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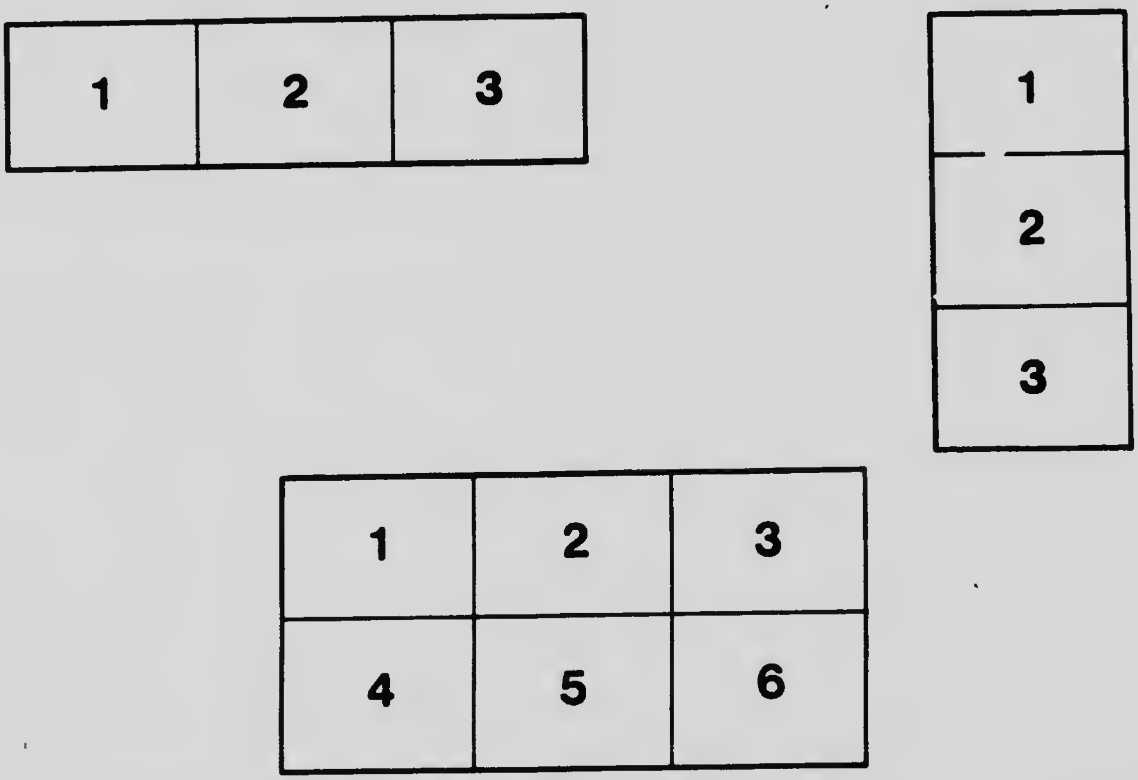
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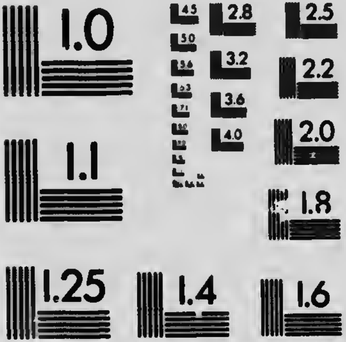


The Pre-Cambrian Geology of Southeastern Ontario

BY

WILLET G. MILLER and CYRIL W. KNIGHT

With an Appendix on the Correlation of the Pre-Cambrian Rocks of Ontario, Western Quebec and Southeastern Manitoba

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO:
Printed and Published by L. K. CAMERON, Printer to the King's Most Excellent Majesty
1914

77° 55′

ECONOMIC NOTES

In November, 1912, the mineral industries in operation in the area covered by this map were the gold mine at Cordova, the Belmont iron mine on an adjacent property, and the quarry of the Ontario Rock Company, on a spur of the Canadian Pacific Railway about three miles east of Havelock.

It will be seen from the map that all the mining and quarrying operations are being carried on in connection with the intrusive rocks, which have been classified provisionally as of Keweenawan age. The gold at Cordova occurs in quartz deposits in the gabbro-diabase, while the Belmont iron deposit has been produced by the intrusion of this rock into crystalline limestone and associated material. The Ontario Rock Company is quarrying a basaltic phase of the rock, commonly known as "trap." This rock is unsurpassed as road material. It may be added that the quarry industry here has been developed directly as a result of the mapping of the area. The good-roads movement, especially in the vicinity of Toronto, caused enquiries to be made at the Bureau of Mines for suitable quarry sites. Several enquirers were directed to the Havelock locality, and work was finally begun by the company mentioned. From the map it will be seen that rock similar to that now being quarried outcrops over a large area. Inexhaustible supplies of road material are thus available. If the mapping of the area had not been undertaken, doubtless these rock outcrops would long have remained unknown and undeveloped.

It is to be hoped that the publication of the map will assist in the development of other industries in the area, and it is believed that it will be found of value to the residents, and especially to tourists who will come in increasing numbers to Belmont and Round lakes when their attractions are better known. The area is so accessible to the centres of populations of the Province, that it is likely to attract many visitors in the future

SIGNS

- *Road*
- *Hill*
- P.O. — *Post Office*
- 609′ — *Elevation above sea level in feet*
- *Strike and Dip*
- *Railway*
- *Swamp*
- *House*

SOURCES OF INFORMATION

Geologically surveyed by Willet G. Miller *and* Cyril W. Knight *in 1907-08*

Topography by W. R. Rogers

Soundings in feet in north part of Belmont lake are from survey by Engineering Field Class of the School of Mining, Kingston, Ont., May, 1912

TOWNS

PETERBOROU

To accompany

Hon. W. H. Hearst, *Minister*

Miles ½ ½

Metres 1000

Elevation
Islands


77°30'
ONTARIO
BUREAU OF MINES
MAP
OF PART OF THE
SHIP OF BELMONT
ROUGH COUNTY PROVINCE OF ONTARIO
(BELMONT LAKE SHEET)
pany Part II, Volume 22, Report of Bureau of Mines, 1913
ister of Lands, Forests & Mines. Willet G. Miller, Provincial Geologist
Scale: or ¼ Mile = 1 Inch
Mile
Kilometre
ations noted on the map are referred to mean sea level.
ands in Belmont Lake are numbered from south to north.
FLUME
Dam
Power House Road
CON. 4
DEER BAY
Silver Id
One Tree Id

ELMONT
OF ONTARIO
Miner 1913
Provin al Geologist
Mile
Kilom re
sea level.
north.
Power House Road
CON. 2
CON. 3
CON. 4
CON. 5
XXI
XX
XIX

