. Due to *chatoyant* or iri-

descent feldspar crystals in this Norwegian stone, the polished panels are very dazzling. If you look at individual crystals you will often see that they are zoned, that is the inside shows a slightly different colour from the outside edges. Around the entrance the floor is made of terrazzo. Here and there in the lower levels you will see slabs of a white, streaky (carbon-bearing) marble below the windows.

18. On the south side of Laurier and directly opposite is a row of three two-storey buildings, made generally of Indiana limestone. In the lower sections, however, at sidewalk level, is a dark green, veined rock. Walk along the street to the spectacularly brecciated block just below the 'Canadian Bank of Commerce' sign at the easternmost corner of this block of buildings and examine it carefully. It seems clear that something has been torn apart and then recemented in this rock's turbulent history.

19. On the north side of the street again the Canadian Building shows uprights faced with black slate with natural cleavage surfaces. At ground level, just inside the sidewalks, a spectacular display of glacial cobbles and small boulders is to be seen in the decorative panels. These are representative of the Precambrian Shield north of Ottawa and have been taken from glacial drift. Here and there among the predominant pink granites, granite gneisses, granite porphyries and red syenite boulders you may find a few white marble boulders.

20. Proceed eastward along the same side of the street to

the annex of the Ottawa Public Library where round, granite pillars and fine-grained Indiana limestone make the general motif. You may note also the thin selvedge of polished black and white (salt-and-pepper-looking) rock below the large glass windows. As you go on to Metcalfe Street and turn the corner to the left, see how the limestone in the older parts of the building has become etched by weathering.

21. North (or left) along the west side of Metcalfe Street you reach the Royal Trust Building in the same block. Step inside the main lobby and see the spectacular display on the south wall. This was made by David Partridge, well-known Canadian artist, from rock chunks taken from the brucite quarry at Wakefield, Quebec, a few miles north of Ottawa on the Gatineau River. The artist has used a great variety of rocks in an array of colours to create the effect he wanted. When you are finished admiring and feeling the artistic merits of the work, look closely and see the yellow-green serpentine, the pink marble, the white and grey breccias, the brucite-bearing limestone in a streak immediately below the right edge of the circle, and some of the very dark, layered rocks. The pillars inside and also the exterior of the building are faced with cement in which is embedded a great variety of tiny pebbles of quartz, including many dark brownish flint pieces. The terrazzo floor of the interior contains mostly buff marble fragments. Altogether this is a superb example of the use of the natural beauty of stones to create artistic effects.

22. Cross the street to the Bank of Nova Scotia Building on the southeast corner of Albert and Metcalfe Streets and note the artificial stone made from fragments of the chatoyant stone you saw in the building at stop No. 17. By matching the colour of terrazzo paste with the average colour of the natural fragments in it, a very presentable artificial stone is manufactured.

23. Proceed east along Albert Street to the Beacon Arms Hotel. Here note the blocks of very white marble with layers and streaks of carbonaceous material. On the floor inside the door you will see dark green serpentine marble. In the main foyer of the hotel, blocks of light pumice (California) have been used skillfully as decorative parts of the wall motif. Straight through at the back, black boulders of *scoria* (bubbly lava flow) make a very beautiful setting for the fountains. An unusual door faced with tan marble is just opposite the elevator door.

24. Cross the street to the Montreal Trust Building and step inside the foyer to see the magnificent display of banded onyx from Czechoslovakia. This rock was made when solutions deposited calcium carbonate, layer after layer, with slight changes in composition making slight changes in the colour and texture of the calcium carbonate being deposited. White crystalline marble pillars are also a feature, along with the grey and green slate of the floor in the entry. On the outside of the building a coarse, black, igneous rock is used for trim at foot-level.

Just along the street you will see the National Gallery where you began.

Trip 3. The Gatineau Parkway and Precambrian Rocks

Time: Two to three hours.

Purpose: To see the Chaudière Falls, Ottawa limestone, various rock types of the Grenville Province of the Precambrian Shield, and scenery along the parkway.

Route: Confederation Square, Wellington Street, Chaudière Bridge, Route 8, Gatineau Parkway.

Mileage:

0.0 Start at Confederation Square. Proceed west on Wellington Street and turn right to Hull.

1.5 Chaudière Falls (from Chaudière Bridge). The Ottawa River plunges over ledges of flat-lying Ottawa limestone. In Hull turn left onto Boulevard Tache (Route 8).

3.0 Turn right to Gatineau Parkway.

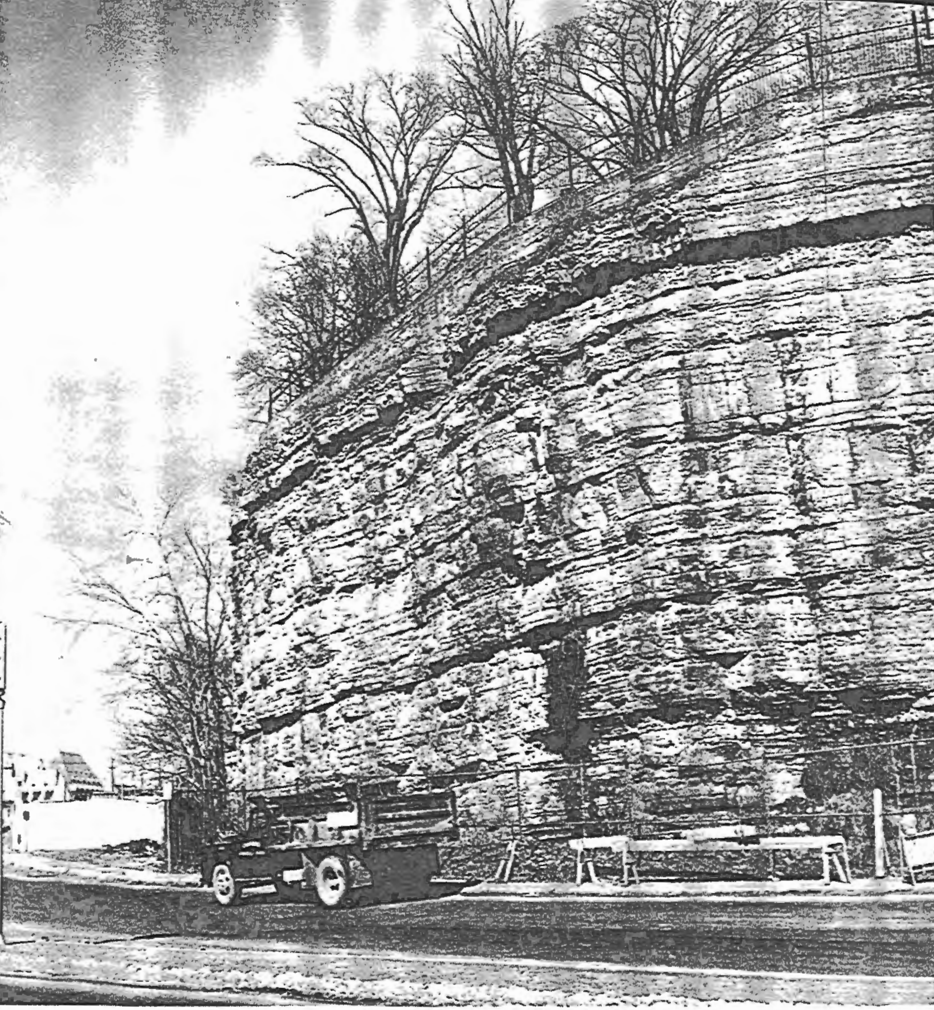
4.0 Outcrop of limestone on left side of road. Look across into the hollow where Fairy Lake is and note the Paleozoic limestone on the far shore with a variety of dips or slopes resulting from the nearness of a major fault.

4.6 Intersection with Mountain Road.

5.3 Beginning of outcrops of Precambrian rocks.

5.5 Highly foliated, pink veined gneiss with large quartz pegmatite on top. Assorted gneisses, gabbro and lighter coloured gneisses along the road.

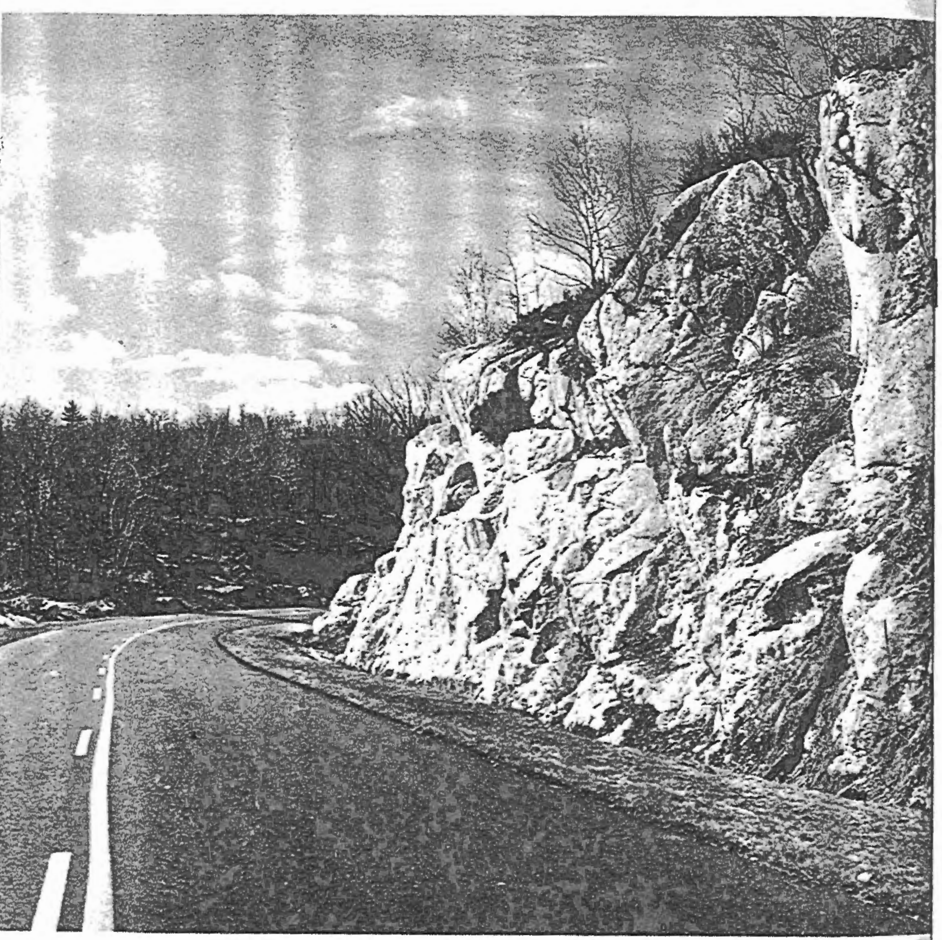
6.2 First of several marble outcrops along the left side of the road.



This great wall of flat-bedded Ottawa limestone is at the southern side of the intersection on Wellington Street, just west of the Garden of the Provinces.

Large, nearly symmetrical ripples in the Ottawa limestone just below the Chaudière Falls.

Close-up views of the horizontally bedded Ottawa limestone at the Chaudière Falls show the distinct differences between adjacent layers.



Dazzling white Precambrian marbles line the Gatineau Parkway in several places near its southern end.

6.5 Road left to the pit and pillar area. Blocks of serpentine have been left by solution of the originally enclosing marble on some outcrops.

6.9-7.4 Marble cliffs and cuts. Note at mileage 7.2 the high cliff with numerous inclusions strung out with a definite, strongly marked alignment. The inclusions are probably remnants of a brittle layer that broke up into pieces to be incorporated in the more plastic marble as it was flowing under great stress.

7.9 Miscellaneous dark and light gneisses, some inclusion-rich marbles here and there. Tourmaline occurs in a rusty, *vuggy* zone (full of natural openings) in this bank.

8.6 Pinks Lake turnoff — miscellaneous dark and light gneiss with patches of marble and with numerous inclusions. Pinks Lake is in a glacially formed bowl and is like thousands of others on the Precambrian Shield. There is an old mica-calcite pit on the opposite shore.

8.9 First glimpses of the flat lands to the south and southwest marking the Ottawa River valley.

9.0 Turnoff to lower Pinks Lake parking lot. An outcrop of highly contaminated and metamorphosed marble occurs just to the northwest.

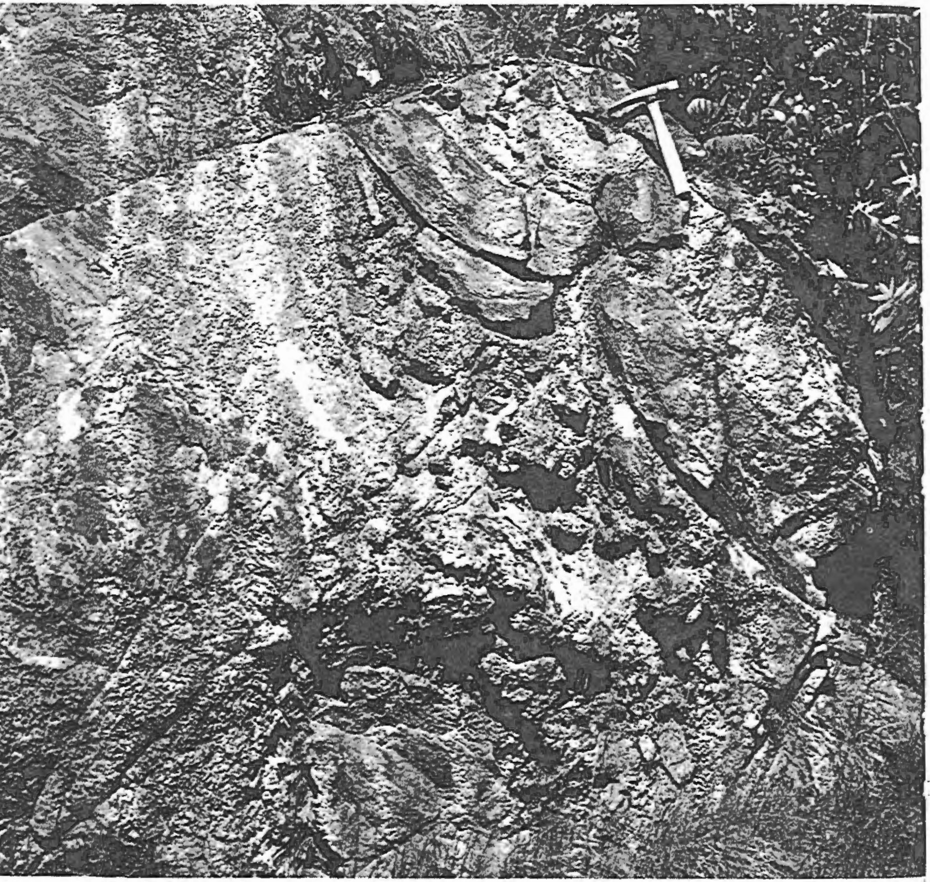
9.3 Notch Road overpass.

9.6 Inclusion-rich marble with gneisses.

9.8 Road junction; take left branch toward Champlain Lookout.

10.1 Granite outcrops.

10.6 Dark gneiss.



Many of the marbles along the Gatineau Parkway are filled with inclusions of other rocks. In some, these are strung out along apparent flow lines and in others they make up a very large part of the rock. Here they are weathering out on a joint surface.

11.2 Mackenzie King Domaine. Several marble outcrops occur just before this.

11.8 Mulvihill Lake parking place.

11.9 To the left, a view out over the Ottawa River valley.

12.3 Broken, pink syenitic gneisses.

12.5 Sweeping left turn and road-cuts of dyke-ribbed, dark grey-green gneiss.

13.2 Black Lake turnoff and parking area. Cliff of dark green gneisses with numerous pink dykes. The former are mostly oligoclase feldspar and diopside with some mica and the latter are mostly pink orthoclase feldspar and quartz.

13.6 Small patches of marble here and there.

14.3 Lac Bourgeois.

15.0 Junction of Fortune Lake road; continue straight ahead toward Champlain Lookout.

15.2 Dark red syenite.

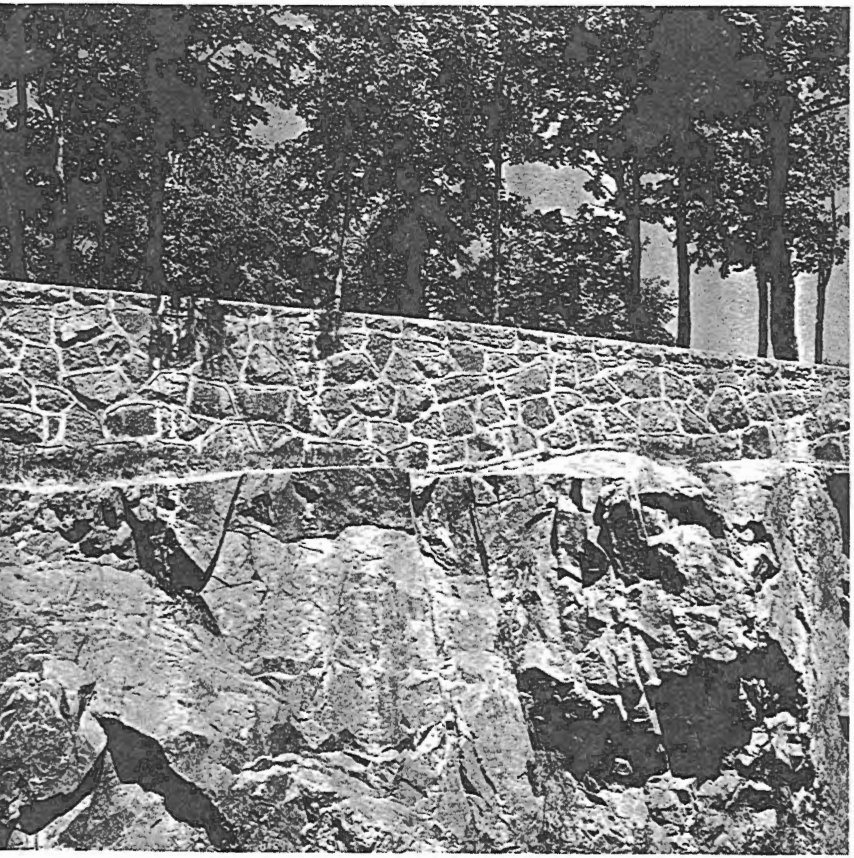
15.9 Huron Overlook with the Ottawa River and flat lands below.

16.0 Dark gneisses.

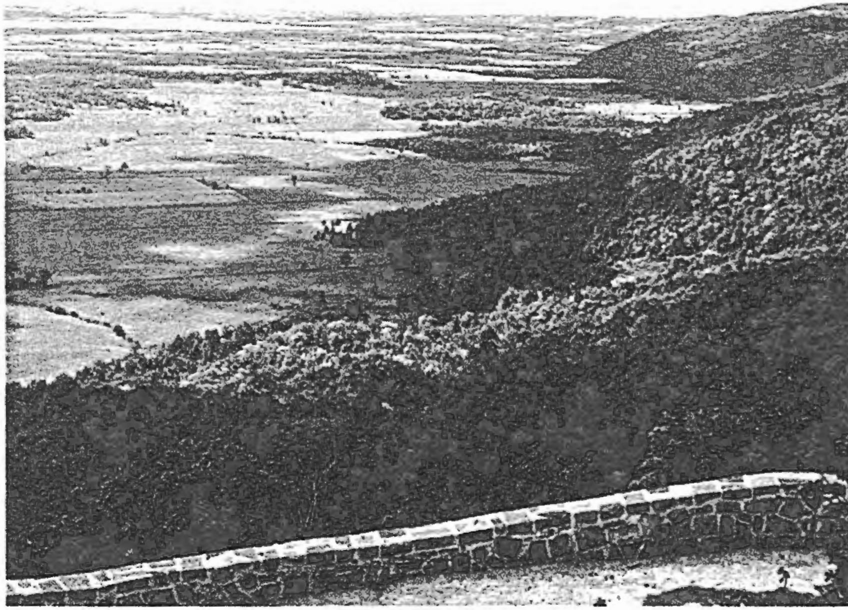
16.1 Brulé parking lot turnoff.

16.5 Champlain Lookout loop.

16.8 Parking area at Champlain Lookout after the loop. From this lookout you will note the sharply marked scarp along which the hills rise abruptly from the flat plains below. There is considerable speculation as to whether this is a fault or a retreating scarp, meaning a strictly erosional feature. You may note the grey, blue-grey and pink, dressed stones in the retaining walls



Retaining and decorative walls along the Gatineau Parkway, especially near the Champlain Lookout end, are built of stone imported from the Montreal area.



Lowlands underlain by Palaeozoic sedimentary rocks to the left, with the distant Ottawa River near the horizon, end abruptly against Precambrian rocks along the Eardley Escarpment, seen here from the Champlain Lookout.

and steps at this lookout. These are imported from quarries in the Montreal area; although it may seem that lots of rock is available in the immediate area, it is not worthwhile to establish a quarry for a small need. Below this lookout, molybdenite can be collected from old workings.

In the distance is the sweep of the Ottawa River with lake-like expansions here and there. Far ahead on the right, Mohr Island splits the river in two and Constance Bay is the bulge on the far side of the river. Numerous other features of interest are pointed out to you by the arrows set in the top of the retaining wall. Note the brook that comes out of the gully just below. Where it reaches the flats far below it changes its nature and, in one section near the farm house and barns, it meanders in a valley of its own cutting.

A ten-minute walk north along the parkway brings you to McCloskey's Field where road-cuts and outcrops of gneisses and marbles are of interest. Some mineral collecting here includes *eckermannite* in dark green crystal clusters. Return by the same road.

18.3 Fortune Lake junction; turn left.

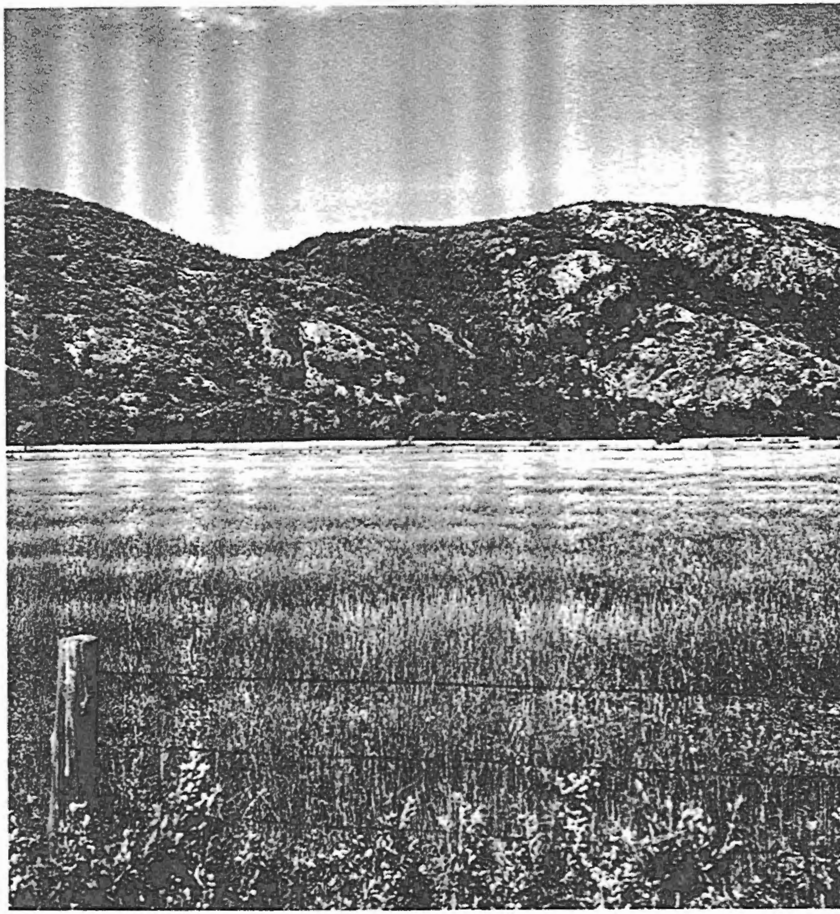
18.7 Ridge Road parking lot.

18.7 Massive grey syenite.

19.2 Massive pink syenite.

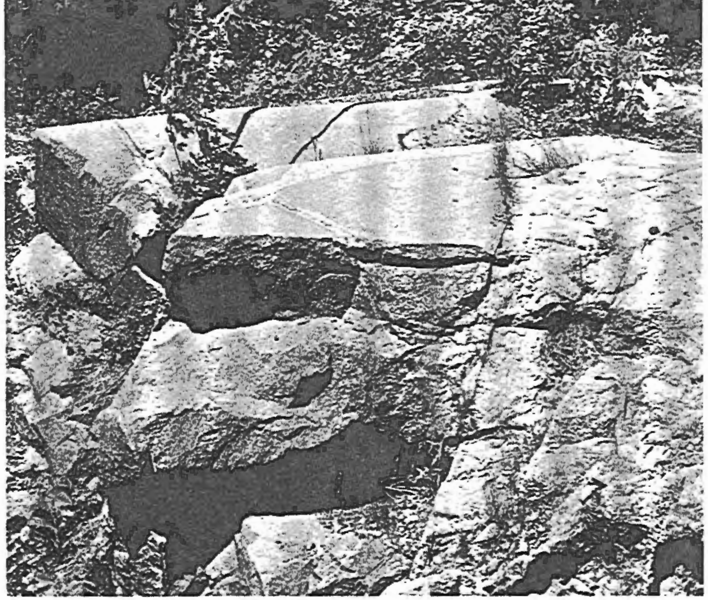
19.4 Dark, fine-grained rock with pink granite dykes (see photos on page 102).

19.6 Fortune Lake is a flooded area with old tree stumps still sticking out of the water. Across the road from



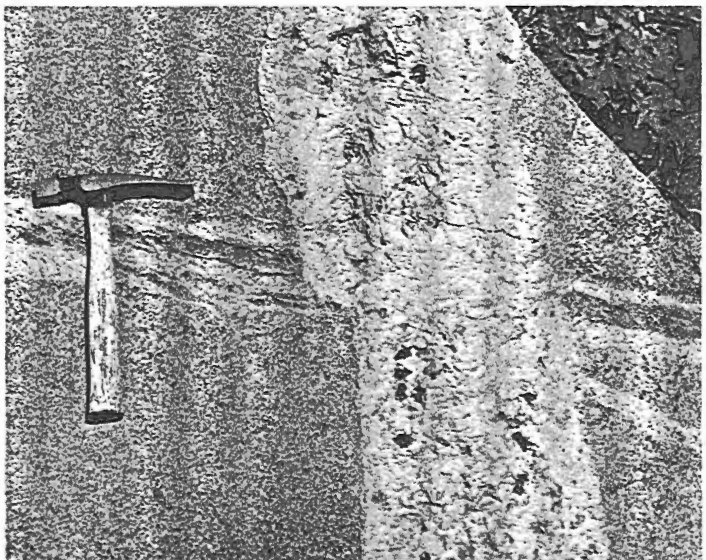
The Eardley escarpment (west of the Champlain Lookout) with Precambrian hills rising abruptly out of the flat plains, near Luskville, west of Aylmer.

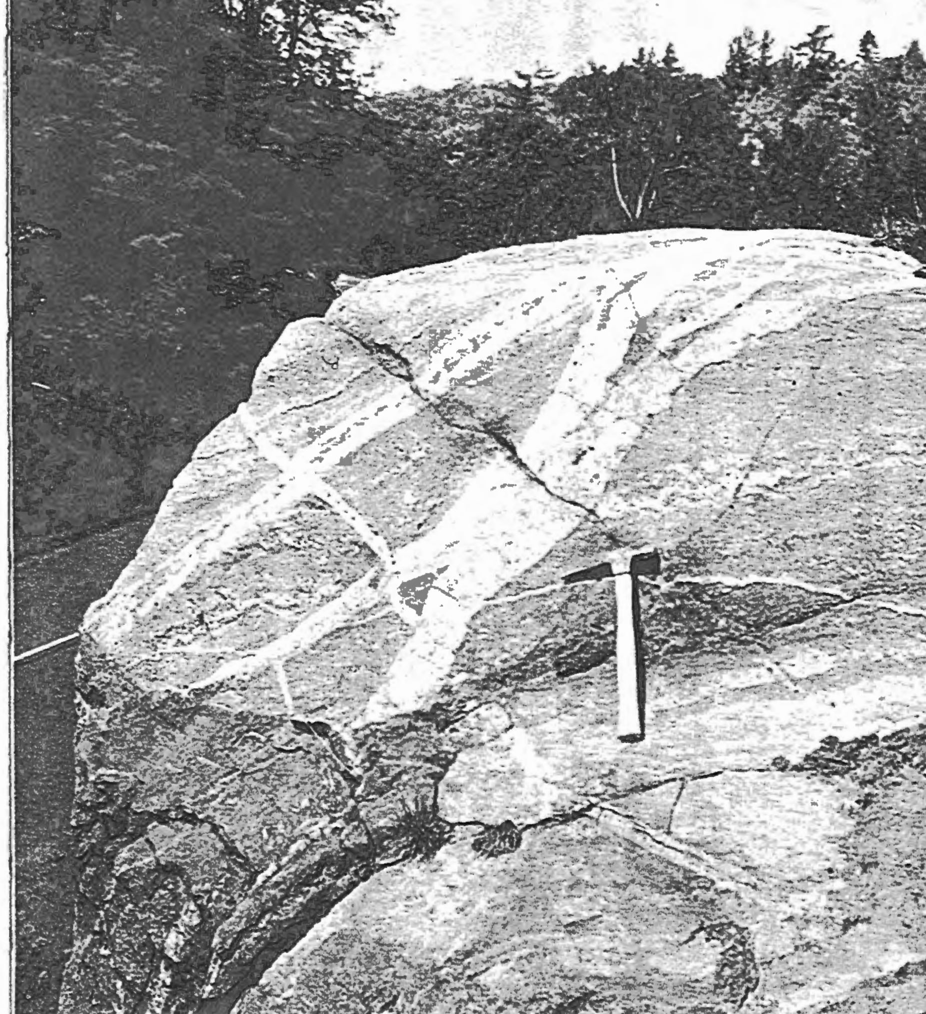
Pinks Lake, along the Gatineau Parkway, is in a basin of Precambrian rocks, like hundreds of thousands of other lakes scattered through the Canadi n Shield.



A smooth, glaciated surface shows different rock types and light coloured dykes, Fortune Lake Parkway.

In this close-up of the dykes above, coarse-grained granite pegmatite cuts a homogeneous, fine-grained rock and another dyke of different material.





Criss-crossing pink aplite dykes cut older gneisses beside the Gatineau Parkway.

the parking area (Artist's Point) you can see coarse syenite with pink granite pegmatites. Outcrops along the road eastward about 500-800 feet include several varieties of syenite and pegmatite with fair mineral-collecting possibilities; occurring are quartz, feldspar, intergrowths of quartz and feldspar, mica and, in one zone along the edge of a large pegmatite, shiny black garnet (andradite). The radioactive mineral *betafite* is present in small quantities.

20.0 Massive syenite. Outcrops all along here are part of the Wakefield syenite, a body covering many square miles to the north and east.

20.8 Junction with the Camp Fortune Road.

21.0 Intersection, Meach Lake Road.

23.2 Intersection with another part of Meach Lake Road.

23.7 Dark gneisses shot through with pink dykes; the opening in the rocks used to have numerous apatite crystals on the floor.

24.2 Marble outcrops.

24.3 Penguin picnic site.

24.6 Kingsmere Road junction.

26.3 Pink calcite locality to the right in the woods, perhaps 200 feet off the highway. Pink calcite with well-formed green apatite crystals is collectable in the dumps.

26.4 Junction with the Champlain Lookout Road. Turn left for Hull (6.8 miles to Route 8) and Ottawa (9.8 miles to Confederation Square).

Trip 4. A Most-of-the-Day Trip West of Ottawa

Time: Four to eight hours.

Purpose: Comprehensive excursion to see Precambrian rocks of many Grenville Province types; rocks of the Nepean, March-Oxford and Ottawa Formations; glacial and post-glacial deposits; and general physiography.

Route: Highway 17 west from Ottawa; turn off to Dunrobin; back roads to Fitzroy Harbour, Kinburn and Antrim; east on Highway 17 to near Carp; northeast to Stittsville; back to Ottawa on Highway 7.

Mileage:

0.0 Start from north side of Confederation Square. Proceed around the square and then south on Elgin Street (leading directly away and slightly downhill from the War Memorial).

0.4 Turn right onto Laurier Avenue (at the signs for Highways 7 and 15).

0.6 Turn left onto O'Connor Street (two blocks). Proceed south on O'Connor until you see the Queensway sign for Queensway West.

1.3 Turn right (west) onto Queensway West. Stay on the Queensway until you see the signs telling you to turn right for Highway 17, the route you will now be following for some miles.

7.9 Turn right off the Queensway at Pinecrest Road and follow Highway 17 signs.

8.6 Intersection with Carling Avenue.

8.9 Road comes down off a terrace onto a lower flat level.

10.6 Parking spot and viewpoint beside the Ottawa River. Note the wide expansion of the Ottawa River here in Lake Deschênes. You can see the outlet with the rapids where the river narrows far to the right beyond Britannia Point. To the north the Gatineau Hills mark the edge of the Precambrian Shield with the flat country on both sides of the river, underlain mostly by flat-lying limestones and shales, in places covered deeply with clay and sand. Occasional outcrops on the river bank just below this spot are of the March-Oxford Formation.

12.7 Small abandoned quarry to the southeast of the road. Rocks here are mostly of the white Nepean sandstone with some dolomitic limestones; the horizon must be very close to the contact with the March-Oxford Formation.

13.5 Railroad underpass.

14.5 Branch road left toward the southeast. In this general direction you can see hummocks or knolls of smooth, rounded Precambrian rocks sticking up through the blanketing clays.

15.2 Small outcrop on the south edge of the road is a round mass (a *boss)* of Precambrian rocks.

16.0 Massive Nepean sandstone outcrops both to the south and the north.

16.7 South March.

17.3 White Nepean sandstone on the south side.

17.5 Junction of Highway 17 and the road to Constance Bay; continue straight ahead toward Constance Bay.

20.0 Low outcrops in the fields on both sides of the road. You can get some indication that the ledge rock is not very far below the surface of the fields by looking at the fences which are held up mostly with piles of boulders, especially at the corners and intersections of fences.

20.8 Massive blocks of March-Oxford sandy dolomites are heaped up to the south of the road; small outcrops occur along the north side as well. Notice how rocks of this formation are brown weathering and if you rub your hand on the surface you will see that they are quite sandy. The weathered surfaces clearly show the bedding or layering by currents, and other sedimentary features.

21.2 Railroad crossing. Outcrops of the March-Oxford Formation continue along the road to this point.

23.1 Crossroad in Dunrobin Village; turn left.

23.3 Sand pit to the right.

23.7 Railroad crossing — flat, level ground. To the south you can see the hills of Precambrian rocks rising from the flat plain.

24.1 Crossroad — to the right along the road coming in here you will notice a small rise on which the houses and trees are situated. This marks an outcropping of Ottawa limestone.

24.7 Scarp — this is the edge of the Precambrian rocks that stand out above the plains to the north, underlain by flat-lying sedimentary rocks.

25.0 Crossroad.

25.6 Power line. The outcrops along here consist of very dark gneisses, dark syenites and syenitic gabbros. Note the complete change of the style of the country here on the Precambrian rocks; rounded bosses or masses of dense, hard rock stick out of the fields, with glacial boulders fairly common, whereas on the flats to the north no rocks of any kind were to be seen in most places.

25.9 Crossroad and right-angle bend.

26.7 Power line.

27.8 Crossroad; go straight through.

29.8 Crossroad; continue straight through.

31.2 From the crossroads we have come down gently off the Precambrian outcrop. At this spot, opposite low brownish cliffs of the March-Oxford Formation, you can see white Nepean sandstone at the back of the field, near the woods. Not far beyond that, Precambrian rocks outcrop.

31.6 Railroad crossing.

31.7 Junction, road right; go straight through.

32.2 The beginning of an uphill section of the road as we come off the low area underlain by rocks of the Rockcliffe Formation.

32.7 Low outcrops of Ottawa Formation limestones are to be found here and there along the ditches and you can see once again that the fence posts are almost all held up with piles of flat slabs of rock.

33.7 Intersection with paved highway; turn left.

34.3 Junction; go straight.

34.8 Crossroad; go straight.

Dark gneisses at Fitzroy Harbour are here cut by a melange of dykes and sills of pink aplite and coarse-grained pegmatite.

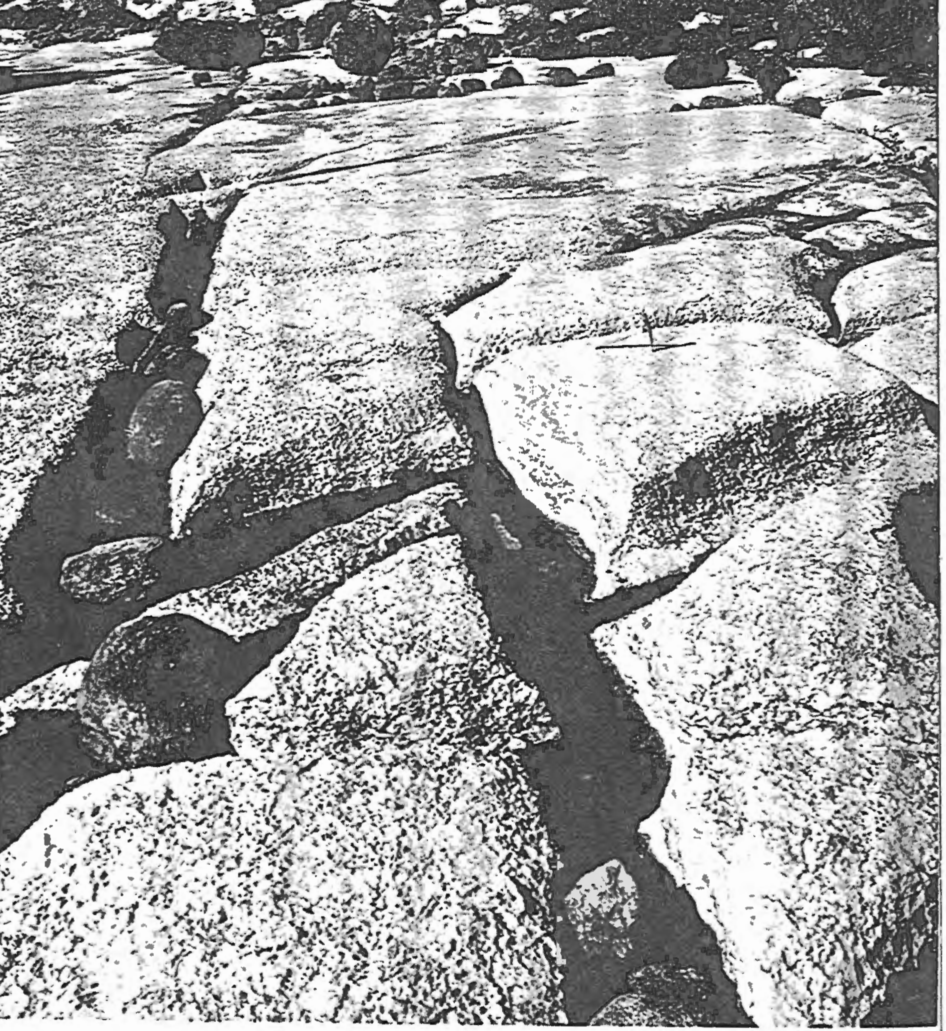
35.2 Crossroad; go straight ahead.