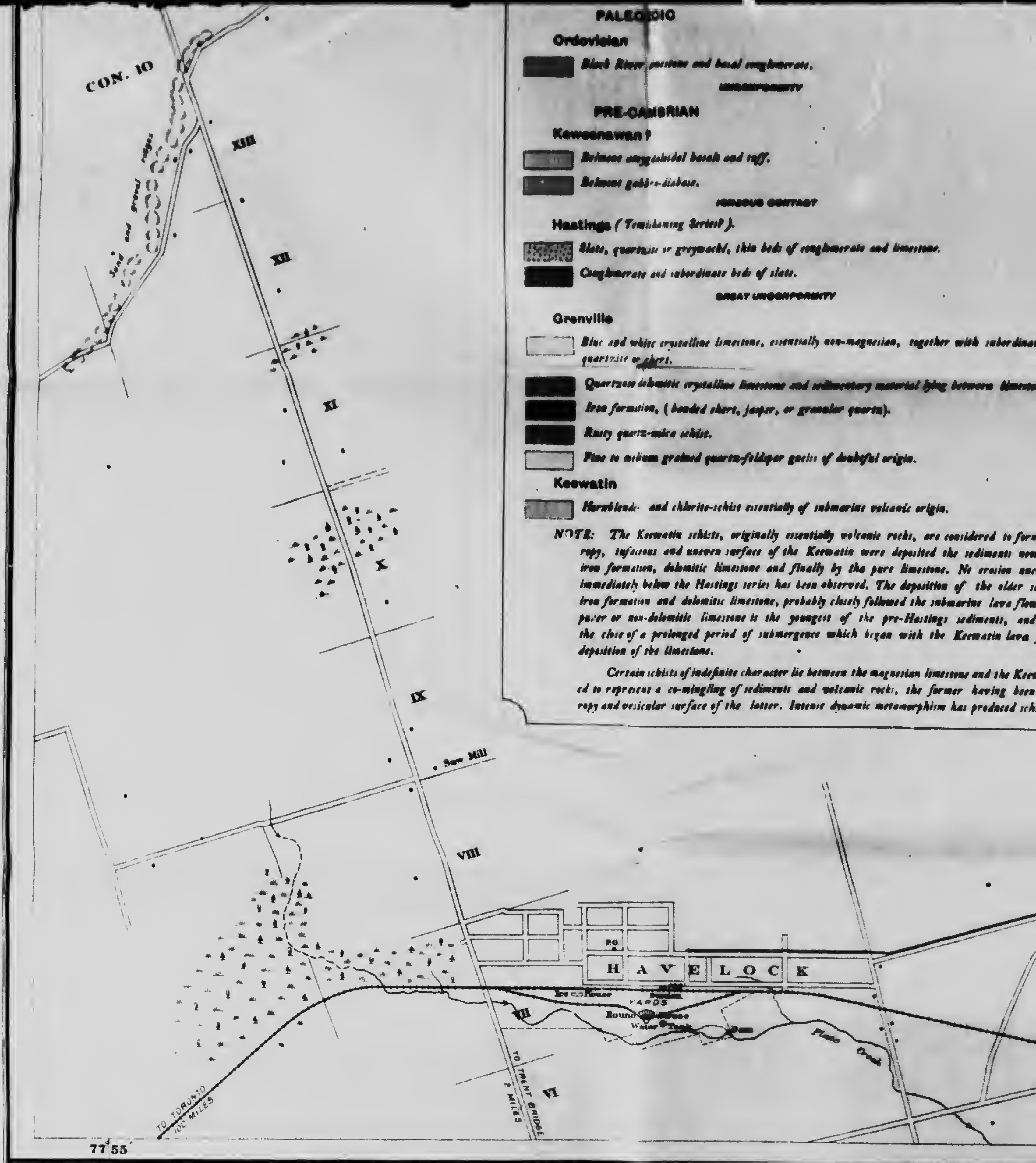
MARMORA
TOWNSHIP AND COUNTY BOUNDARY
BELMONT
PETERBOROUGH
HASTINGS
XXIV
XXIII
XXII
XXI
XX
XIX
XVIII
CON. 1
CON. 2
BELMONT
IRON MINE


XX
XIX
XVIII
Gull Rock
ROUND LA
Mill
CON. 9
LEGEND
GLACIAL and RECENT
PALEOZOIC
Ordovician

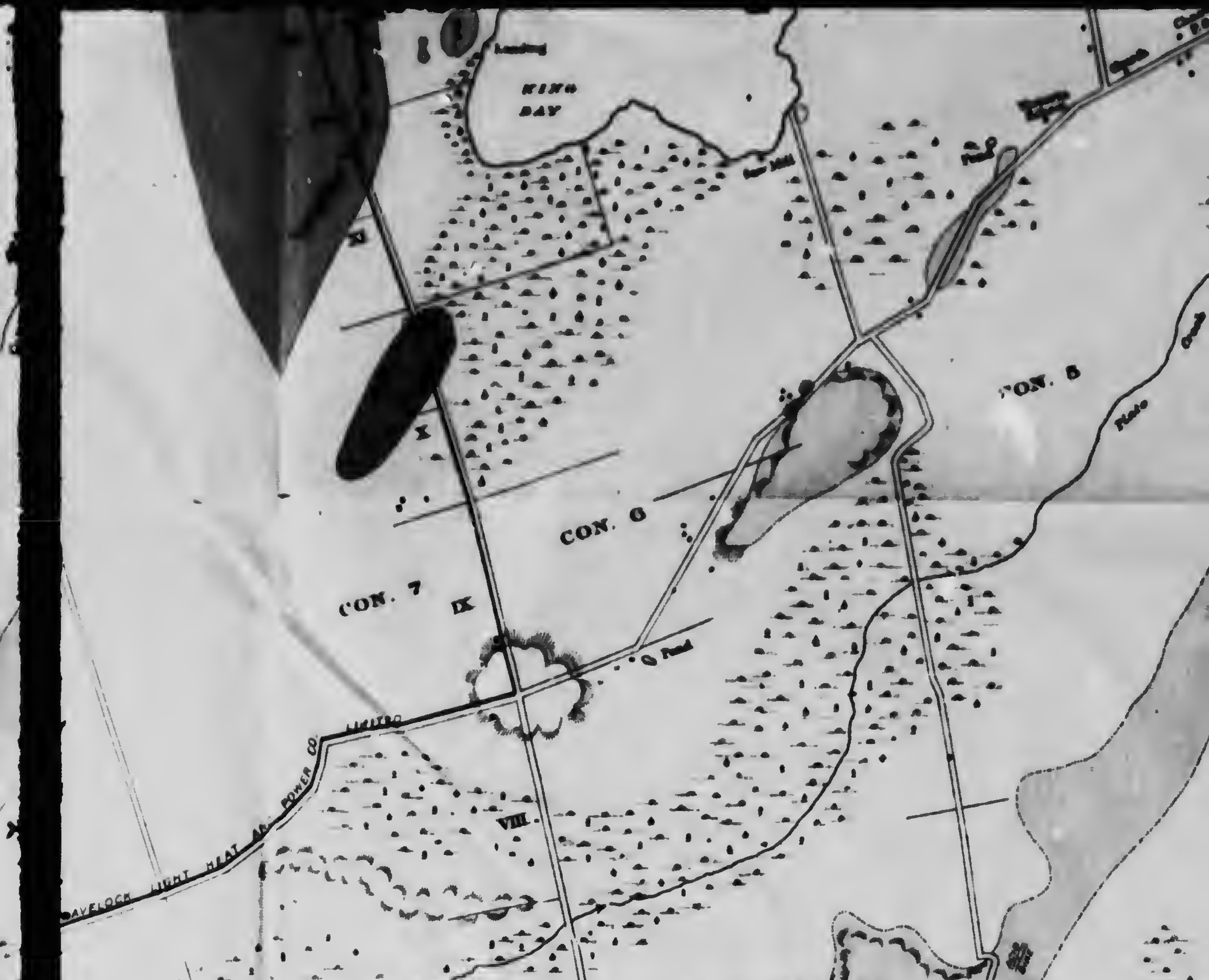
LAKE
BELMON
XVII
XVIII
XIX
NORTH RIVER BAY
Squaw Pt
Long Id
Race Rock Id
Lunch Id
Ship Id
Marys or Burnt Id
Raft Id
Schooner Id
Sidonia Id
CON. 6
LAKE
El. 603'
CLARK BAY
CONTACT BAY
Landing
CUMMING BAY
PORPHYRITIC
SAW-MILL BAY
Old Mill