35.8 Bridge with outcrops of flat-lying rocks to the right and in a bend of the river downstream or right.

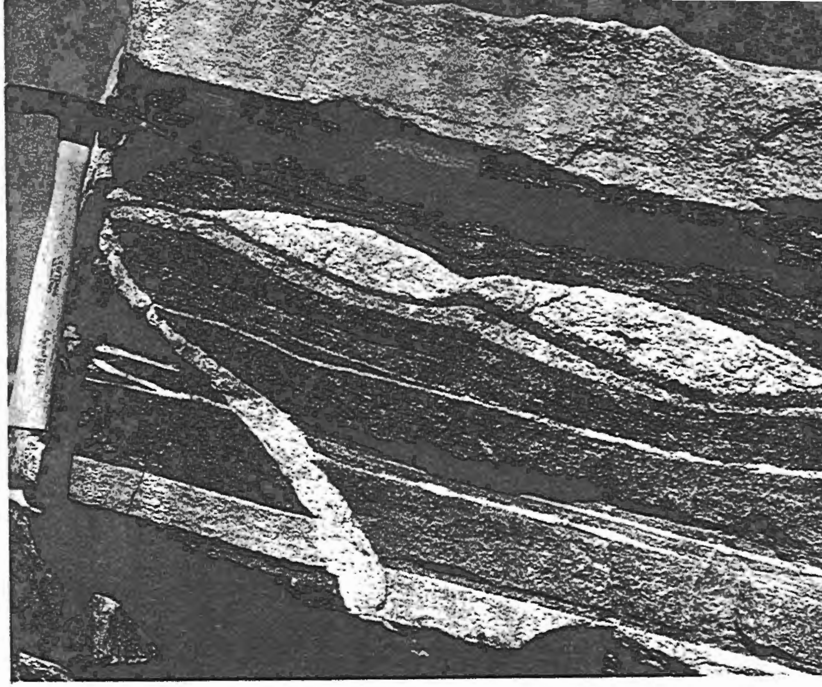
36.0 Intersection near railroad tracks and Fitzroy Station. Turn right to Fitzroy Harbour.

36.9 Just inside the town limits turn sharply left (not the paved loop which goes in among the houses). After going about 500 feet, turn right through the little settlement, past the garages and over a small hill.

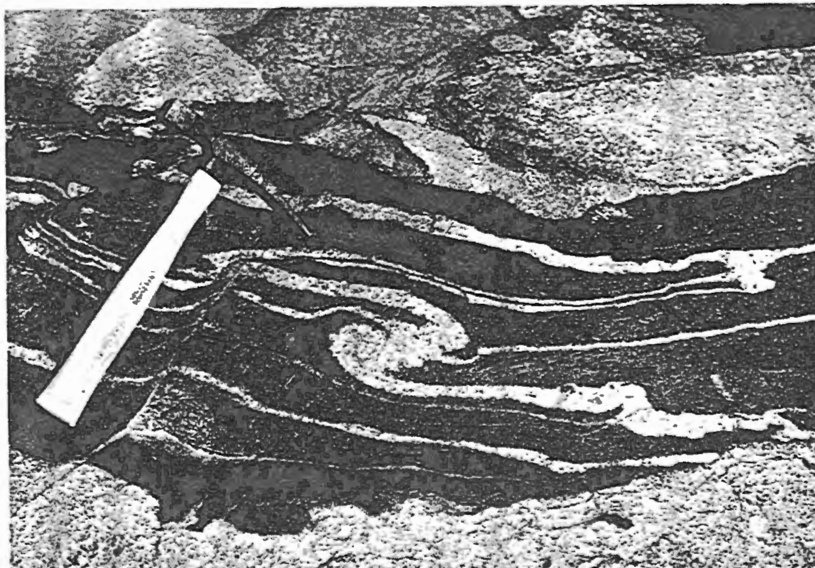
37.1 Beginning of outcrops of very white, coarsely crystalline Precambrian marbles.



An outcrop of very white Ottawa limestone in the Ottawa River bed dissolves slowly away, leaving the more-resistant matter standing up in relief. The dark, manganese-stained boulders contrast with the white limestone. This is seen at Alumette Rapids, west of the National Capital area.



The above is a pattern of aplite dykes and lens-like masses in dark gneiss; below is a roll-flow structure in gneisses. These occur below the power dam at Fitzroy Harbour.



38.1 Long dam that backs up the Ottawa River to provide storage for the power-house on the other side. Below this dam, closer to the power-house, is a wonderful display of Precambrian rocks. See for example the photos on pages 30, 109 and 111.

Return to the crossroads at the railroad and the Fitzroy Harbour turnoff.

40.2 Intersection near Fitzroy Station; turn right across the railroad.

40.3 Intersection; turn left.

41.2 Power line and outcrops of crystalline marble on both sides of the road. Occurring regularly for the next several miles are outcrops of a variety of rocks of the Grenville Province of the Precambrian Shield.

44.3 Crossroad with radio tower; turn right.

44.5 Outcrop of white crystalline Grenville marble.

45.4 Road-cut in mixed Precambrian gneissic rocks of considerable variety. From here you can look down over the flats to the south, but Precambrian rocks continue to poke through for another mile and three quarters.

46.2 Dark Precambrian rocks in road-cuts. Village of Kinburn is in sight just ahead.

46.6 Carp River.

46.9 Kinburn.

47.1 Railroad crossing.

47.2 Junction with old Highway 17; continue straight ahead toward the southwest.

49.5 Stop sign and intersection with Highway 17; turn left.

50.7 Beginnings of low outcrops of grey limestone of the

Ottawa Formation. Note how the edge of the limestone hill is marked fairly sharply by the sudden increase in the number of cedar trees.

52.2 Top of the hill with a sweeping curve to the left and small road to the right. From the top of this limestone hill you can look across the valley to another limestone ridge beyond the farms, and farther back to the southwest to a distant ridge which is another Precambrian mass over near Blakeney and Pakenham.

52.8 Limestone outcrops all along the road and just under a thin cover in the surrounding fields and woods.

55.8 Long road-cut with many different kinds of limestone exposed in one-half-inch to three-inch layers. Some fossils.

56.9 Crossroad.

58.5 Crossroad.

59.2 Road junction; continue ahead on Highway 17.

60.5 Road to Carp airport.

61.4 Crossroad; turn right toward Stittsville.

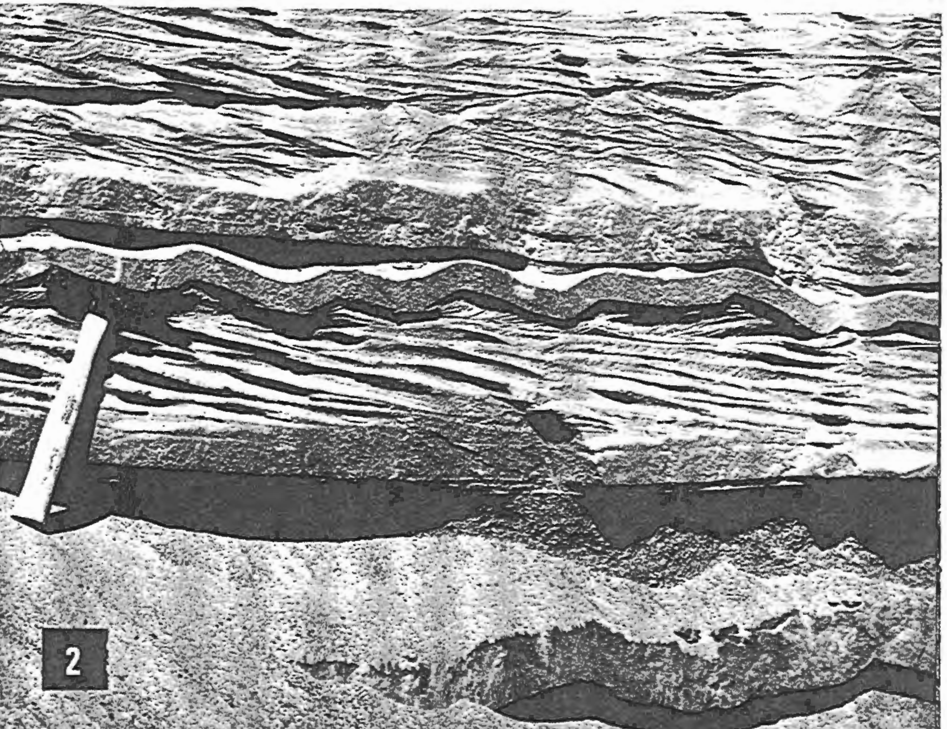
64.9 Intersection.

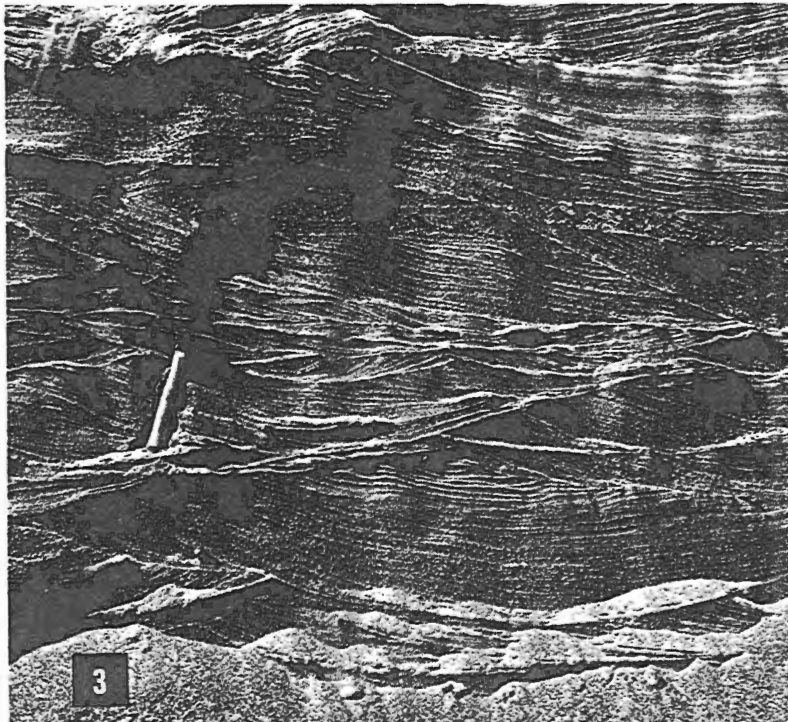
65.2 Crossroad.

66.1 Major sand and gravel pits occur on this ridge of glacial outwash material. In the pit to the left the big boulders thrown aside by the operators are of a considerable variety of Precambrian rocks that have come down from the north on the ice, and slabs of limestone and dolomite derived more locally. The pit on the right consists of exceptionally pure sands and, depending on where the day-to-day operations of the pit are located, Sedimentary features in the post-glacial sands at the sand pit two miles east of Stittsville.

1 and 2. Ripple lamination. Notice in 2 how several of the layers, perhaps slightly bounded together with clay, stand out on the surface.

3. Broad crossbedding.





you may see a variety of sedimentary features well illustrated in the cliffs of sand; ripply crossbedding, massive crosslamination, slump structures and others may be noted. In the major pit to the left you may see some evidence suggesting a readvance of the ice over the area because the top layer is often made up of very large boulders, quite different from the finer gravel and sands underneath.

67.7 Major intersection with Highway 15; turn left on Highway 15.

68.5 Abandoned quarry on left side of the road in rocks of the Ottawa Formation.

71.5 Dolomitic limestone outcrop.

73.3 Outcrop of mottled grey dolomite of the March-Oxford Formation at the southwest end of the road approach to the railroad underpass.

76.8 Intersection with the Queensway.
Proceed back to Ottawa by the route of your choice.

Trip 5. Short Trip Near Hazeldean, West of Ottawa

Time: Two to three hours.

Purpose: To see the Precambrian rocks, the Nepean and March-Oxford Formations and some physiography.

Mileage:

0.0 Start at the north side of Confederation Square. Proceed around the square and south on Elgin Street (leading directly away and slightly downhill from the War Memorial).

0.4 Turn right on Laurier Avenue (at the signs for Highways 7 and 15).

0.6 Turn left on O'Connor Street (two blocks). Proceed south on O'Connor until you see the sign for Queensway West.

1.3 Turn right onto Queensway West and follow Queensway.

9.0 Junction with Highway 15; turn left or southwest on Highway 15.

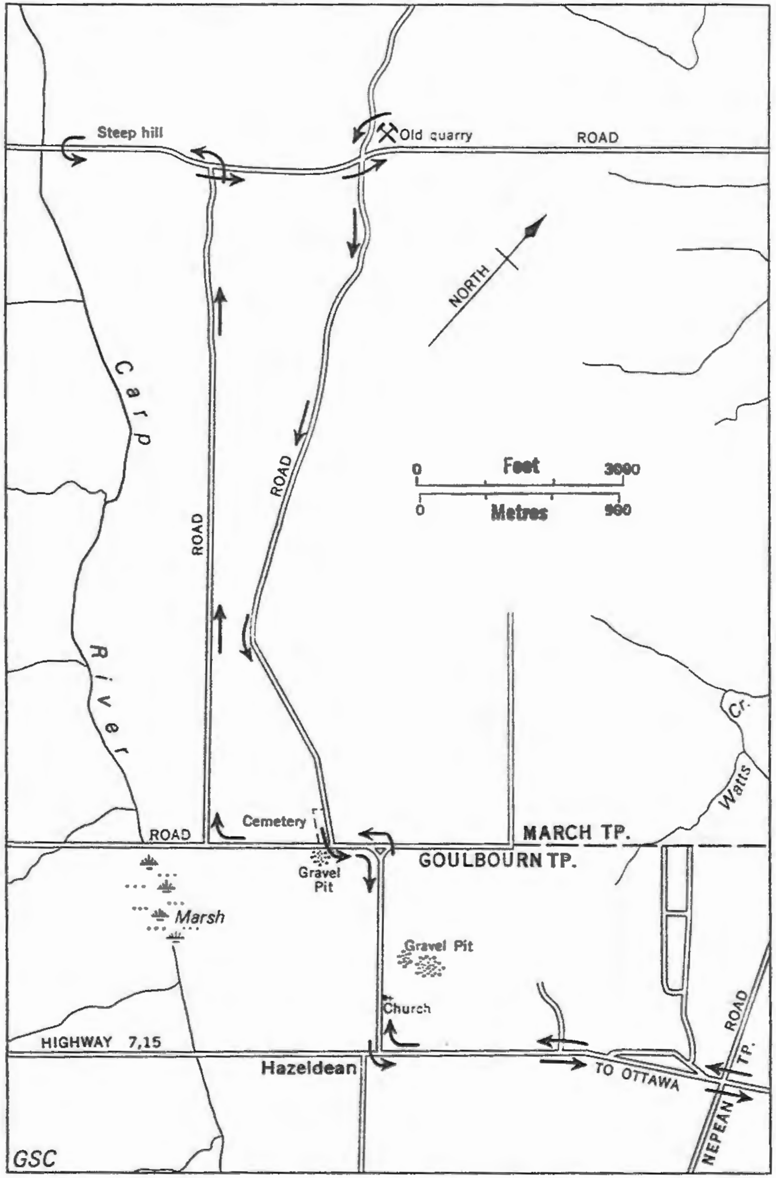
9.5 Abandoned quarry in March-Oxford Formation just to the north of the large house on the hill, to the left or southeast of the road.

10.1 Intersection with Baseline Road.

12.1 Railroad underpass.

12.3 Outcrops of March-Oxford Formation at the southwest end of the railroad underpass. Sandy and silty dolomites are grey with green and purple patches.

14.0 Outcrop of March-Oxford Formation to the right or northwest. Entry to Glen Cairn housing development



Trip 5. Hazeldean area

is to the left or southeast, large piles of boulders to the right.

14.3 Outcrop of March-Oxford Formation on both sides of the road. Dark, brown-grey sandy dolomite.

14.4 Hazeldean sign.

14.9 Anglican Church sign; turn right.

15.1 Anglican Church made of Nepean standstone.

15.2 Gravel pit to the right.

15.3 Top of hill; first outcrops and scatterings of Nepean sandstone boulders.

15.5 Crossroad; turn left.

15.6 Crossroad and cemetery; continue straight ahead.

15.7 Halfway down the small hill is a sand and gravel pit to the left or southeast. In several layers of the sand, small clam shells are found in place, which means that

Small pelecypod shells weathering out of marine sands, just northwest of Hazeldean.

this was at one time a shallow marine deposit. The view out over the flats ahead shows clearly where the ridge of Nepean sandstone on which we are situated gives way on the other side of a major through-going fault to younger, flat-lying limestones of the Ottawa Formation which were later covered by surficial deposits. The fault, just below the foot of the ridge, can be traced for more than 20 miles from where it is first recognized east of the Rideau River, west and northwestward through the Hazeldean area and beyond into the Carp district and perhaps as far as Fitzroy Harbour.

16.0 Crossroad; turn right on the flats. Along the next mile or so the ridge of Nepean sandstone on the other side of the fault stands up clearly to the right.

17.3 The flat gives way suddenly to rounded hills of Precambrian gneisses, shot through with granite dykes. These *bosses* or knobs of dense, tough rocks have been rounded in many places and their surfaces made quite smooth by the passing of the most recent glaciation. Note how these round glacial bosses or 'boiler plates' alternate with flat, grassy or swampy areas that seem to have been filled in between the ridges. Farming on this kind of land is very difficult as you can plainly see.

17.9 Crossroad. Outcrops in this vicinity are gneissic Precambrian rocks. On the weathered surfaces a clearly distinguishable layering stands out as ridges and hollows. Masses and clots of quartz and bright pink feldspar occur here and there in the rock. You may notice, too, the difference in colour between the weathered surfaces and the freshly blasted ones beside the road.

As a short side trip you can turn left and go for about a quarter to half a mile and see the fault scarp again, except that this time the scarp is of the Precambrian gneisses against the limestones of the Ottawa Formation on the flats below. It is particularly striking here with the very steep hill on the road. Turn around and go back to the crossroads where we stopped to look at the gneisses.

Proceed straight ahead if you took the side trip. Otherwise turn right (northeast) and go 0.5 mile to another crossroad and a bend in the main road. Just beyond this crossroad and to the left is an old quarry with heaps of waste in which good specimens of pink feldspar and glassy, white or milky quartz may be found in abundance. From the crossroad turn right or southeast off the paved road.

21.1 To the right are some excellent 'boiler plates', made by the scraping of the glacial ice over the Precambrian gneisses.

21.4 Edge of the Precambrian rocks, beginning of the Nepean sandstone (although you cannot see it below the covering of drift here). The country changes very sharply in character, however, and glimpses of the white Nepean sandstone can be seen where it outcrops on the rise on the other side of this slight valley.

21.8 Small quarry in Nepean sandstone to the right.

22.1 Another quarry of Nepean sandstone to the left.

22.3 Scarcely visible from the road is a series of quarries for flagstone and building stone, at the back of the field to the left.

22.4 Crest of the ridge of Nepean sandstone which occurs just below the surface all along here.

22.6 Crossroad; turn left.

22.8 Crossroad; turn right.

23.3 Intersection with Highway 15.
Return to Ottawa.

Trip 6. A Half-Day Trip East of Ottawa

Time: Two to four hours.

Purpose: To see Leda clay and landslip in it, terraces along the Ottawa River and in old abandoned channels in the Mer Bleue region, the Ottawa limestone, the Rockcliffe Formation, and scenery along the Ottawa River in the eastern section of the city.

Mileage:

0.0 Start at north side of Confederation Square. Proceed east on Rideau Street.

0.4 Turn left on Sussex Street (actual mileage to here depends on where you start on Confederation Square — Sussex is first street onto which a left turn from Rideau is permitted).

0.7 St. Patrick Street, go straight through.

1.1 Lady Grey Drive branches to the left. From here the view upriver shows the limestone cliffs at Nepean Point. A walk or drive down Lady Grey Drive will show cliff sections of the Ottawa limestone.

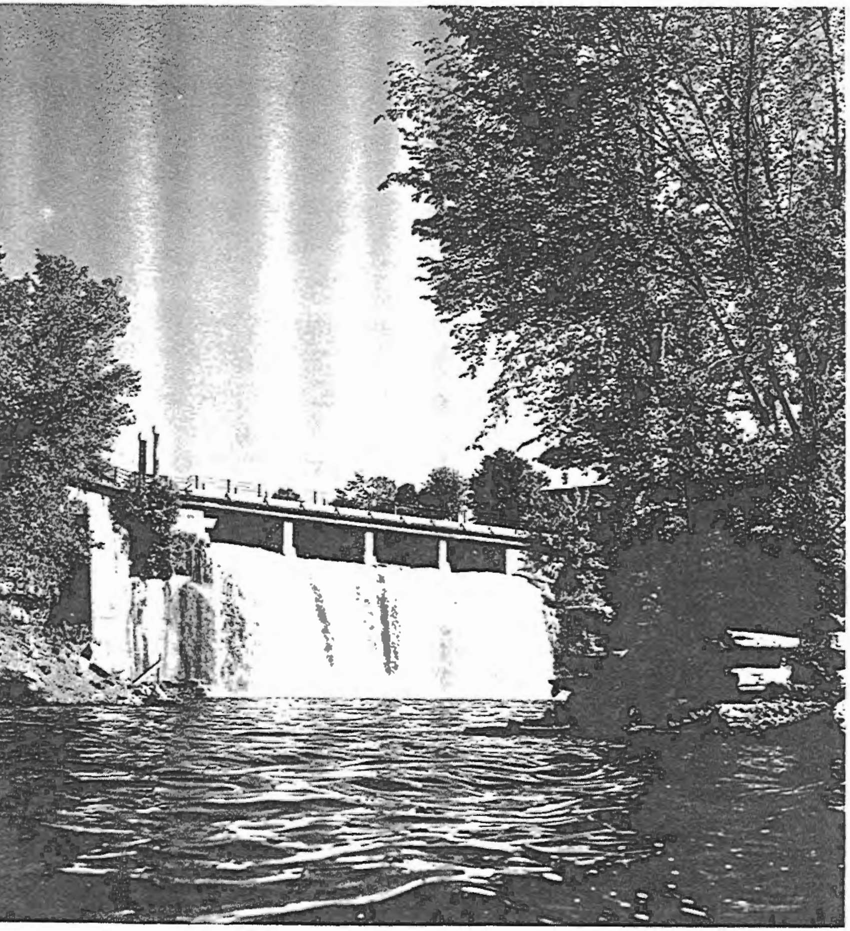
1.4 National Research Council. You may note the pale khaki sandstone (from Wallace, Nova Scotia) out of which this building is constructed.

1.3 Overpass to Macdonald-Cartier Bridge.

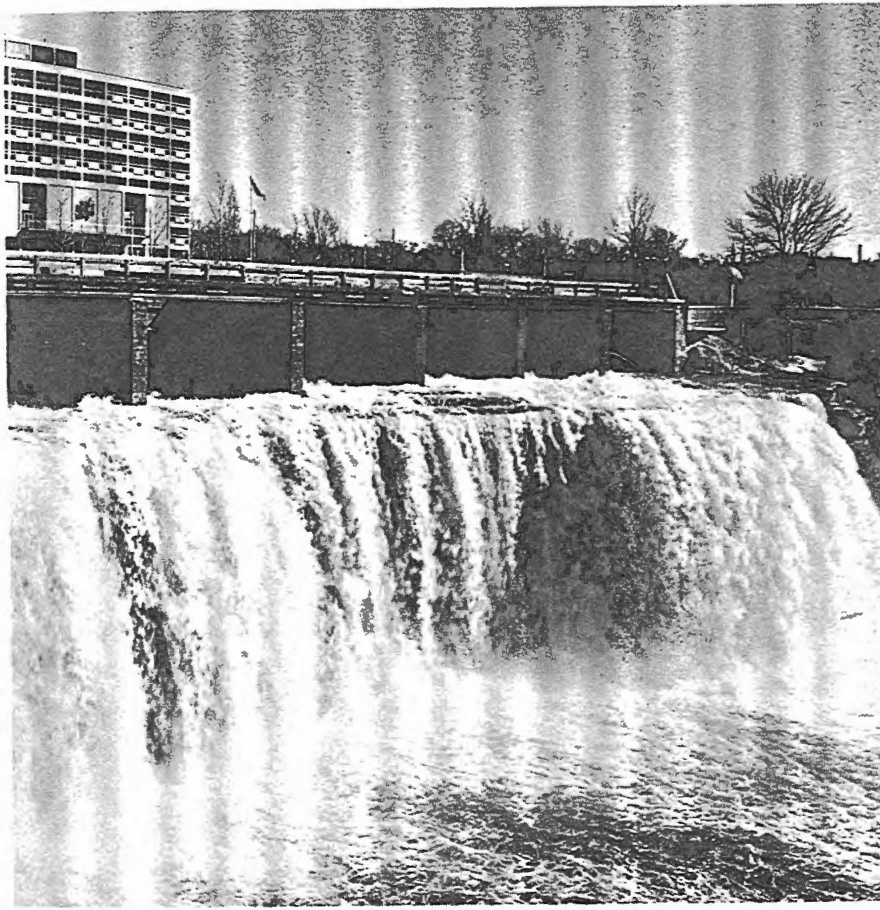
1.5 Bridge over the west branch of the Rideau River.

1.7 Rideau River bridge, east branch of river. Green Island and the Ottawa City Hall is in between.

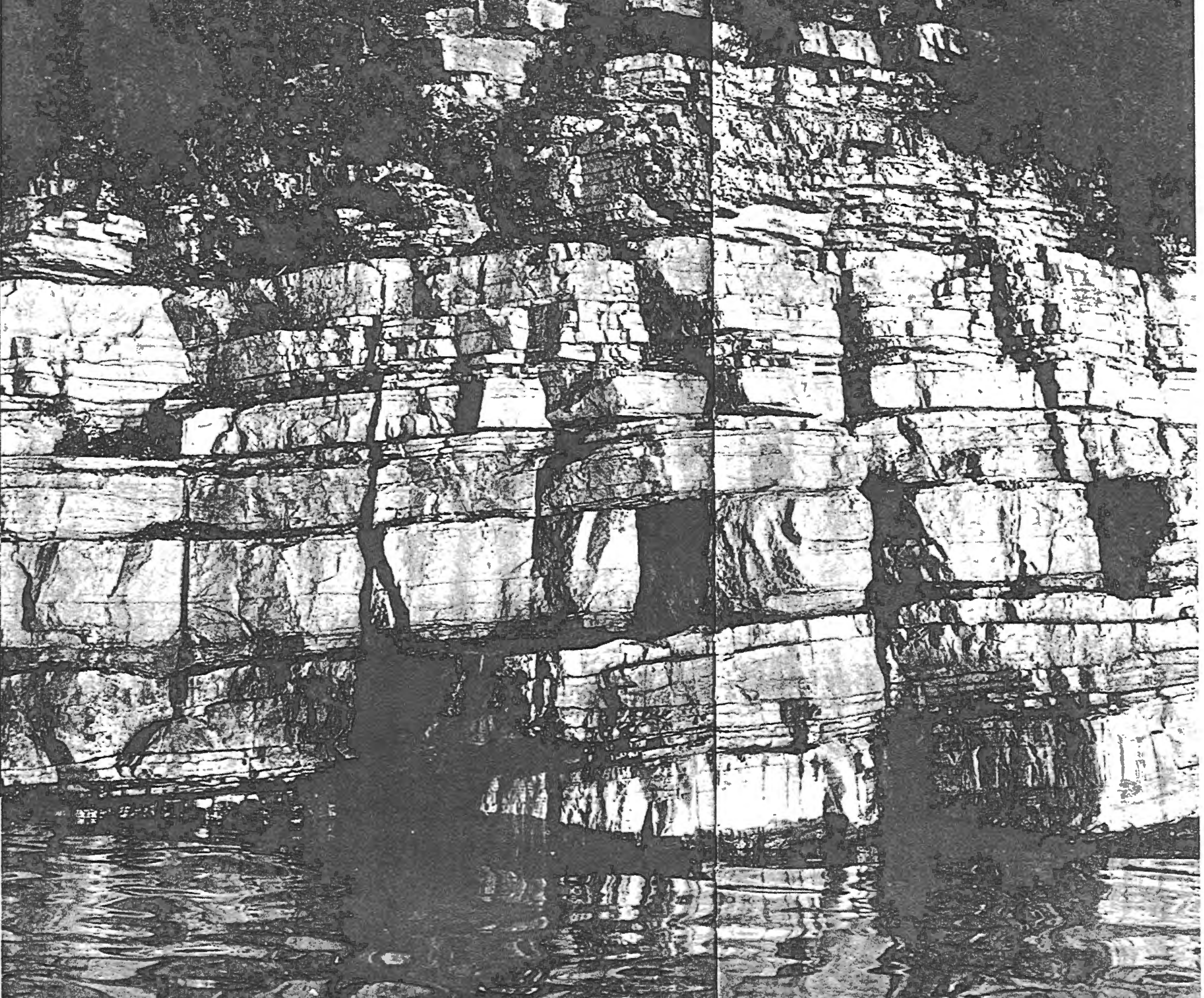
1.8 Intersection with road to Rideau Falls Park (left). A side trip of a few minutes is well worthwhile. Here the



The smaller of the two Rideau Falls on the west side of Green Island.



The main or eastern Rideau Falls in spring is a veritable curtain of white water as it spills over flat-lying layers of Ottawa limestone.

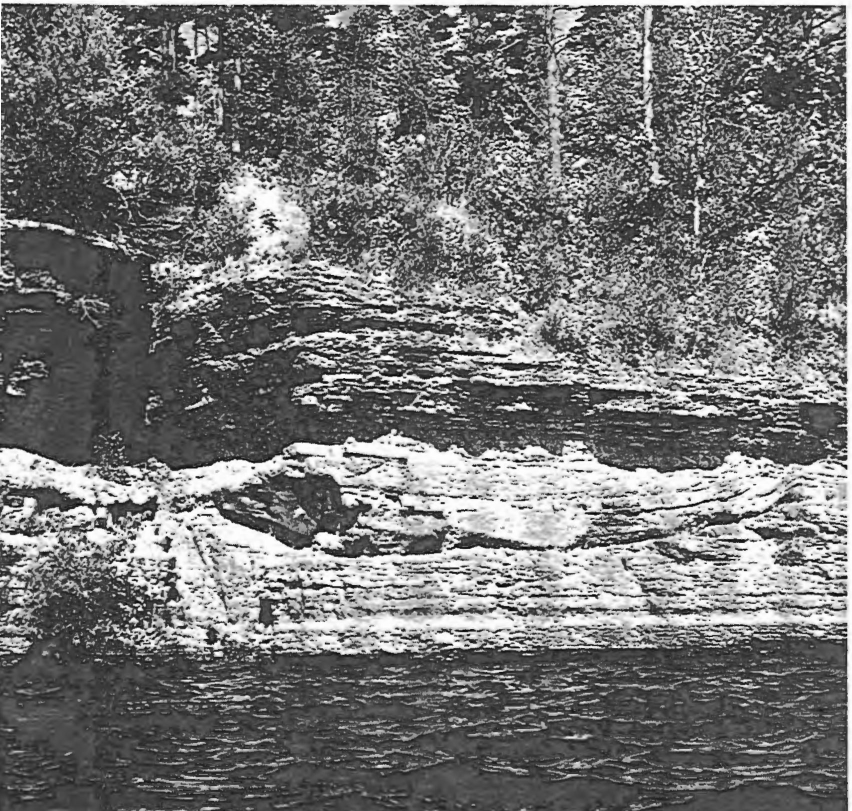


Bedding and jointing in the Ottawa lime-stone just below the Prime Minister's residence on the Ottawa River.

Rideau River plunges over cliffs of the Ottawa limestone into the Ottawa River below. It seems fairly likely from a study of the regional history that the Rideau Falls are a fairly recent addition to the scenery, having formed only after the Ottawa River had carved its present valley (see page 24).

2.0 Ottawa limestone outcrops under the fence of Government House.

Prominent 'scour and fill' in outcrops of the Rockcliffe Formation, just below Rockcliffe Park on the Ottawa River.



2.3 On the inside of the curve, outcrops of Ottawa limestone.

2.8 Lookout Point — good exposures of the Rockcliffe Formation are available here and along the road to the east. A walk down the small road leading downriver to the right and the Gatineau ferry will enable you to see exposures of the Rockcliffe Formation of quite a thickness. From this point the Gatineau Hills rise conspicuously to the northwest and the Ottawa River spreads in both directions. Large glacial boulders are visible in the woods and along the roadside at this section of the parkway. A view upriver shows a rocky point made of Ottawa limestone across the cove. The Gatineau River is opposite.

2.8-3.4 Cliffs of the Rockcliffe Formation expose limestone, siltstone, and minor shales.

4.1 Along the Rockcliffe Parkway here, a very flat area marks the lower terrace of the Ottawa River valley. Off to the left, and just below the parking areas, cliffs expose the grey, quick clays of the Ottawa Valley.

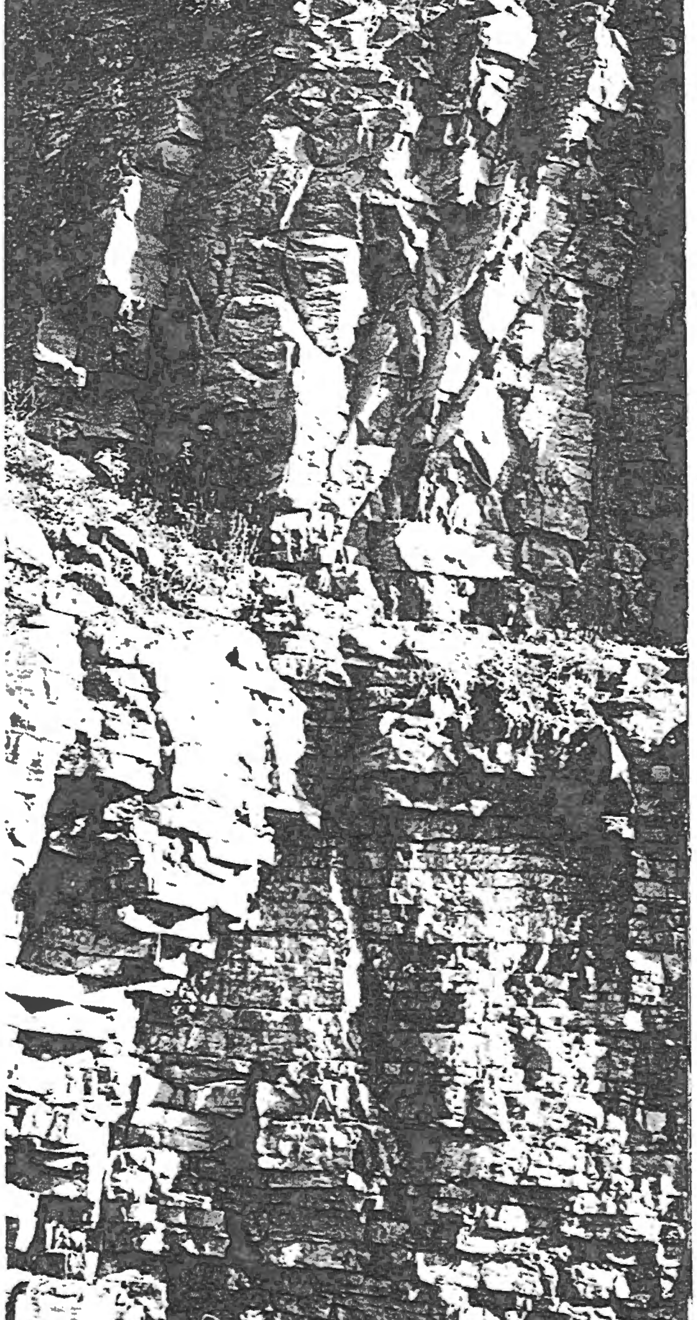
4.4 Intersection; turn left.

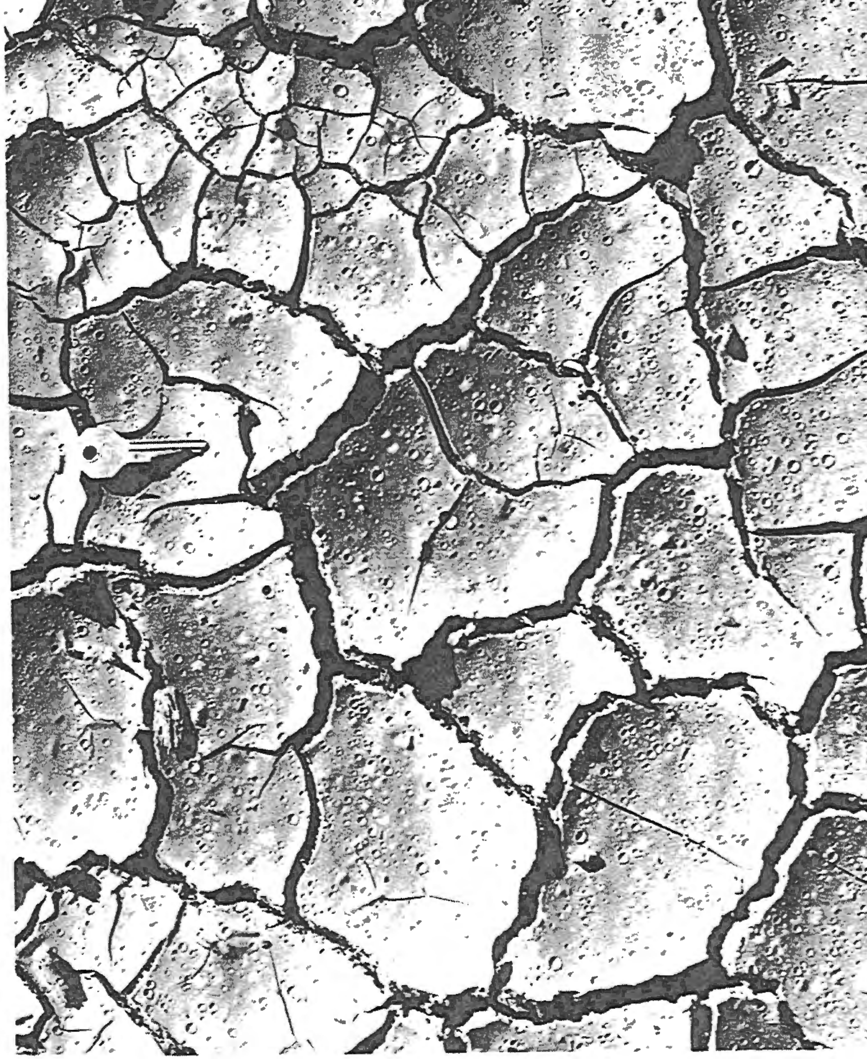
4.7 Main gate to Royal Canadian Mounted Police buildings; turn right (south) on St. Laurent Boulevard.