BELMONT
LAKE
CON. 6
CON. 7
NORTH RIVER BAY
BAY
Long I'd
Race Rock I'd
Lunch I'd
Ship I'd
Marys or Burnt I'd
Raft I'd
Schooner I'd
CUMMING BAY
SAW-MILL BAY
Old Mill
CONTACT BAY
CLARE BAY
KING BAY
Landing
Mill
Pond
Victoria School
XVIII
XIX


XVII
XVI
CROW RIVER BAY
N T
Crow River Point
MYER BAY
Portage Road
XV
CROW RIVER
XIV
44
30
Small patches of
Black River
limestone
XIII
XII
XI
CON. 2


PALEOZOIC
Ordovician
Black River limestone and basal conglomerate.
UNCONFORMITY
PRE-CAMBRIAN
Keweenawan ?
Belmont amygdaloidal basalt and tuff.
Belmont gabbro-diabase.
IGNEOUS CONTACT
Hastings (Temiskaming Series?).
Slate, quartzite or greywacké, thin beds of conglomerate and limestone.
Conglomerate and subordinate beds of slate.
GREAT UNCONFORMITY
Grenville
Blue and white crystalline limestone, essentially non-magnesian, together with subordinat
quartzite or chert.
Quartzose dolomitic crystalline limestone and sedimentary material lying between limesto
Iron formation, (banded chert, jasper, or granular quartz).
Rusty quartz-mica schist.
Fine to medium grained quartz-feldspar gneiss of doubtful origin.
Keewatin
Hornblende- and chlorite-schist essentially of submarine volcanic origin.
NOTE: The Keewatin schists, originally essentially volcanic rocks, are considered to form
ropy, tufaceous and uneven surface of the Keewatin were deposited the sediments now
iron formation, dolomitic limestone and finally by the pure limestone. No erosion unc
immediately below the Hastings series has been observed. The deposition of the older s
iron formation and dolomitic limestone, probably closely followed the submarine lava flow
purer or non-dolomitic limestone is the youngest of the pre-Hastings sediments, and
the close of a prolonged period of submergence which began with the Keewatin lava
deposition of the limestone.
Certain schists of indefinite character lie between the magnesian limestone and the Kee
ed to represent a co-mingling of sediments and volcanic rocks, the former having been
ropy and vesicular surface of the latter. Intense dynamic metamorphism has produced sch
CON. 10
Sand and gravel ridges
XIII
XII
XI
X
IX
VIII
VII
VI
Saw Mill
P.O.
H A V E L O C K
Ice House
YARDS
Round House
Water Tank
Dam
Plato Creek
TO TORONTO 100 MILES
TO TRENT BRIDGE 2 MILES
77°55'

th subordinate beds of fine-grained
ween limestone and Keewatin.
dered to form the basement. On the
sediments now represented by schists,
erosion unconformity preceding that
the older sediments, including the
ine lava flows of the Keewatin. The
diments, and was deposited towards
ewatin lava flows and ended with the
e and the Keewatin. They are consider-
having been deposited on the uneven,
produced schists difficult to describe.
Landing
KING BAY
Saw Mill
Pond
CON. 8
CON. 7
CON. 6
XI
X
IX
VIII
VII
VI
V
Pond
TRANSMISSION LINE OF HAVELOCK LIGHT HEAT AND POWER LIMITED
Crusher
740'
Ontario
School
CANADIAN PACIFIC
660'
667'
680'
642'
700
650
600
550
A
Horizont
77 50'


KING BAY
XI
X
CON. 7
IX
CON. 6
CON. 5
HAVELOCK LIGHT HEAT AND POWER CO. LIMITED
VIII
VII
Crusher
VI
V
CANADIAN PACIFIC
700'
650'
600'
550'
A
Horizonta
77°30'

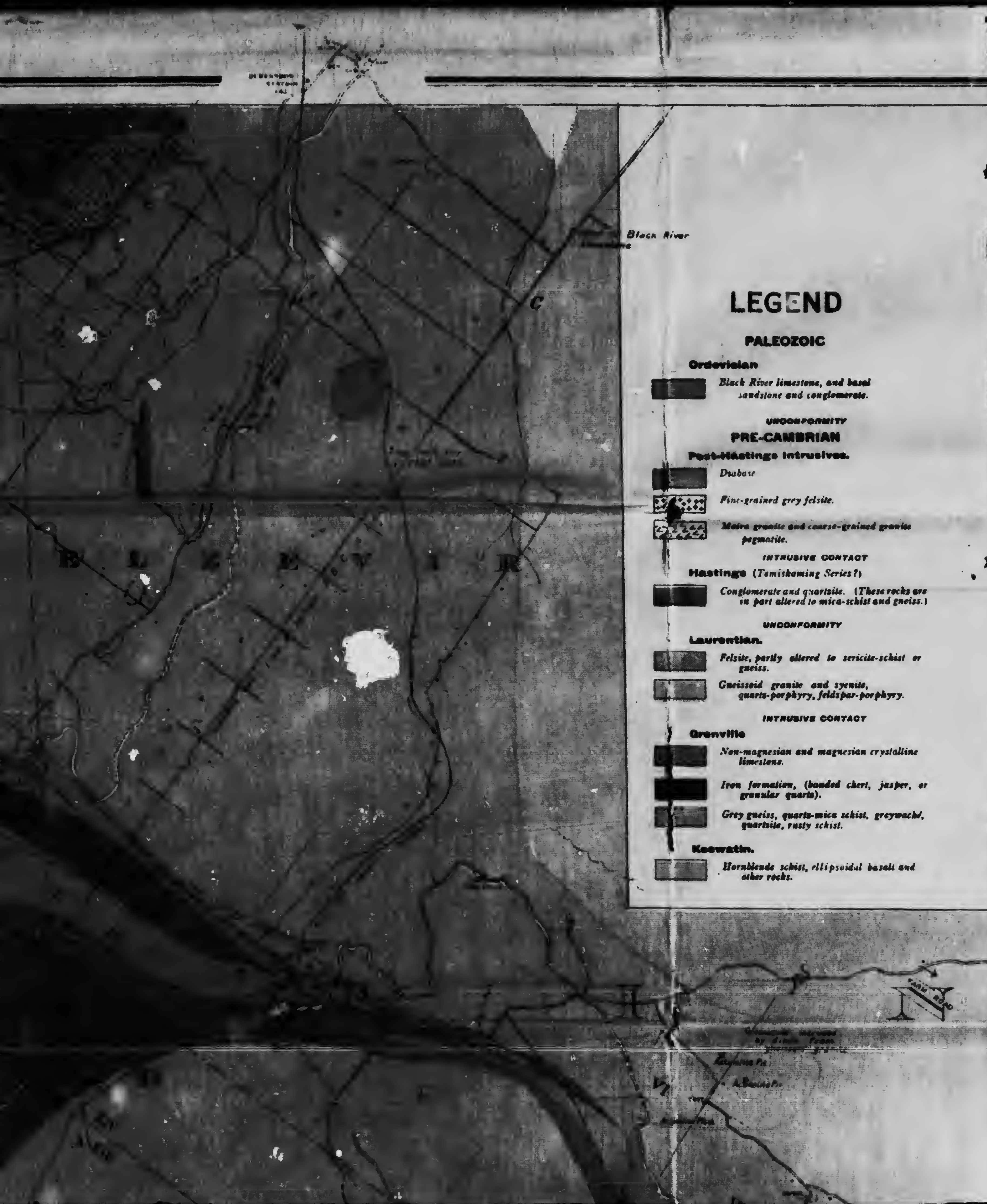
CON. 5
CON. 4
BLAIRTON IRON
AND MARMORA
Sand and gravel ridge
Cheese Factory
TO MONTREAL
RAILWAY
Blairton Sta.
BELMONT
LAKE
Section A.B.
Horizontal Scale: ½ mile - 1 inch.
Vertical Scale: 200 feet - 1 inch.
B

Map Nº 22 a.