5.2 Airport road leads to the left and a view out over the flat terrace on which the Rockcliffe Airport is built. Continue south on St. Laurent Boulevard.

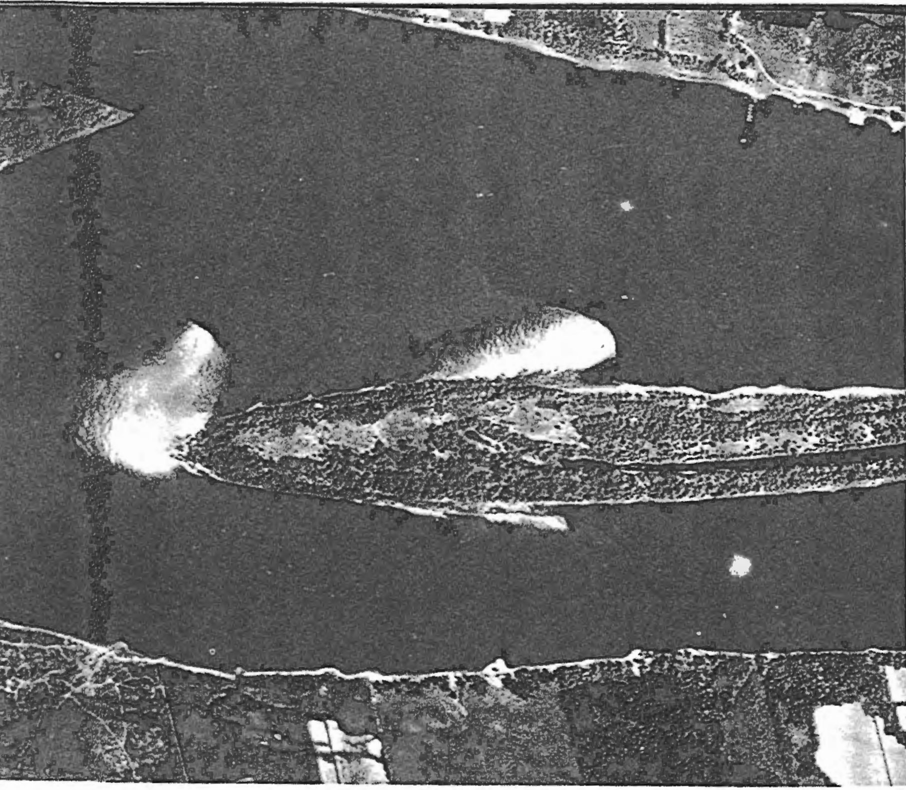
5.5-5.7 Many outcrops of the Ottawa Formation. This area has several old limestone quarries, some of which have had high-rise apartment buildings built right into them.

Thin-bedded limestone overlain by much more massive limestone, St. Laurent Boulevard.





Drying muds on a quarry floor show the mark of a passing shower, St. Laurent Boulevard.

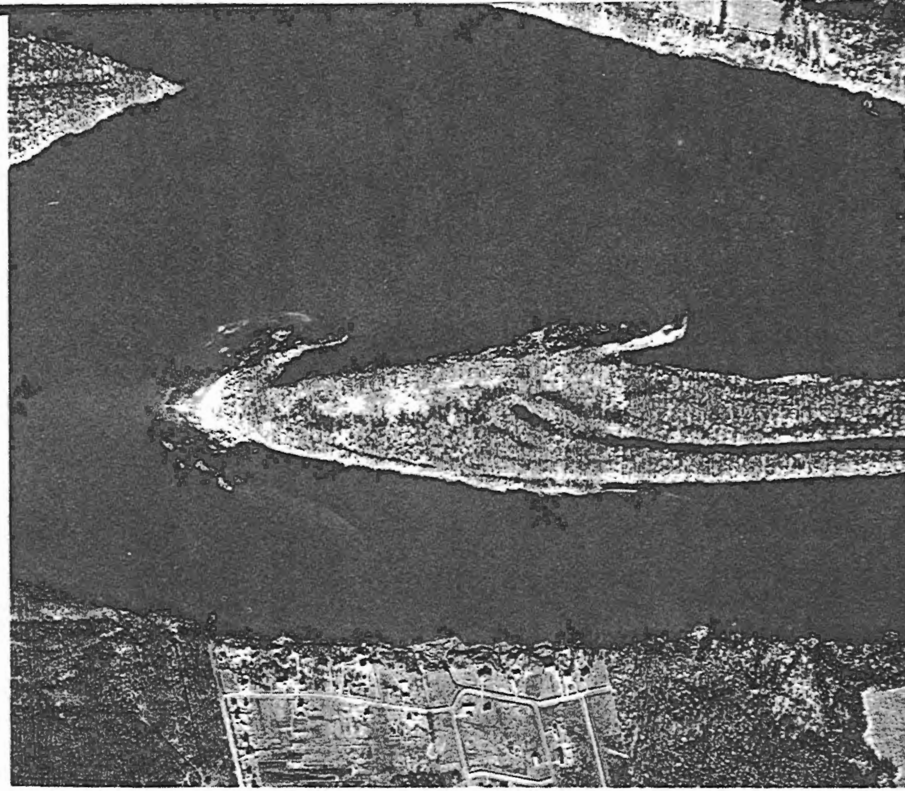


Duck Island, in the Ottawa River opposite the National Resear h Council and the lower end of Rothwell Heights, looked like this in the early 1920's.

5.9 Intersection; turn left (east) on Montreal Road (17).

6.0 Steinberg's (grocery market). Visible at the back of the parking lot is a low bank of fossiliferous shaly Ottawa limestone, also some of the upper dark shale (Eastview). Continue east on Montreal Road.

6.8 A deep quarry in the limestones of the Ottawa Formation lies to the right and the airport road leads off to



About forty years later Duck Island shows significant changes in the pattern of the sand (the white patches at the upper end and the sides). Small landslides have taken place along the lower shore.

the left. Limestone outcrops are abundant around here on all the side streets.

7.4 Main gate of the National Research Council. Limestone outcrops occur on both sides of the road.

7.6 Intersection with Blair Road.

8.4 Second terrace level is clear in the flat fields to the left. The road comes down onto this from the old rocky topography on the Ottawa limestone. The terrace itself curves around out of sight on the outside of this hill and extends well over toward Rockcliffe Park.

8.8 Opposite Miss Ottawa Motel. Views to the right or north show glimpses of the landslide scarp seen in the photo on pages 18-19. The hill opposite is on one side of the old backwall or lip of the landslide. The low area between the hills to the right and the high terraces on the left was made when a great quantity of clay was removed in the construction of the Queensway.

9.1 Junction of Lemay Road. The landslide toe lies in the field to the west of Lemay Road and below this position. It is visible by looking carefully in among the houses now built on it (the photo on pages 18-19 shows an aerial view just before the houses were built). The terrace here extends on around through to the community of Rothwell Heights. It is essentially a break in the edge of the terrace that accounts for the landslide (again see the photo, pages 18-19). Matching terraces on the other side of the river are visible in the distance across the Ottawa Valley.

9.3 Queensway or Highway 17 clover-leaf with old Montreal Road. Go under and take Highway 17 east towards Montreal. To the northwest across the flats the toe of the landslide is still visible.

9.8 Green Creek crossing. Clay banks are exposed here and the river meanders on its flat valley bottom (see

Streams cut dendritic patterns into the flat clay lowlands along the Ottawa River. When farmers come to clear and cultivate these areas the gulleys are often left wooded to make patterns like this on the face of the land. ▶

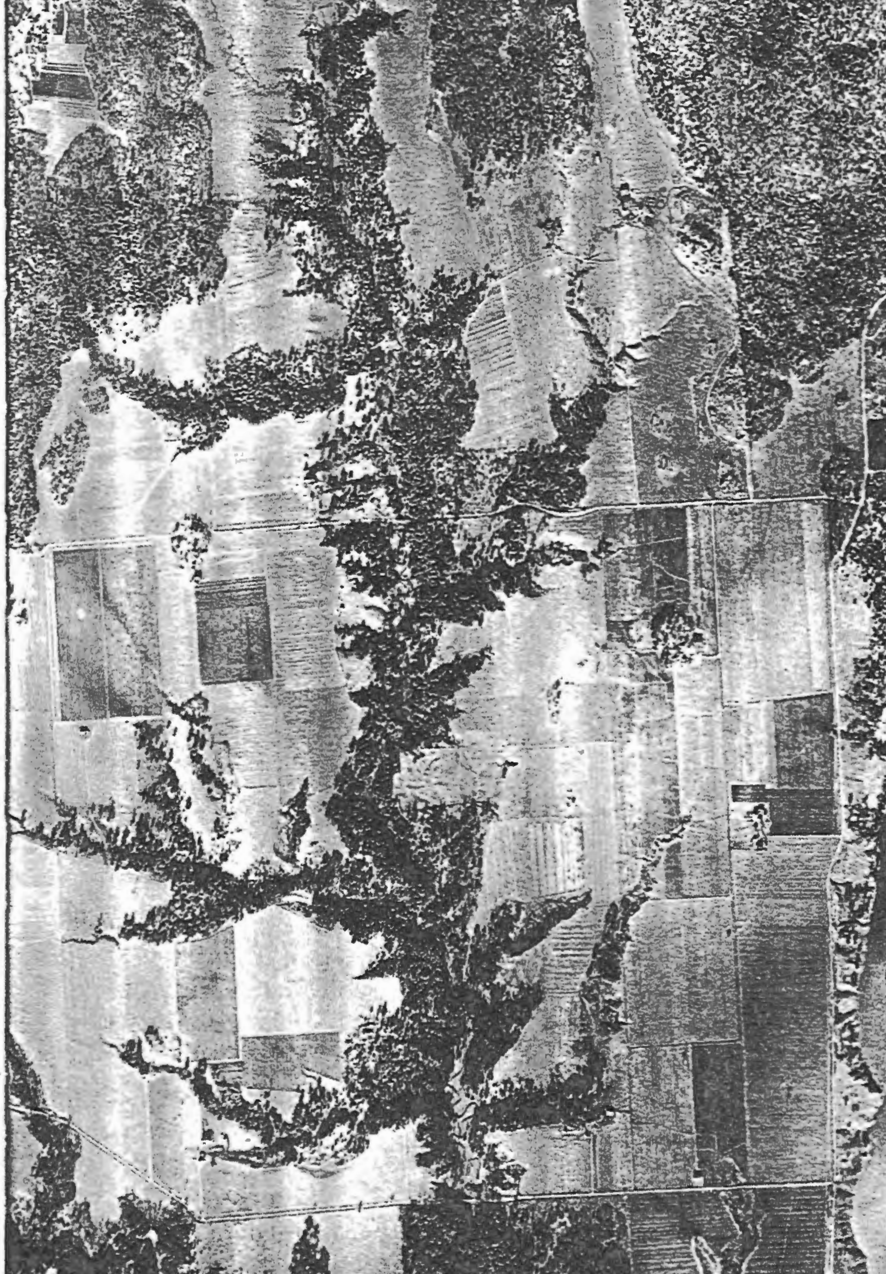


photo on pages 58-59). The power installation on the Ottawa River at Carillon has raised the level of the river high enough to back up Green Creek this far, which accounts for its lack of current at this crossing. Terraces are visible in the valley walls above here.

10.3 Junction of the old Montreal Road. Old railroad cuts just to the south (or right when you are travelling east) expose sandy beds of the Rockcliffe Formation. From here to mileage 11.0 you can see the edges of the flat terraces backed to the south or right by the steep fronts of the next terrace levels.

11.8 Branch road to Hiawatha Park. A side trip of a little less than a mile to the river bank presents excellent exposures of the clays that underlie most of this flat. Terraces are visible to the right or south all along this section of the highway; the village of Orleans is on the edge of one of them.

12.7 Outcrops of Ottawa limestone, with an old quarry ahead and to the right, and in the old railroad cuts nearby.

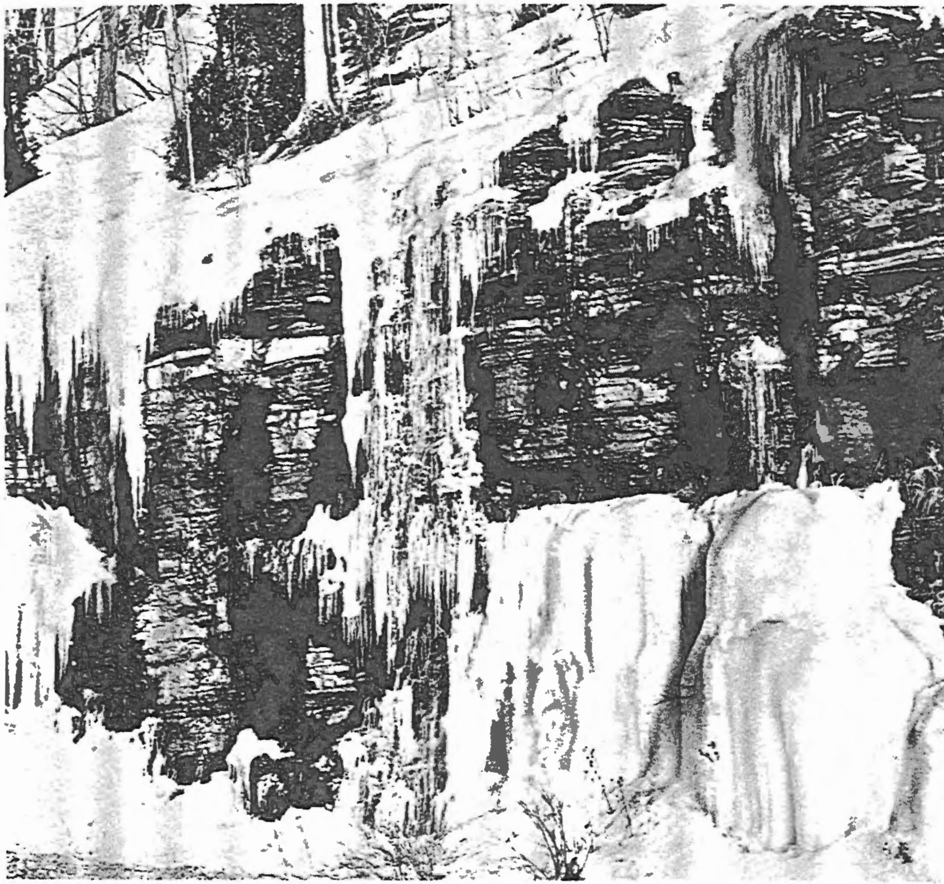
13.2 Junction with the east exit of Orleans.

13.8 Quarry in the Ottawa limestone, about 100 yards south of the old railroad.

15.3 Navan Road.

16.9-17.1 Rockcliffe Formation in cliffs and cuts up to 45 feet high. This locality has many beds or layers of heavy massive sandstone. Clearly exposed on the right-hand side of the old quarry as you look at it from the road is a fault of small displacement.

17.4 The major terrace comes right to the river's edge here.



An outcrop of the Rockcliffe Formation below the large quarry on Highway 17 between Orleans and Cumberland. Surface waters form the icicles along the top of the outcrop but the large masses of snow and ice in the lower right corner are from water oozing out of one of the bedding planes.

A light dusting of snow emphasizes the terrace beside Highway 17 about a mile west of Cumberland.

17.9 Rockcliffe Formation outcrops in road-cut to the right or south.

18.6 Picnic site. The village of Cumberland is just beyond and the dock of the Masson ferry sticks out into the river. Terraces are very beautifully shown just south of the highway between here and Cumberland. Across the river the flats at present river level give way to various terrace levels and eventually the Precambrian hills in the distance.

Turn around here and return along Highway 17 toward Ottawa.

20.4 Rockcliffe Formation quarry again.

27.1 Take the west entrance to Orleans (be sure to take the second road; the first one is one-way against you).

27.5 Junction with the old Montreal Road leading into Orleans. Continue straight ahead on the old Montreal Road.

27.6 Junction with road marked 'Quarry'; turn left.

27.9 Quarry gates. Outcrops on the outside of the quarry allow you to inspect in a general way the Ottawa Formation. Arrangements can be made with the operating company to go into parts of the quarry where many feet of the Ottawa limestones are well exposed, and, on top, superb glacial striae (see photo on page 56). The bottom part of the quarry exposes members of the limestone sequence of the Ottawa-St. Lawrence region known as the *Pamelia* and *Lowville formations;* the *Chaumont* and *Rockland* units occur higher up. (These limestones are all older than those exposed in the Canada Cement quarry in Hull, visited in the trip that follows.) Turn right at the quarry gates and follow the country road.

29.8 Junction of the Cyrville Road; proceed straight across the intersection.

30.0 Turn right at Kemp Road, just about opposite the school. Note the hill almost as soon as you start along Kemp Road. This is a back terrace of an old river channel, one of several that we cross in the next few miles. (See photo on page 27.)

31.0 Turn right at Renaud Road.

32.2 Turn left on Weir Road (County Road 42).

32.5 Railroad crossing.

33.0 Old river bank (see photo on page 27). We are now crossing an old channel of the Ottawa River.

33.6 Old river bank.

34.3 Old river bank. Junction of the Ridge Road just at the top of the hill; turn right. Along the next mile and a half the road wanders along the edge of this former island fairly close to the old river bank and you will get several views into the former channel to your right.

35.9 Junction; continue straight ahead.

36.4 Old river banks on the end of the island.

36.7 Railroad crossing.

37.0 Junction with Russell Road.

38.4 St. Laurent Boulevard.

39.9 Queensway; turn left to return to Ottawa.

Trip 7. Ottawa — Hull — Gatineau

Time: Two hours.

Purpose: To see cliffs of Ottawa limestone along the south side of the Ottawa River, extensive road-cuts in the Ottawa limestone and limestones in the quarry of the Canada Cement Company in Hull, terraces in several places, and extensive exposures of the Nepean sandstone on the north side of the Ottawa River.

Mileage:

0.0 Start at the north side of Confederation Square. Proceed east on Rideau Street.

0.4 Turn left onto Sussex Street. (Actual mileage depends on where you started at Confederation Square.) Sussex is the first left turn permitted, at the bank of traffic lights.

0.5 After you turn you may note the very large building on the left. The first storey and the extensive carvings and decorations around the handsome centre door are built from Stanstead granite. The upper part of the building is made of Nepean sandstone trimmed with sandstone from Wallace, Nova Scotia. The older building at the corner of Sussex and Rideau is made mostly of very large blocks of native limestone.

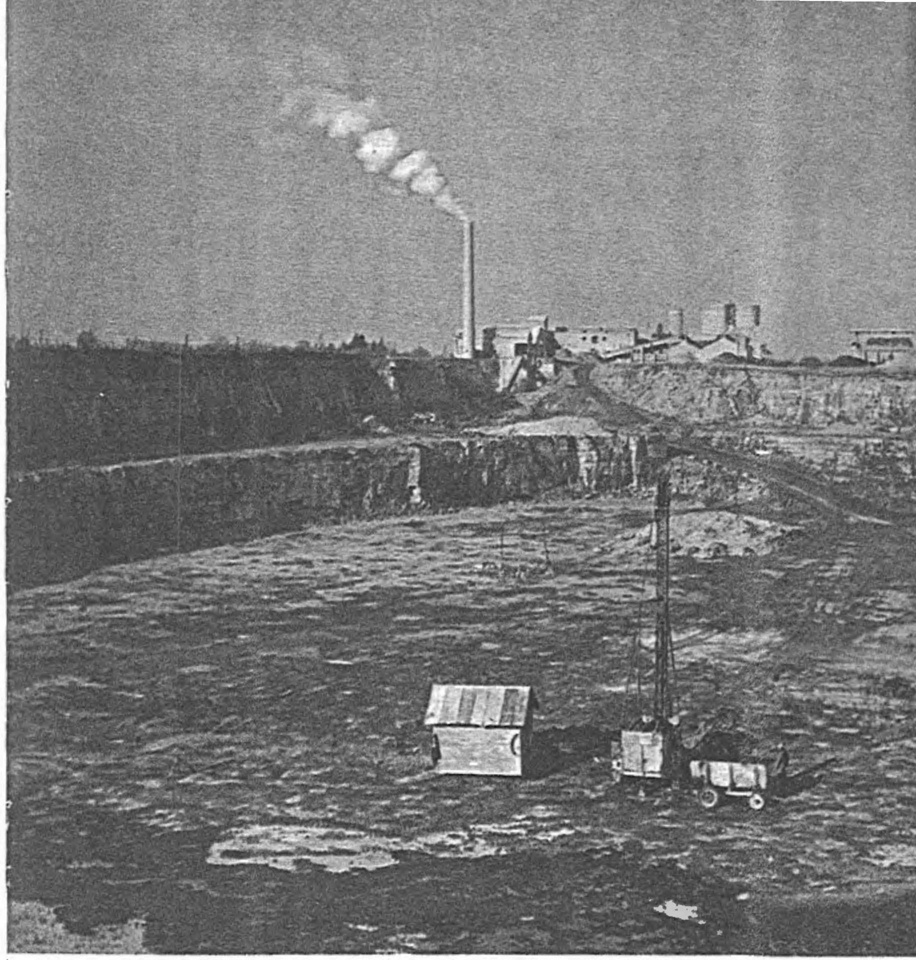
1.0 The Macdonald-Cartier Bridge and bluffs of Ottawa limestone at Nepean Point and other places along the river can be viewed from the open section just beyond the castle-like building, the Royal Canadian Mint (Nepean sandstone again).

1.4 National Research Council — this is built almost entirely of Wallace (Nova Scotia) sandstone except for the light grey Stanstead (Quebec) granite in the bottom storey around the lowest windows. Just beyond is the City Hall on Green Island in the Rideau River. This building is constructed of slabs of Indiana limestone with, once again, Stanstead granite making the lower level. Turn right to Hull via the Macdonald-Cartier Bridge.

2.1 From the middle of the bridge, views along the Ottawa River banks show several cliffs of flat-lying Ottawa limestone. The Rideau Falls are made where the Rideau River plunges over cliffs of Ottawa limestone into the Ottawa River. Depending on the season, the falls may be beautiful curtains of water or be almost completely dry. Ahead to the north the Gatineau Hills are on the horizon.

3.0 An excellent place to study limestones is in the extensive cuts in Ottawa limestone that occur along the main road here for approximately a mile. The very large quarry of the Canada Cement Company lies to the right and is the type location of the Hull Member of the Ottawa Formation. The lower level in the quarry is part of the darker, more shaly, lower Hull Member which makes cement almost in its existing state. The more massive limestones of the upper section, higher in calcium carbonate and lower in silica, need enrichment in the latter (crushed Nepean sandstone is used) to bring it to the proper composition.

From here follow Route 11 signs. (The indicated mileage and your route may change a little here



Cement is made from the limestones of the Hull Member of the Ottawa Formation, at the Canada Cement quarry on east side of Hull.

because of reconstruction of the road system. The Alonzo Wright Bridge will be marked so start again there if you notice changes.)

7.3 Turn right across the Gatineau River on the Alonzo Wright Bridge. Terraces are prominent to the left and ahead. Down the hill toward the bridge great banks of clay are exposed.

7.6 Centre of the bridge. The Gatineau flows over ledges of Precambrian rocks forming well-marked rapids just upstream. The banks of the river and the valley sides are very well terraced. These are clearly visible straight ahead. Turn right at the intersection ahead onto the road to Pointe-Gatineau (Rue Principale).

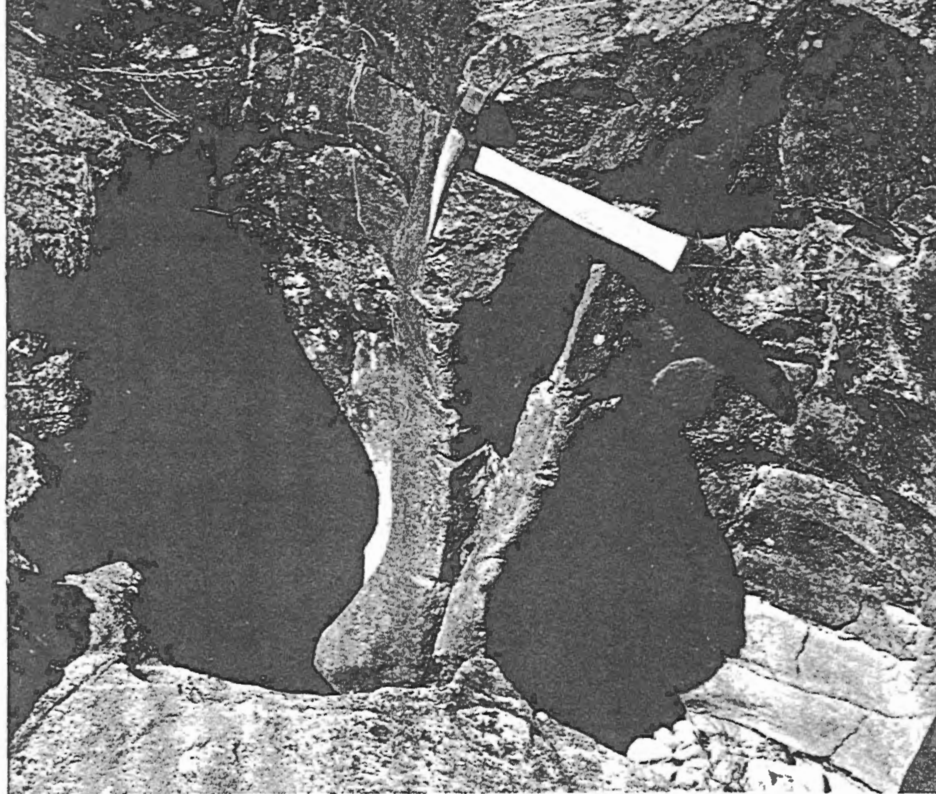
7.9 Road leaves the lower terrace and travels up over the edge of the next terrace, very well marked here. To the left an excellent flight of terraces is visible.

8.7 The view across the Gatineau River shows several terrace levels.

11.4 Pointe-Gatineau and the eastern end of the Lady Aberdeen Bridge; turn left onto Route 8 (Gréber Blvd.).

16.9 Leave the main road and turn left toward the 'beach' just before the construction tower. Nepean sandstone outcrops in the main road ditch just ahead. This road goes through almost continuous Nepean outcrops to the shore of Beauchamp Lake.

17.4 Beauchamp Lake. Nepean sandstone in fairly massive form occurs in the ridge with quarries of various sizes and ages scattered along it. Just beyond the edge of



Round pot holes bored into the solid rocks by current-propelled boulders, just above the highway crossing of the Lièvre River at Masson.

the Nepean ridge, Precambrian rocks outcrop, and the ridge boundary is the northern boundary of the Paleozoic rock plains to the south. You may note that the Nepean sandstone is not nearly as well bedded here as it is at the classic quarry localities in the vicinity of Hazeldean, nor is it anywhere nearly as white as in the best of those localities. Return to the main highway.

17.7 Route 8 again; turn right back toward Ottawa.

19.2 Main traffic light in Gatineau. As a side trip you may wish to turn right here and go 1.1 miles to the crest of the hill. When you get there you will realize at once that you are on top of one of the major terraces in the district, with a good view out over the river flats below. Return to Route 8.

20.4 Paiement Boulevard; turn right.

20.9 Intersection with the second concession road (called 'Blvd. St. Rene Ouest' on the other side leading toward Gatineau). From the intersection you may notice that the terraces are in excellent view from here. The edges have been cut into and, in or two places, such as to the right below the major gully, a delta has been formed at the old shoreline level. Turn left along Blvd. St. Rene.

21.2 Power line crosses. The ridge right here marks the outcrop of Nepean sandstone. You may note the abundance of boulders of Nepean sandstone in the fields.

21.5 Nepean sandstone outcrops occur intermittently along the road this far and continue off to the right for some distance, where they seem to merge with the terrace.

22.3 Turn left at the crossroads onto St. Antoine.

23.2 Main road again (Route 8). Return to Ottawa along Route 8 and the Macdonald-Cartier Bridge.

Trip 8. South of Ottawa:

Dows Lake — Hog's Back — Uplands

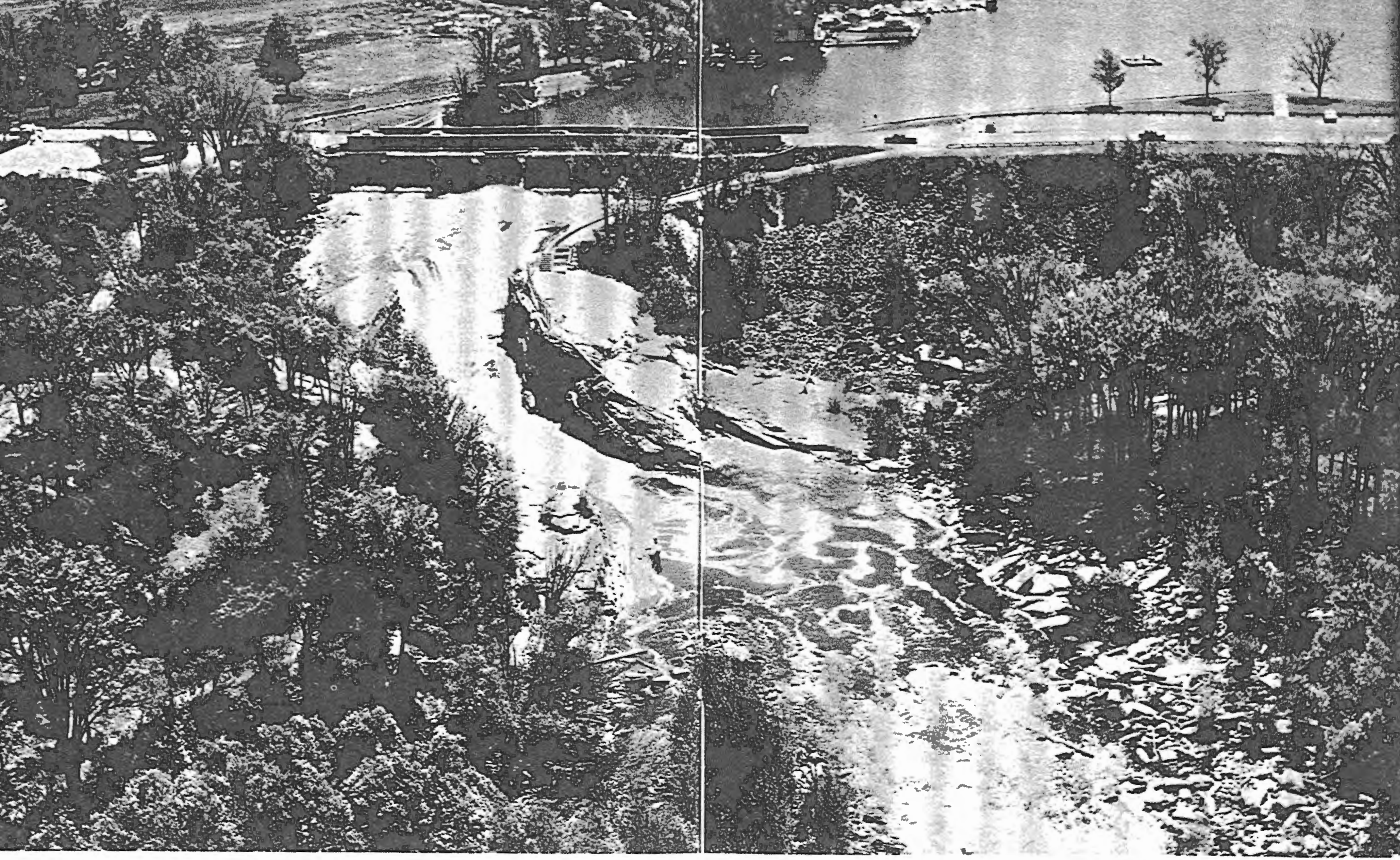
Time: About two hours.

Purpose: This trip takes in a part of the Rideau Canal, complicated rock structures of Ottawa limestone and the Rockcliffe Formation at Hog's Back, the effect of faulting on the flat-lying sedimentary rocks in the Ottawa area, old quarries used during the construction of the Rideau Canal, superb terraces around Mooneys Bay, large sand pits developed in deltaic and shallow water environments of the *Champlain Sea,* old sand dunes, and flat-lying and tilted limestones of the Ottawa Formation.

Mileage:

0.0 Start at Colonel By Drive at the intersection of the ramp from Bronson Avenue, southeast corner of Dows Lake. This may be reached from the centre of Ottawa by proceeding west on Wellington Street from Confederation Square to O'Connor Street and south on O'Connor to Somerset Street (10 blocks); turn right and go west on Somerset to Bronson Avenue; turn left and proceed south on Bronson Avenue for about 1.3 miles to the bridge over the canal. After crossing the bridge take the turnoff to Colonel By Drive.

It may be noted here that the bank on the north side of the canal is quite steep. Outcrops along here are of Ottawa limestone on the higher ground, and principally shales on the lower ground including Dows Lake and the flats northward to Nepean Bay and southward to the Rideau River and beyond. Across the lake the



The dam and overflow at Hog's Back. The natural course of the river before installation of the canal system was to the right in the valley bottom.

higher ground once again is Ottawa limestone, this time lying on the west side of a large, through-going fault that extends northward across the river and southeastward for twenty miles. It is this same fault that makes the upended rocks at the rapids behind Carleton University, and a branch of which makes the sharply uptilted rocks at the corner of the Walkley and McCarthy Roads (to be seen later in this trip).

Proceed southwest and southerly along Colonel By Drive.

The very first section after you leave the clover-leaf runs along a dyke-like fill that was originally put here by Colonel By and his engineers in the late 1820's to maintain the level of the canal. He flooded a cedar swamp to make what is now Dows Lake, and when the canal is drained in the late fall you can still see some of the original stumps. An extension of the old swamp to the south has recently been filled to make a large flat open area. Cutting through it on the southwest is the sunken railway, and the excavation has exposed fossiliferous black shales and grey limestone. When this cut was being put through in 1964 and 1965 the blocks of black shale thrown out made for excellent fossil hunting, with numerous trilobite tails and heads on many of the bedding surfaces.

0.5 Terraces to the right across the canal are now quite conspicuous on the skyline. The Hartwell Locks raise the level of the canal up to the next terrace level.

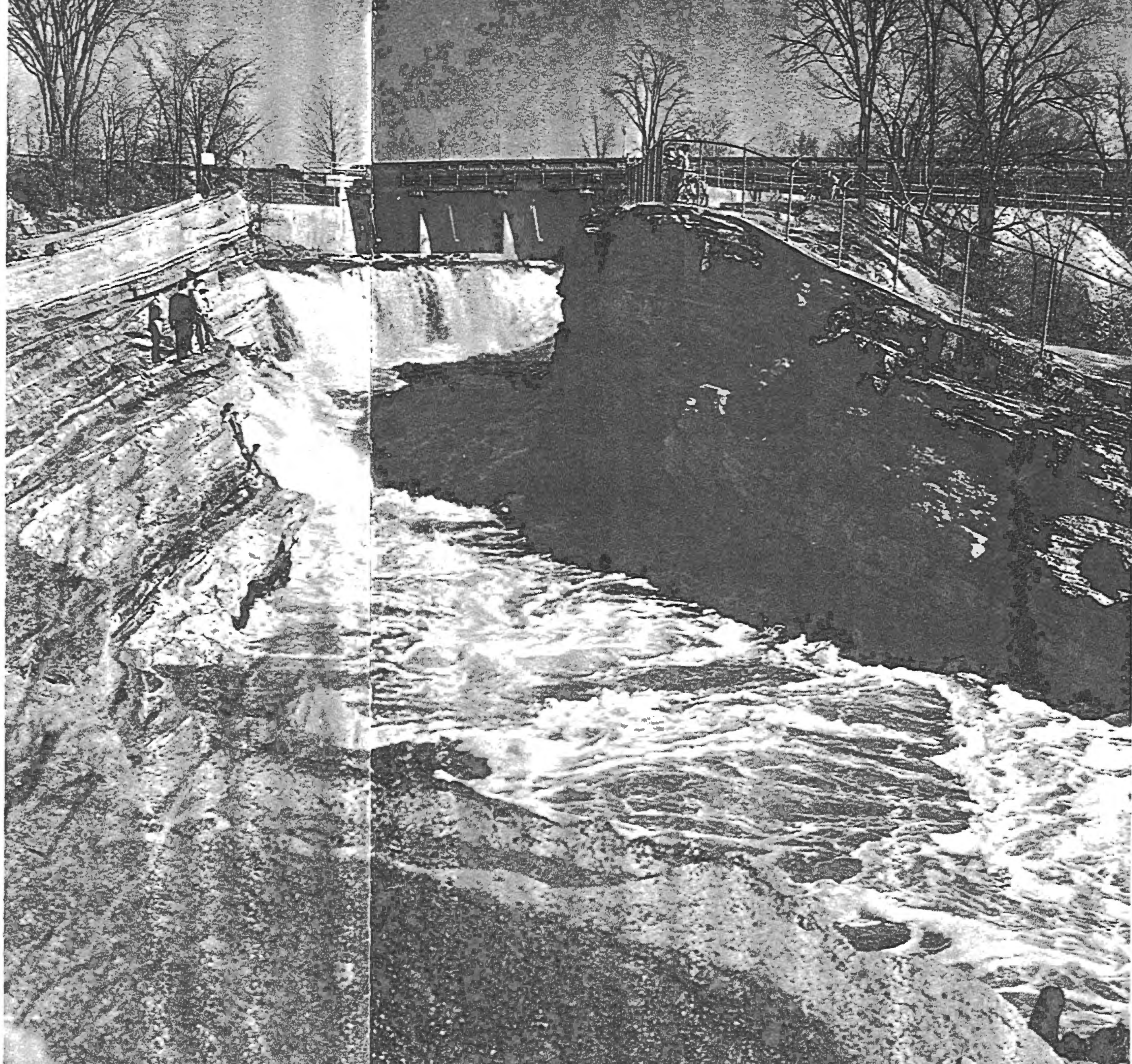
1.3 Heron Road Bridge over the Rideau River and canal.

1.6 An excellent view of the falls at Hog's Back (Prince of Wales Falls) and the dam system that holds the river back here. The locks raise and lower the boats between the lower level and the dam-held upper level on the right.