ECONOMIC NOTES

The area contains a variety of mineral deposits and rocks of economic importance, viz.:—iron pyrites, gold, mispickel, talc, crystalline limestone, actinolite and trap.

IRON PYRITES


Black River
C
B E L L E V I L L E
LEGEND
PALEOZOIC
Ordovician
Black River limestone, and basal sandstone and conglomerate.
UNCONFORMITY
PRE-CAMBRIAN
Post-Hastings Intrusives.
Diabase
Fine-grained grey felsite.
Moira granite and coarse-grained granite pegmatite.
INTRUSIVE CONTACT
Hastings (Temiskaming Series?)
Conglomerate and quartzite. (These rocks are in part altered to mica-schist and gneiss.)
UNCONFORMITY
Laurentian.
Felsite, partly altered to sericite-schist or gneiss.
Gneissoid granite and syenite, quartz-porphyry, feldspar-porphyry.
INTRUSIVE CONTACT
Grenville
Non-magnesian and magnesian crystalline limestone.
Iron formation, (banded chert, jasper, or granular quartz).
Grey gneiss, quartz-mica schist, greywacké, quartzite, rusty schist.
Keewatin.
Hornblende schist, ellipsoidal basalt and other rocks.
VI

ONTARIO
DEPARTMENT OF LANDS FORESTS AND MINES
BUREAU OF MINES

MAP

(Actinolite - Cloyne Sheet)

SHOWING GEOLOGY ON A BELT OF COUNTRY THIRTY MILES LO

HASTINGS, ADDINGTON A

PROVINCE OF ONTARIO

To accompany Part II, Volume 22, Report of Bureau of Mines, 19

Hon. W. H. Hearst, *Minister*. Willet G. Miller, *Prov*

Scale: $\frac{1}{31680}$ or ½ Mile = 1 Inch

Chains 100 80 40 20 0

Metres 1000 500 0 1 2

ND

IC

ne, and basal conglomerate.

ORMITY

RIAN

ssives.

lsite.

oarse-grained granite

CONTACT

g Series?)

artzite. (These rocks are mica-schist and gneiss.)

RMITY

ed to sericite-schist or

and syenite, feldspar-porphyry.

CONTACT

magnesian crystalline

anded chert, jasper, or).

mica schist, greywacké, schist.

llipsoidal basalt and

ranite

SIGNS

▪	*House*
	Hill.
	Swamp.
551	*Elevation above sea level.*
	Road.
	Railway.
— — —	*County boundaries.*
— · —	*Township boundaries.*
o P.P.	*Prospect pit.*
✧	*Actinolite pits (actinolite and serpentinous or talcose minerals.)*
▭	*Actinolite bands.*