A closer inspection of the falls shows quite clearly that the present outlet of the river is through a breach in sharply tilted and broken rocks. A well-marked terrace is to the right.

1.8 Intersection with the Hog's Back Road. Drive across the road and into the parking lot. Looking up Mooneys Bay from here you will see conspicuous terraces to the west side of the bay (the right side, as you look at it). Mooneys Bay was made by the original canal builders when they dammed up the course of the river to back up the water and make smooth navigation. You can get an idea of how much the river has been expanded here by being backed up by looking at it when the level is allowed to go down for the winter months. Proceed out of the parking lot and eastward.

2.0 Hog's Back parking lot on the left. Park here and walk down to the falls. The region of the Hog's Back Falls is criss-crossed with small faults and the rock structures are thus complicated. The bank at the back of the east side of the river is in Ottawa limestone, and has some small quarries used at the time of the original canal building. The shaly and sandy rocks around most of the falls area are of the Rockcliffe Formation. By going down to the lower end of the falls and looking upstream you can see how the rocks are bent, twisted,



The falls on the Rideau River at Hog's Back spill into this new gorge with the broken and tilted, layered sedimentary rocks on each side.

and broken by faults so that the layers on the two sides do not match. Back across the bridge and down the west side you can see ripple-marked surfaces of the Rockcliffe Formation. Here you can walk on the curving surfaces of the folded rocks.

A few minutes walk downstream on the east side of the river you reach a series of rapids below the bridge,

Rapids in the Rideau River beside Carleton University are made on the upturned edges of units of the Ottawa Limestone marking the trace of the Gloucester fault.

opposite Carleton University and just above the railroad bridge. The rocks here are the upturned edges of layers of Ottawa limestone, marking the proximity of the Gloucester fault, traceable for many miles across the country (see the geological map).

Continue east on Hog's Back Road after leaving parking lot.

2.1 Old quarries and faces of limestone on both sides of the road. Limestone was quarried here for the original Rideau Canal by Colonel By and his cohorts in the 1820's.

2.2 Intersection with Riverside Drive; turn right.

2.7-3.1 Open views across Mooneys Bay show excellent terraces on the west side. At and near the upstream end of the bay, where the river bends, two terraces are clearly visible with the lower one developed on the corner. The small valleys coming off the upper terrace make conspicuous nicks in its edge.

3.1 Walkley Road intersection; continue along Riverside Drive.

3.5 Riverside Drive moves from the lower terrace level to the upper terrace level in the hill here.

4.0 Railroad crossing.

4.5 Road intersection; turn right (opposite Sunoco station).

4.6 Beginning of large sand pits over the bank to the right.

4.9 Huge pits to the right with the Rideau River beyond.

5.1 Intersection of Hunt Club Road; continue straight ahead.

Erosion pattern and micro scree slopes, Uplands sand pits.

5.3 Road leading down into one of the sand pits. If you want to walk down here you will be able to collect small clam shells, occasional barnacles and other shells that show that this was at one time a marine shoreline and shallow near-shore area. Back up on top you may observe the Uplands Airport, one of the very large ones in Canada, built on the flat. Turn around here, and return along the same road.

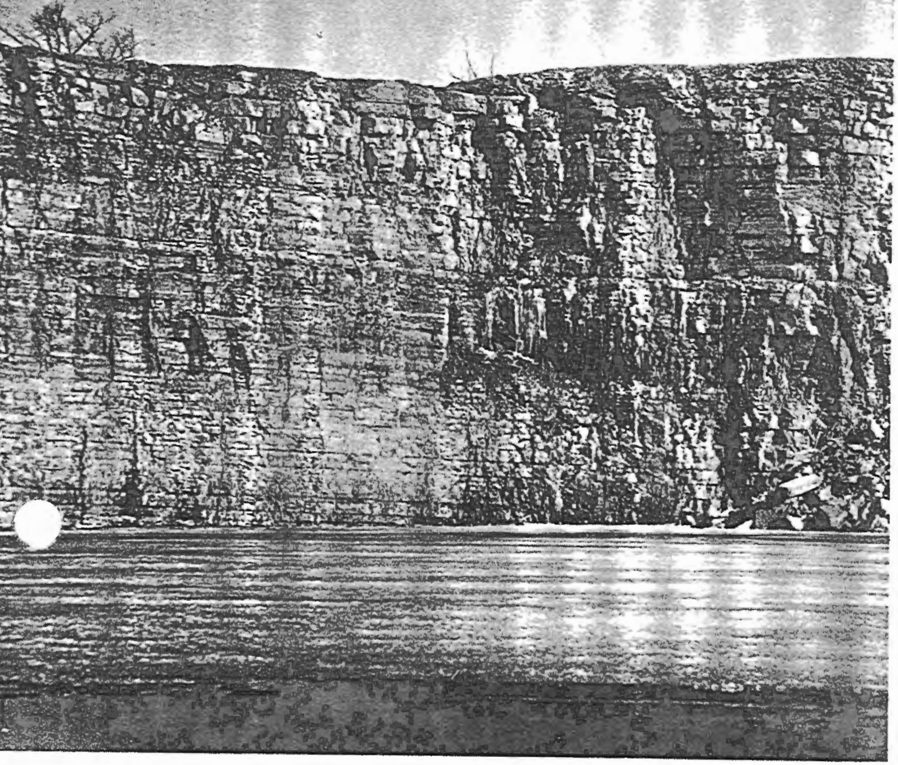
5.6 Intersection of Hunt Club Road; turn right.

6.0 Intersection with road into military part of the airport; continue straight through.

7.2 Stop 100 yards before the intersection with the McCarthy Road leading to the airport on the right. From here, gently rolling dunes are visible in the fields to the right. These were formed by wind-blown sands when the area was freshly exposed following the retreat, a few thousand years ago, of the vast post-glacial sea that flooded this region. You may drive a few hundred yards up towards the airport and see the orange-yellow dune sand in the low cut and in the ditches there. Otherwise, turn left at the intersection and go north on McCarthy Road.

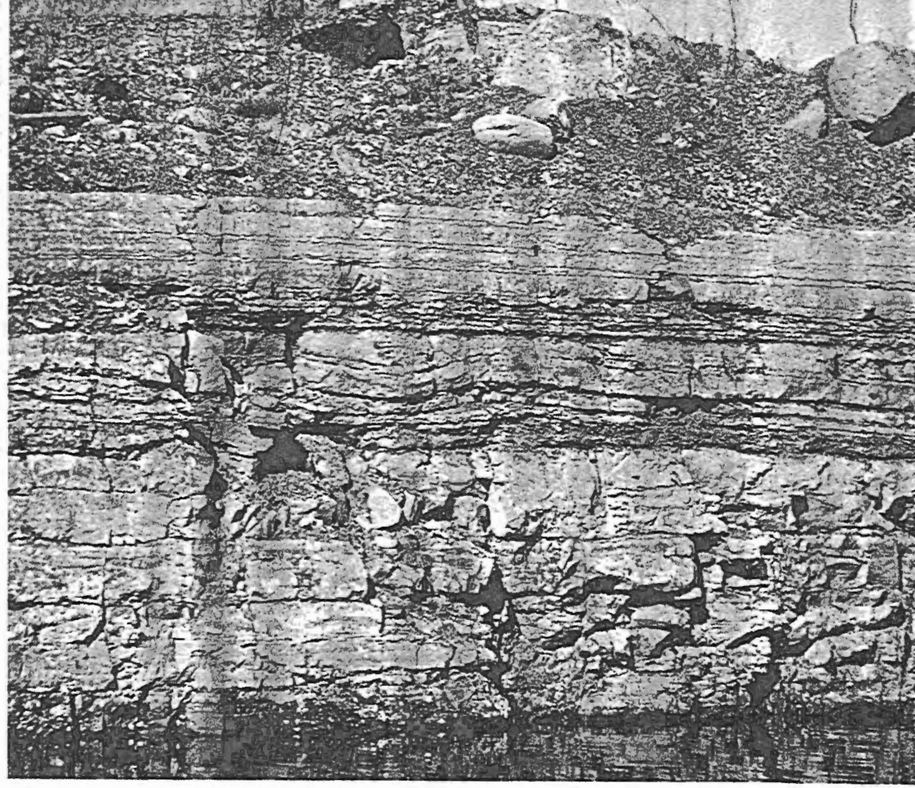
7.8 After a gradual rise you arrive at the crest of a limestone hill. Low cuts in the ditches show flat limestones. To the right, just over the edge, is a quarry from which a large tonnage of Ottawa limestone is extracted each year. Note carefully that in this section the limestone is flat lying, with the horizontal layering undisturbed except by occasional joints.

8.2 Railroad crossing.



This large quarry on McCarthy Road shows the very regular bedding or layering and numerous small joints in the Ottawa Limestone.

8.6 Sharply marked limestone hill with steep road-cuts on each side. Note carefully that the Ottawa limestone dips or slopes to the north at 30 to 35 degrees in this section. A study of the geological map will show that this spot is immediately adjacent to a fault system related to a major through-going fault (the Gloucester fault) that extends from the Hull side of the Ottawa



In this closer look at the bedding in the quarry, flat-lying, even-bedded limestone units with shaly layers are overlain by glacial debris. This is south of the fault zone where limestone beds stand up on edge.

River, through the area near Dows Lake, across the Rideau River at Carleton University, through this area and off to the southeast for 20 miles. Just to the east of here it brings together limestone of the Ottawa Formation on the west with the younger shales higher up in the section to the east.

Ottawa Limestone tilted up on edge marks the trace of the fault system across McCarthy Road. Note the gently dipping or sloping surface of breakage near the top of the outcrop and the minor bending about half way up the cliff.

8.7 Walkley Road. You may return to downtown Ottawa either by (1) turning left and driving a little over half a mile to Riverside Drive at Mooneys Bay, then turning right and returning along the route of the first part of this trip; or (2) by turning right and driving a little less than a mile to Bank Street, then turning left and proceeding straight into town on Bank Street.

PARTICULAR FEATURES AND WHERE TO SEE THEM

Surficial Deposits

Clays

Rockcliffe Parkway, below parking lots near the (eastern) Manor Park end.

Ottawa River banks at Hiawatha Park, off Highway 17, north of Orleans.

Green Creek, between Cyrville Road and Queensway crossing.

Rideau River just above Mooneys Bay; below dam and spillway, south end of Long Island.

Sands and gravels — mostly washed glacial debris

Pits just west of Stittsville junction (Highway 15) and road northwest to Carp (marine beach deposits).

Uplands Airport area, opposite the airport on the west side, off Riverside Drive (*Champlain Sea* sand).

Pits off Mountain Road, northwest of Hull (alluvial sands).

Constance Bay sand hills.

Bearbrook area, southeast of Navan (glacial outwash).

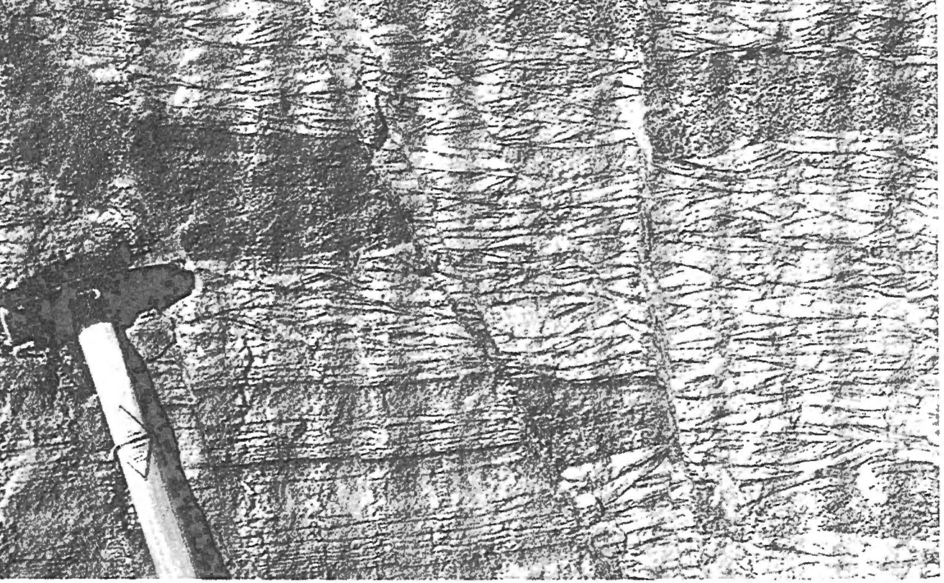
Peat

Mer Bleue (just east of Ottawa).

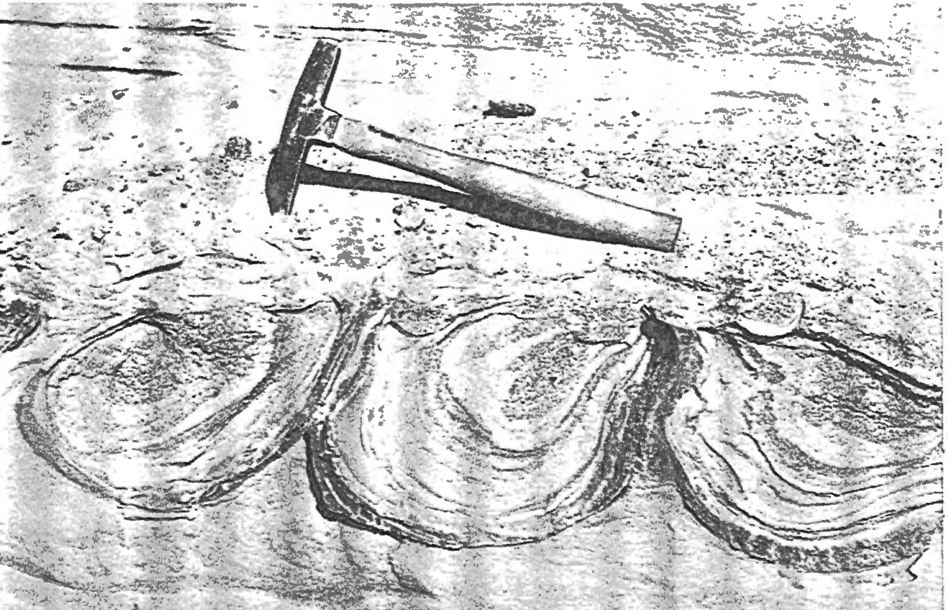
Stabilized Dunes

Hunt Club Road and the airport road near uplands.

Conroy Road east of Blossom Park and southeast to Hawthorne Road and beyond.



Post-glacial features displayed in the wall of the sand pit just off the Mountain Road. In the top photograph, finely-laminated and cross laminated sands have been slightly offset along tiny faults. The bottom photograph illustrates slump structures.



Surface Features

Terraces and old shorelines

Gatineau-Templeton and eastward to Masson, north of Route 8.

Green Creek-Orleans area.

Highway 17, one to three miles west of Cumberland. Blackburn-Navan area and south.

'The Ridges', west end of Mer Bleue (abandoned river channels, shorelines and islands).

Route 8, Breckenridge to Luskville.

Escarpments (fault or fault lines)

Eardley escarpment (best seen from near Luskville or from Champlain Lookout on the Gatineau Parkway).

Small roads, one to three miles northwest of Hazeldean.

Rock Formations

Gloucester-Collingwood-Lorraine Formations

Rideau River — at low water at several localities between Billings Bridge and Queensway crossing.

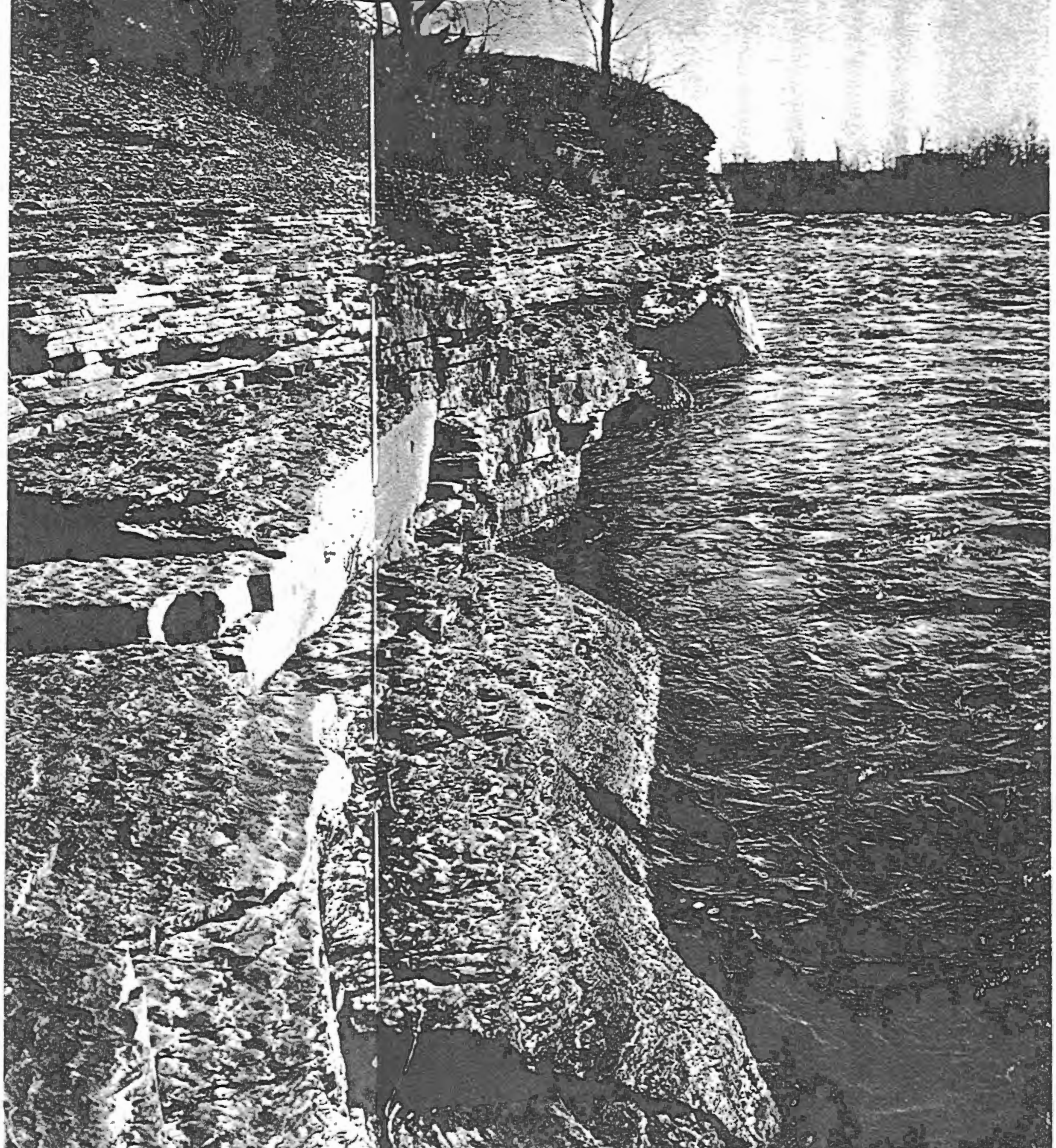
Construction sites in eastern and southeastern sections of Ottawa.

Cyrville road at Green Creek.

Ottawa Formation

Orleans quarry — southeast of the old Montreal Road at the Orleans turnoff.

Frazer Duntile quarry — in city of Ottawa, Clyde Avenue south of Carling Avenue.



Flat-lying Rockcliffe Formation at Deschênes on the north side of the Ottawa River.

Blue-green, lime-rich waters fill partly abandoned quarries west of Aylmer.