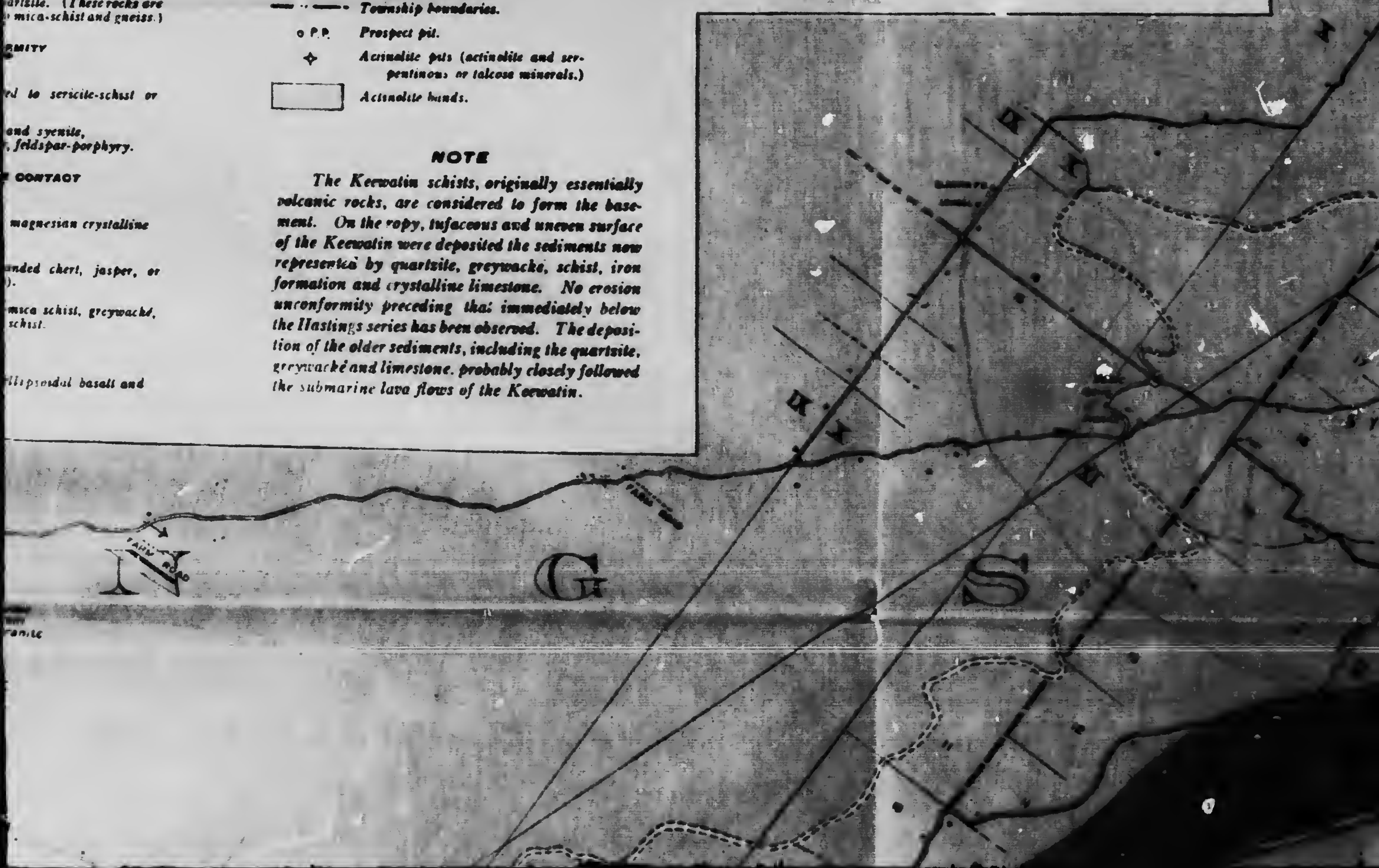
SOURCES OF INFORMATION

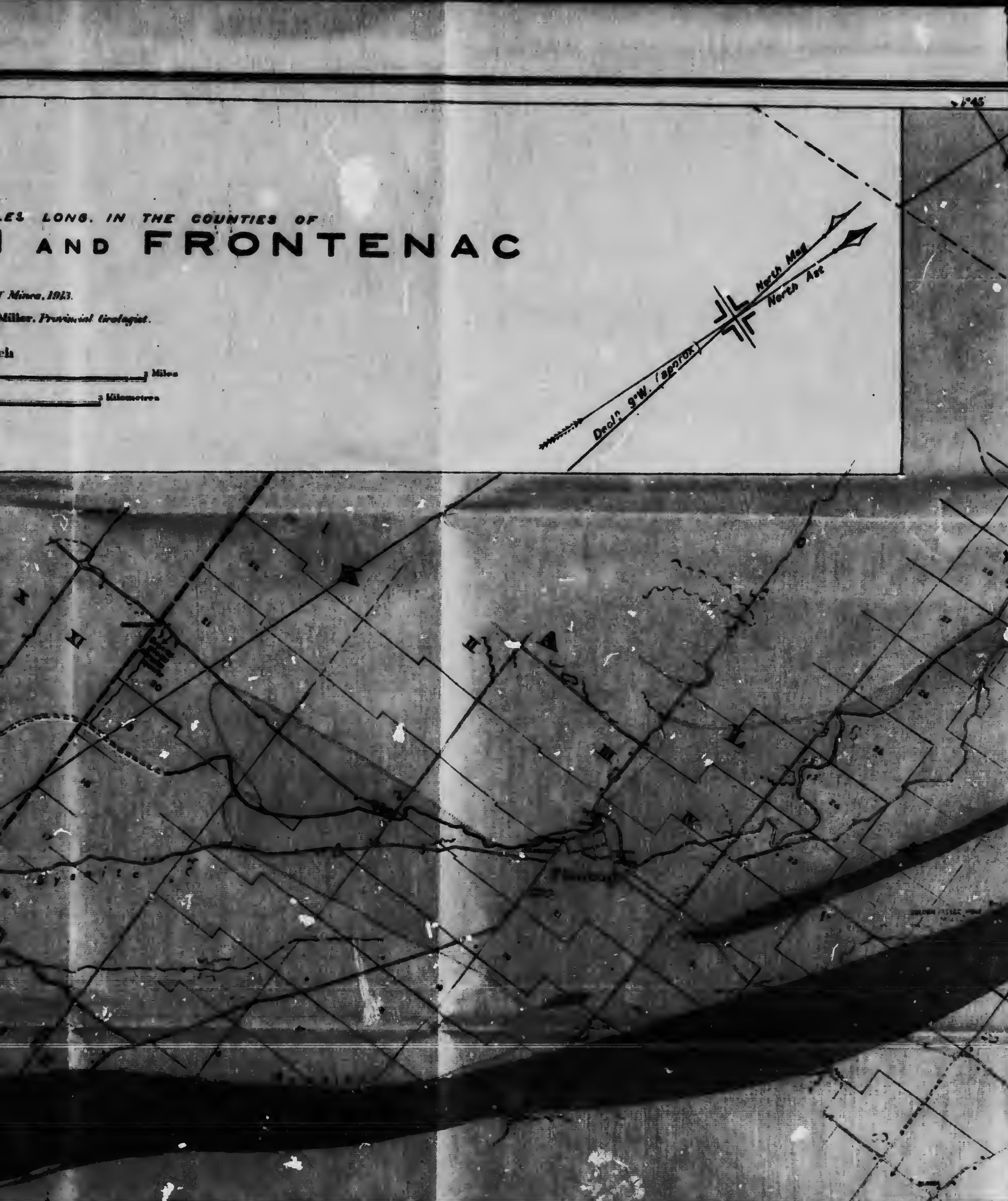
Geology by Willet G. Miller *and* Cyril W. Knight.

Topography by W. R. Rogers.

NOTE

The Keewatin schists, originally essentially volcanic rocks, are considered to form the basement. On the ropy, tufaceous and uneven surface of the Keewatin were deposited the sediments now represented by quartzite, greywacke, schist, iron formation and crystalline limestone. No erosion unconformity preceding that immediately below the Hastings series has been observed. The deposition of the older sediments, including the quartzite, greywacké and limestone, probably closely followed the submarine lava flows of the Keewatin.




LONG. IN THE COUNTIES OF
AND FRONTENAC
Mines, 1913.
Miller, Provincial Geologist.
Miles
Kilometres
North Mag
North Ast
Decl^n 9°W. (approx.)
Syenite

41°45
77°16'
SKOOTAMATTA
D
VIII
VII
IX
C


Cloyne
MARBLE LAKE
GEORGIA L.
KASHWAKAMAK LAKE
LAKE
GULL LAKE
El 866'

ECONOMIC NOTES

The area contains a variety of mineral deposits and rocks of economic importance, viz.:—iron pyrites, gold, mispickel, talc, crystalline limestone, actinolite and trap.

IRON PYRITES

Southwest of Queensboro, in Madoc township, the Canadian Sulphur Ore Company are mining a body of iron pyrites which occurs near the contact of a band of rusty schist and an intrusion of grey felsite. The Company has recently built a spur line from the Bay of Quinte railway to the property. Two other deposits of iron pyrites the Blakley and the Palmer, occur short distances from here: they have been worked from time to time.

GOLD

A property, commonly known as the Golden Fleece, which is located about a mile and a half northeast of Flinton in Kaladar township, has been operated in the past for gold. The deposit occurs at the contact of conglomerate and greenstone schist. The Ore Chimney, which lies six miles northeast of the Golden Fleece, near the southwest corner of Barrie township, also occurs at the contact of these two rocks.

MISPICKEL

This mineral is found on the property of Mr. Joseph James, at the village of Actinolite (formerly known as Bridgewater).

TALC

A large body of talc is being worked on the outskirts of the village of Madoc. It occurs in a dolomitic, crystalline limestone. The greater part of the product goes to the talc mill at Madoc where it is ground and shipped. Development work has also been done by another company on an adjoining property where a body of talc has recently been discovered.

CRYSTALLINE LIMESTONE

Immense bodies of crystalline limestone are found in the area. A quarry is being worked about a mile south of Actinolite on the Bay of Quinte railway. The crushed rock is used for making artificial stone.

ACTINOLITE

There are extensive deposits of actinolite in the townships of Elzevir and Kaladar, which are at present lying idle. In past years this mineral has been ground and used for roofing purposes. Certain varieties appear to be suitable for decorative purposes. The mineral is often associated with calcite, talc and serpentine. The locations of these occurrences are shown on the map.

TRAP

The greenstone northwest of Actinolite has in a few instances escaped metamorphism. Thus there are certain restricted areas which appear to contain rock suitable for road material. Schistose varieties of this rock are not desirable for road-making purposes

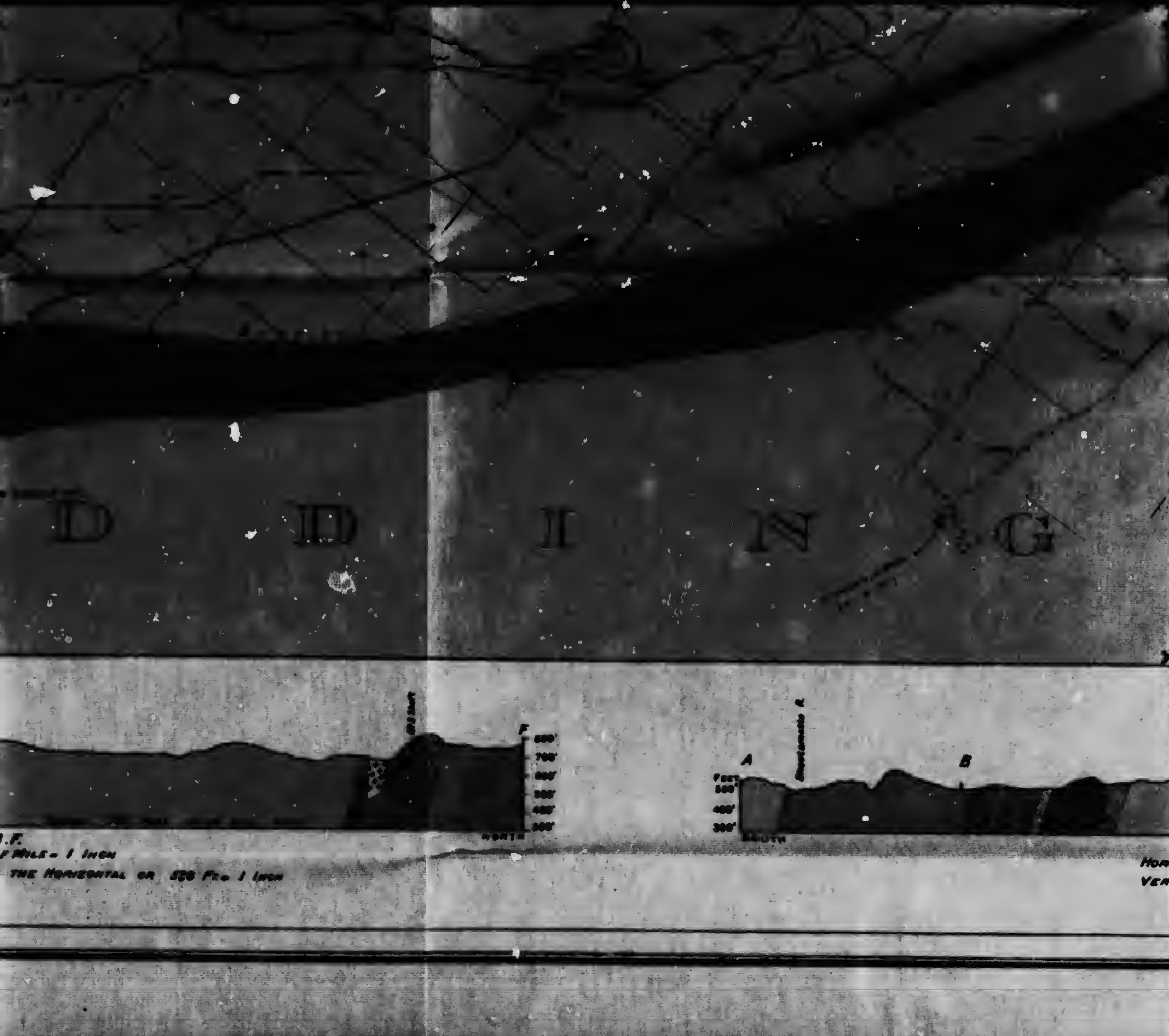
Toronto, 132 mls.


Keewatin.
Hornblende schist, ellipsoidal basalt and other rocks.
Longitude West from Greenwich