Ottawa River cliffs — below Parliament Buildings, accessible from the lowest lock area of the Rideau Canal; and below Supreme Court Building, accessible from the lower parking lot on both sides.

Canada Cement quarry — Hull, north and east of Route 11. Quarries north of Aylmer, Quebec.

Highway 17 — outcrops along the road for several miles between the bottom of the hill southeast of Antrim and to within a mile or so of the junction with Highway 44, south of Carp.

Montreal Road — several old quarries east of Eastview.

Rockcliffe Formation

Rockcliffe Parkway — cuts above and below road; road down to Gatineau ferry landing.

Rockcliffe Airport — road-cut on way down to airfield from upper levels; and cliffs along the scarp to the east from the foot of the hill.

Highway 17 — road-cuts and high wall (partly quarried) on southeast side of road near where it comes close to the Ottawa River, approximately 8 miles east of Ottawa.

Deschênes Rapids — both sides of the river. Best exposures are on Québec side, accessible from the main road through Deschênes village from Route 8.

Ottawa River — abundant outcrops on both shores, 4 to 6 miles west of Aylmer.

Ottawa River — opposite Quyon and eastward on the south shore.

Hog's Back — in and around the waterfalls area.

March-Oxford Formation

Both sides of the highway through Dunrobin, from near the turnoff on Highway 17 to ½ mile southeast of railroad crossing.

Highway 15 — road-cut (low) at west end of railroad underpass, 2 miles west of Bells Corners, and again near Hazeldean.

Highway 15 — old quarry 1½ miles southwest of Queensway.

Nepean sandstone

Highway 17 between South March station and Carp, both sides.

Hazeldean area, northwest of Highway 15.

Old quarries east of Gatineau.

Lièvre River at Masson.

Area west of Bells Corners.

Precambrian Rocks (Grenville Type)

General

Field trip on page 105.

Gatineau Parkway field trip on page 87.

Grenville Marbles

Gatineau Parkway about 2 miles north of Route 8. Road-cuts about a mile southeast of Fitzroy Station on way to Carp.

Road to power station at Fitzroy Harbour.

Around old Kingdon Mine and near Galetta.

Gneisses

Road-cuts on road from Fitzroy to Carp.

Gatineau Parkway.

Syenite

Wakefield and north on Route 11.

Fortune Lake part of Gatineau Parkway.

Dykes

Black Lake stop on Gatineau Parkway.

Meach Lake Road loop, Gatineau Parkway.

Almost any of the larger Precambrian road-cuts.

MINERAL COLLECTING

Ever since a spate of mica, apatite, and feldspar mines opened up in the 1880's and 1890's, the area mainly to the north of Canada's capital has been a well-known collecting ground for display-quality mineral specimens. Several score of old pits and trenches, now commonly overgrown with trees and bushes, mark the sites of prospecting and primitive mining operations. Larger holes in the ground, often filled with water and sometimes with considerable mounds of dumped-out material, are the indicators of the more successful operations. Many of these places still offer excellent collecting for the amateur. In this guide just a few of the easily accessible spots will be mentioned. Highly recommended for the rock hound or addicted collector are *A Guide to the Geology of the Gatineau-Lièvre District* by D. D. Hogarth, available from the National Capital Commission, and *Rock and Mineral Collecting in Canada, Vol. II, Ontario and*

Quebec by Ann. P. Sabina, available from the Queen's Printer, Ottawa, or the Geological Survey of Canada, 601 Booth Street, Ottawa.

Along the Gatineau Parkway

Trails and walkways in the woods of Gatineau Park commonly come close to places where minerals can be collected. Some of the spots are outlined in the following.

Fortune Lake — The parking area at Fortune Lake (marked *Artists Point)* is opposite a road-cut in syenite, cut by pegmatite dykes. Black mica, pale yellow pyrite or fool's gold, pink calcite and green amphibole may be collected in the outcrops almost directly opposite the parking lot. About 700 feet west along the road where coarse-grained pegmatites cut the syenite is a breccia of syenite chunks. Black or very dark specks of the radioactive mineral betafite are to be found in it. At an intermediate locality (a little closer to the parking lot) the margins of a pegmatite are marked by dark garnet.

Site near intersection of two branches of the parkway, about 1 mile west of Pinks Lake parking lot turnoff — This intersection is the junction of the parkway branch leading west and northwest toward the Champlain Lookout and another branch leading northward towards Kingsmere and the Meach Lake Road. About one-tenth of a mile along the Meach Lake branch the road is on an embankment, some 20 feet or so high. In the woods to the west an old overgrown mound is made up of dark boulders of pink calcite and, here and there, well-formed apatite crystals are embedded in the pink calcite.

Old apatite cave — A few apatite crystals are still available in the floor of the opening in the road-cut on the east side of the parkway about half a mile south of its southeastern intersection with the Meach Lake Road. When first opened up by construction crews this 'cave' was literally loaded with fairly well formed apatite crystals that had been released from the enclosing calcite marble by solution.

Champlain Lookout — The Gatineau Parkway at the Champlain Lookout cuts through a group of peculiar black rocks which have come mostly from the alteration of other rock types under the influence of high temperature and high pressure, so that they are now pyroxenite and pyroxene gneiss. Here and there in these rocks, lenses and blobs of pink calcite marble are to be found. Where the calcite has been dissolved by circulating ground-water, crystals which at one time were embedded in it are often lying in the ground or almost loose. You will find some of these at the point of the 'island' made by the parking area on the one side and the looping road on the other, and again at a road-cut on the uphill side of the sharp turn just before the Champlain Lookout parking area. Books of mica, irregular clusters of shiny dark pyroxene crystals, feldspar and quartz crystals are to be found here. Below the lookout is an old molybdenite prospect. To get to it you walk down below the parking area and then back along the hillside, parallel to the parkway in the direction of Ottawa. A great number of excavations and mounds of material thrown out are found scattered through the woods. Mica, calcite, pyroxene, and flakes of silvery, metallic-looking molybdenite are to be found.

Headley Mine — At the old Headley Mine, apatite in green crystals, dark brown mica, and pink calcite are to be found by digging in the old dumps and cliffs. To get to this spot you park at the junction of the Mine Road and the Notch Road. The Notch Road is accessible either from Old Chelsea or from the Mountain Road. The Mine Road can be reached from its intersection with Gamelin Boulevard in Hull. Directly opposite the road junction is an open field with a path that goes straight back from the junction, swings along the back of the field and leads gradually into a fairly well worn trail. A little bit past the second field, about two thousand feet from where you began, the trail forks and you take the right-hand fork up the slope. At about the time you have given up hope (as the trail seems to be fairly heavily overgrown) you will encounter the first pits. Over the next hundred yards or so you will see several more quite conspicuous mounds of material and pits in the rock nearby.

The best mineral collecting is to be found by digging into the old dumps, usually on the downhill side, and turning over each piece of rock. The choice mica crystals are invariably found in the pink calcite, and a half-hour's digging will usually turn up several good specimens here. This spot is particularly well known for the zoning in the mica crystals, marked by the colour changes parallel to the crystal outline. The mineral connoisseur can find about twenty different minerals in these pits.

Forsyth Iron Mine — A body of magnetite occurs in a set of complicated rocks with complex structure at what is

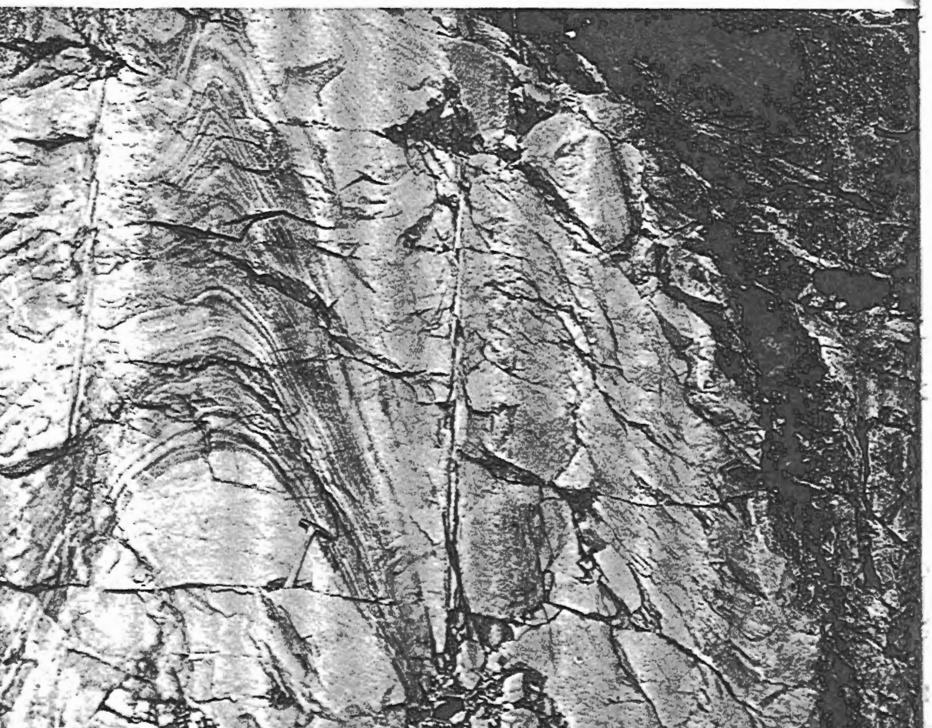
called the Forsyth Mine at the intersection of the Mine Road and a road coming in from Ironside and Route 11 to the east. It is reachable from Ironside on Route 11, or along the Mine Road from Gamelin Boulevard in Hull. This property, which has been explored off and on for many years, was again dewatered in the early 1960's and has seen intermittent activity of an exploratory nature. Large quantities of fresh rock are exposed in the dumps and in them various dark gneissic rocks are mixed with fairly coarsely crystalline, coloured marbles of several varieties. Magnetite, scapolite, chlorite and graphite-bearing marbles are to be found here.

Dacey Mine — This is probably the best collecting ground within easy driving distance of the National Capital. It can be reached by driving north on the Cantley Road to a point a little more than 8½ miles above the Alonzo Wright Bridge, then turning left on Holmes Road and, once across the bridge over the brook, turning immediately right and proceeding on into the John Holmes farm. This is private property and the courteous thing is to gain permission for either parking or proceeding farther. The old pit is located on the far hillside beyond the low-lying area past the Holmes farm. An old house stands very close to it.

A large dump, several smaller ones and several pits are available for collecting. The best collecting is in blocks of coarse, pink calcite where green apatite and well-developed books of phlogopite occur. Pyroxene-rich rocks are also to be found here and there and, more rarely, black tourmaline in small crystals and clusters. Occurring in the wall-rocks, beyond the water-filled pit, are crystals of mica with cleavages as much as several inches across. Some of the pink calcite found on the dump and in place is a spectacular deep salmon colour.

Brucite Quarries — The Aluminum Company of Canada has had mining operations in quarries south of Wakefield on the Gatineau River. The old Maxwell Brucite Quarry is about 2 miles south of Wakefield and is no longer in production. This is private property and permission to go into

At the Maxwell quarry the contact between Precambrian marbles on the left would show internal fold structures and pyroxenite on the right.



This dramatic view across the Maxwell Brucite Quarry at Wakefield shows a large bulb of pyroxenite encased in marbles.

the quarry must be obtained from the Aluminum Company of Canada at Wakefield. The country rock is generally crystalline limestone into which masses of pyroxene-rich rock have been folded or pushed when the rock was in a plastic state. Along with these, masses of pink calcite sometimes occur. In some places tiny nodules of brucite (magnesium hydroxide) occur in concentrations rich enough to make it commercially possible to grind up the rock and separate the magnesium compound. This was then shipped off for use in making fire-resistant bricks and furnace linings. In this pit a considerable variety of minerals and pretty rock types are to be found, including dark green pyroxene-rich rocks, masses of pink calcite, green apatite, yellow-green serpentine-rich limestone, white and pale blue-grey calcite, and white marble. Rocks from this locality were used by David Partridge in making the mural in the Royal Trust Building described on page 85. Twenty to thirty mineral species can be found here by the ardent collector.

Cross Quarry is south of Wakefield and about half a mile south of Farm Point. It is generally similar in overall geology and mineralogy to the Maxwell quarry and was in active production until 1968.

FOSSIL COLLECTING

Fossil collecting is not really good anywhere in the National Capital area, but, for those who persevere, the urge to collect can be satisfied with fair results in several places.

Fossils are generally described as the remains of ancient life and may consist of the original hard parts, such as shells,

bones, or teeth of ancient organisms, their imprints, their tracks, or thin carbonaceous films — all that is left of the creature after partial chemical decomposition. Fossils occur only in those rocks that, at the time of their accumulation, were suitable for the preservation of remains of living things, and whose history since that original accumulation has allowed the continued preservation of such remains. Rocks that have been melted or severely squeezed or completely recrystallized during their history would not really be expected to have fossils in them. Nor would those that were formed prior to the existence of life on earth.

The rock record in the area of the National Capital extends back into time well beyond 1,000 million years. The older or Precambrian part of the area — the part older than the beginning of abundant life on earth, about 600 million years ago — is thus not known to contain fossils. However, this is only partly because the rocks are too old. From our studies in other places it seems possible that living things did exist rather sparsely on the face of the earth in these very early times, but the severe deformation, folding and faulting, and squeezing and crystallization that these rocks were subjected to in Precambrian times has obliterated any evidence of living things that might have been there.

Fossil hunters in the National Capital area should thus sensibly confine their efforts to rocks of the upper part of the geological column, that is from the Nepean sandstone on up to the present time.

Below are listed some of the better localities.

Frazer Duntile Quarry — This very large quarry is located to the south of Carling Avenue in the west end of Ottawa. It is easily accessible from the Queensway at the Maitland Avenue interchange by turning south on Maitland and then east (left) at the first turn.

The quarry is in the Ottawa limestone and the best fossil hunting is in the upper beds exposed. You may find corals, both simple and compound; brachiopods of several varieties (these are small bivalves); a few clam-like pelecypods; a few flattened, snail-like gastropods; and rare trilobites. The rock is the lower part of the Ottawa limestone.

Stewart Quarry, south of Rockland — Some reasonably good fossils are found in a large unused, abandoned quarry just east of the National Capital area. To get there travel east on Highway 17 to Rockland, take the turn (right) into the village, and then turn south (right) just before the church. Proceed for about 1½ miles following the twists and turns of the road and you will see the quarry off to your right as a large cut into the limestone escarpment.

For geology students it might be mentioned that this is the type locality of the Rockland Formation, seen in the highest 40 feet or so of the exposures at the quarries. Beneath that lie that Chaumont and Lowville Formations. For collectors the best harvest is generally in the darker shaly beds. You may also find that it pays to search some of the rubble heaps where weathering has softened the rock and loosened the fossils that may be in it. Here you can find corals, brachiopods (bivalves), bits and pieces of trilobites with rare whole ones, and straight cephalopods. A large example of the last is seen on the quarry floor in one of the levels as a large tapering cone with cross partitions.

Clarence Township Quarry — A large limestone quarry, operated by Clarence Township for road material and other purposes, is located near Sarsfield, a small community about 18 miles east of the centre of Ottawa, past Navan. The quarry is a little less than ½ mile south of the east-west road through Sarsfield at a point approximately 3½ miles east of the village. Great numbers of cloche-hat-shaped bryzoans, called *Prasopora,* are found in this quarry and brachiopods are also fairly abundant. The best specimens of fossils are commonly found in the partly disintegrated rubble at the old workings or on the original weathered surfaces along the edges of the quarry. The limestone exposed here is fairly high up in the section of the Ottawa limestone (the Sherman Fall Formation) and, therefore, is younger than those seen at Orleans, the Frazer Duntile quarry in Ottawa west and the Canada Cement Plant in Hull.

Dows Lake — During excavations around Dows Lake to relocate the railroad in 1964 and 1965, large blocks of black shale and limy shale were thrown out and used for fill along the lake shore and in the flat to the south. For a period these supplied excellent fossil hunting, having some layers jammed with the *pygidia* or tails of *Ogygites* — a trilobite which, when whole, is three to five inches long. Also common was a straight type of cephalopod which appeared in the rocks mostly as a shiny imprint, generally of triangular outline with a very long taper. Unfortunately, piles of shales of this type weather very rapidly and thus, in addition to the revision of the landscapes in this neighbourhood, fossil hunting at this locality may have ceased to exist by the time you read this. Similar fossils are available in the same kind of dark shales in the Rideau River at extremely low water at several places between Billings Bridge and the bridge at Eastview, and again on the Cyrville-Blackburn Road at the crossing of Green Creek.

Montreal Road-St. Laurent Boulevard intersection — Outcrops of shaly limestones and rubbly beds just behind Steinberg's store on the north side of Montreal Road near the intersection of St. Laurent Boulevard are, in places, quite fossiliferous and small specimens can be picked up here. These rocks are high up in the Ottawa limestone section.

EPILOGUE

Nature has been generous indeed in the scenic features she has left at the site of our National Capital. The natural beauty has prevailed even though man, in the short century and a half of his existence here, has been busy changing the landscape to meet his needs. He has stripped away many of the great forests; his floodgates now control the natural waterfalls; his works have dimmed the crystal clear rivers and streams and have even sullied the fresh northern air with smoke and fumes. But he has also enhanced the beauty of the landscape with carefully planned parkways and spreads of beautiful flowers; he has built gardens and canals, greenswards and rows of lovely trees to replace dismal swamps filled with voracious insects; his dams have stilled the roar of waterfalls and provided placid lakes for pleasure and beauty and the energy to do his work for him.

Man's efforts, however, are puny when we think of the tremendous changes wrought by Nature in the evolution of each part of the scenery as we know it today. The Ottawa River, disturbed and disrupted by great glaciers in the recent geological past, still traces in a general way the path followed by its ancestors for millions of years. The Gatineau Hills to the north, founded on rocks a thousand million years old, mark the place where ancient mountains once reared their heads high into the sky, but gave way slowly but inexorably to the patient processes of erosion, until at last they were worn down to flatness. And now, among beautiful woods and lakes and foaming brooks, we see the evidence that tells us that uplift of this edge of the Canadian Shield, a few millions of years ago, allowed erosive processes to etch into the ancient plain again to form the rolling hills and valleys we know.

Road-cuts and river valleys show up in their ledges of limestone and cliffs of shale, glimpses of another time when waves and currents, in the shallow seas of half a billion years ago, piled sands and silts and limy muds into bars and banks and left in them the remains of abundant living things, so important in their day but now only marks on the stone. In the stranded boulders and the disrupted streams, the polished hilltops and great heaps of waste, we see a time — a few tens of thousands of years ago — when the capital area lay deep beneath the continental ice sheet as part of an unbroken wintry scene. Thick clays and bedded sands full of tiny shells, peat bogs and abandoned river channels on the dry land tell us that only a few thousand years ago, well within the span of recorded human events, the salty sea filled the Ottawa Valley and spilled onto the flat lands on both sides. As it slowly withdrew, lakes were formed and drained, rivers changed their courses, and sand dunes were humped up by the wind and later covered by forests.

We know too, from what we have seen, that the view is slowly changing right before our eyes as frost splits apart boulders and grains of sand, as streams continue to erode the land and rain dissolves limestone outcrops. These processes are of infinite slowness yet are enough to have changed the land so that it is not quite the same as it was when first seen by the earliest explorers.

Here, then, in the nation's capital where we see the works that symbolize our country's human progress, let us enjoy the natural beauty that surrounds us and think modestly of the tiny glimpse of the grand story of the evolution of the earth and its living things that we are permitted to see in our individual lifetimes.

INDEX