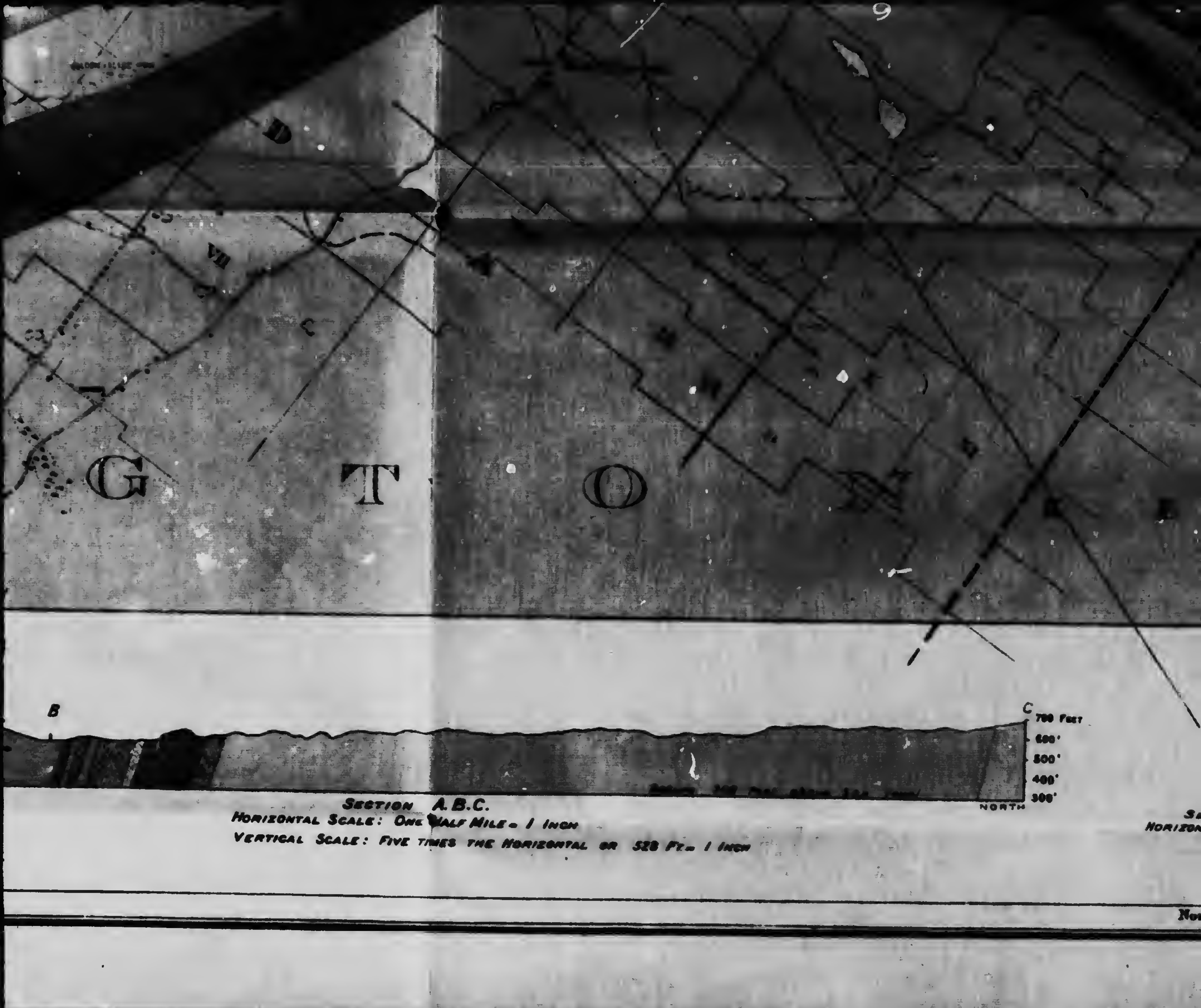
greywacké,

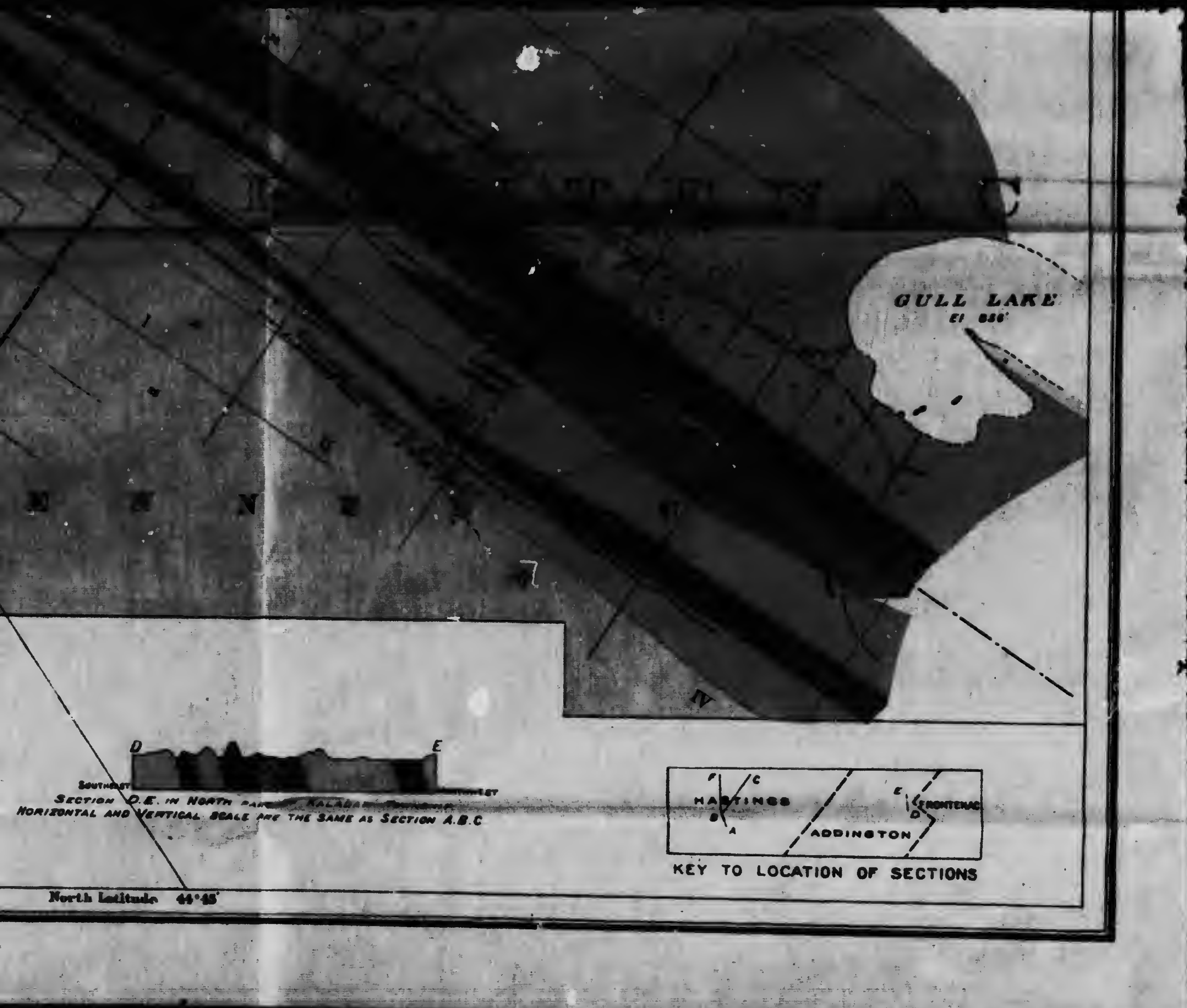
...als and

...unconformity [illegible] immediately below the Hastings series has been observed. The deposition of the older sediments, including the quartzite, greywacké and limestone, probably closely followed the submarine lava flows of the Keewatin.



D D I N G
F
A
B
FEET
NORTH
MILE = 1 INCH
THE HORIZONTAL OR
HOR
VER


G T O
B
C
700 Feet
600'
500'
400'
300'
NORTH
Section A.B.C.
Horizontal Scale: One Half Mile = 1 Inch
Vertical Scale: Five times the Horizontal or 528 Ft. = 1 Inch


GULL LAKE
EL 856
IV
D
E
SOUTHEAST
NORTHWEST
SECTION D.E. IN NORTH
HORIZONTAL AND VERTICAL SCALE ARE THE SAME AS SECTION A.B.C
F
C
HASTINGS
B
A
E
D
FRONTENAC
ADDINGTON
KEY TO LOCATION OF SECTIONS
North Latitude 44°45'

REPORT OF THE BUREAU OF MINES

VOL. XXII., PART II.

The Pre-Cambrian Geology of Southeastern Ontario

BY

WILLET G. MILLER and CYRIL W. KNIGHT

With an Appendix on The Correlation of the Pre-Cambrian Rocks of Ontario, Western Quebec and Southeastern Manitoba

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1914

Printed by
WILLIAM BRIGGS,
29-37 Richmond Street West,
TORONTO.

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MAPS

TABLE

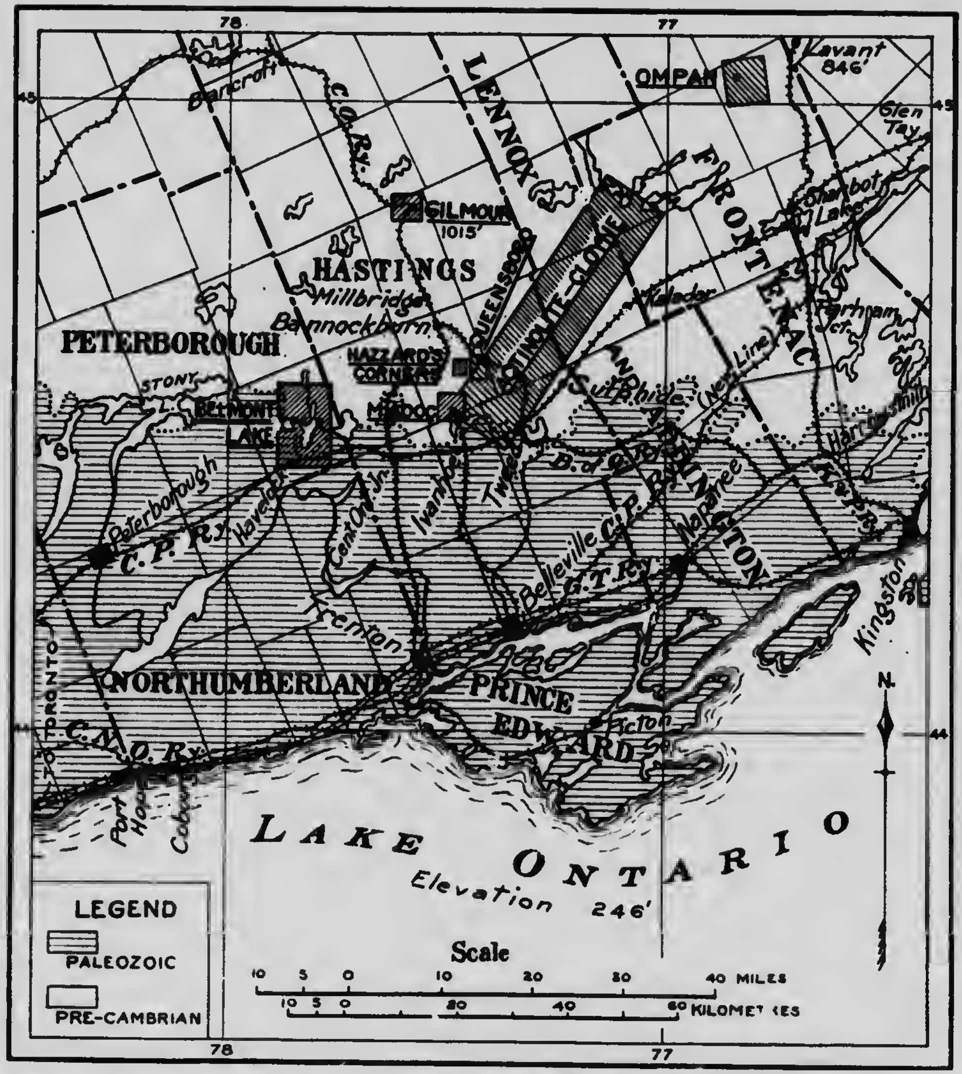

Fig. 1. Index map of part of southeastern Ontario, showing the Belmont Lake, Actinolite-Cloyne, Madoc, Hazzard's Corners, Palmerston or Ompah, Gilmour, and Queensboro areas.

THE PRE-CAMBRIAN GEOLOGY OF SOUTHEASTERN ONTARIO

By WILLET G. MILLER and CYRIL W. KNIGHT

INTRODUCTION

From time to time during the last six or seven years, when opportunity offered, the authors have made a study of the pre-Cambrian rocks of part of southeastern Ontario. Owing to the necessity for field work in other sections of the Province, time has not permitted of the mapping and detailed examination of all of the district described in the following pages. Seven distinct areas were selected, along a strip of country sixty-five miles in length, which were considered to present the best conditions for the study of the characters and relations of the rocks. In other words, these may be called key areas for the district.

The areas lie in the counties of Peterborough, Hastings, Addington and Frontenac, within thirty or forty miles of the north shore of the east half of Lake Ontario. Their relative positions and their location are shown on the index map, Fig. 1. They have been mapped on scales varying from 800 feet to one-half mile to the inch. A geological map of each of the seven areas accompanies this report.*

The region, embracing the district under review with its continuation into the adjoining Province of Quebec, is classic ground to the student of pre-Cambrian geology. To its rocks was first applied the name Laurentian, which received world-wide recognition. The descriptions of the characters and relations of these rocks and of the Huronian, found farther to the northwest beyond the region, made the work of the early Canadian geologists famous.

While the Laurentian, as first defined, has been shorn of most of its members, not now including crystalline limestones and certain other rocks, and while there are some geologists who would even discard the term, it still has great significance in Canada. The name is retained for the oldest granites and granite gneisses which occupy vast areas in this country.

Within this region was also found, at several somewhat widely separated localities, the *Eozoon Canadense*, Fig. 2, which appealed strongly to the imaginations of geologists and biologists of a past age and led to many animated discussions and a few acrimonious controversies.

In addition to being of such interest from the standpoint of pure science, the rocks of the district are of economic importance. Many mineral deposits, and structural and decorative materials, are found in association with them. Ores, or metallic minerals, that have been or are being mined, include those of gold, lead, zinc, iron, copper, arsenic and sulphur. Within the areas mapped, or at no great distance from them, have also been produced talc, mica, feldspar, corundum, sodalite, graphite and actinolite. Beautiful marble is quarried, and trap, the best of road materials, is being shipped from the dis-

* Maps Nos. 22a, b, c, d, e, f, g. Most of the maps contain notes giving summaries of the geology of the areas. They were distributed during the meeting of the Int. Geological Congress in Toronto, in August, 1913.

trict. Lying so near the more populous parts of the Province, and containing such mineral resources, in addition to prosperous farms in certain localities, and possessing attractions for the fisherman, the hunter and the summer tourist, the district will receive more attention in the future than it has in the past. It is, therefore, believed that the maps and the report will be of service and will tend to make the resources and the attractions of the district better known.

While we believe that the descriptions, on following pages, of the relations of the rocks give a fairly complete geological history of the region, in so far as it can be determined from the exposures, we have not been able to decide on the age of rocks in certain outcrops. Difficulties are due chiefly to the severe dynamic metamorphism to which the region has been subjected and to the fact that much of the surface is covered with glacial and recent deposits. Further reference will be made in the descriptions of the various areas to the doubtful interpretation of certain evidence.

Of the maps published with this report, we may be permitted to say, in the words of Van Hise and Leith " . . . . A geologic map represents an approximation to the

Fig. 2—Eozoon Canadense.

Weathered surface of specimen, natural size, (Geology of Canada, 1863, page 49). The layers are composed of pyroxene, while the interstices are filled with calcite. The material is not now considered to be of organic origin. The eozoon-like structures found in some of the areas described on following pages consist of quartz, in place of pyroxene, and calcite or dolomite

truth, limited in its accuracy and adequacy by the general stage of advancement of the science, and perhaps failing short of this limit if the map maker does not fairly represent that advance. The maps published with this monograph are closer approximations to the truth than the maps previously published. These maps in turn will be superseded by better approximations as facts accumulate and geologic knowledge advances. It is hoped that the user of these maps will measure them by their advance over pre-existing maps rather than by the distance they fall short of the ideally perfect map."*

We desire to express thanks and high appreciation to Mr. W. R. Rogers, topographer of the Bureau of Mines, for the kindly interest he has taken and the valuable work he has done in connection with the preparation of the maps. He has also written a general description of the topography of the region.

To Messrs. A. G. Burrows, N. L. Turner and W. K. McNeill, we are under obligation for most of the analyses of rocks that are to be found in the report.

We are also indebted to Mr. P. E. Hopkins who spent a few weeks in the area during the autumns of 1911 and 1912. His paper on the pyrite mines near Queensboro accompanies this report.

* U. S. Geol. Surv. Monograph LII, The Geology of the Lake Superior Region.

SUMMARY OF CONCLUSIONS

The chief results of our work are the following:

(1) It has been proved that rocks of Keewatin age, similar in character to those of northern Ontario and the Lake Superior region, occur in large volume in southeastern Ontario. Heretofore it has been held by certain writers that Keewatin rocks do not occur here and that no basement for the Grenville sediments was to be found in this part of the Province. In some areas, rocks that in the past were called amphibolites, and were considered to be in whole or in part of sedimentary origin, are found to be more or less highly metamorphosed Keewatin lavas.

(2) The Grenville sediments have been classified and their relations determined. These sediments were deposited on the surf of the Keewatin lavas, and consist, normally, at the base of greywacké or quartzite, fine in grain, rusty schist (clay rock), and iron formation (banded chert or jaspilyte); the last-named rock had not previously been recognized in southeastern Ontario, Fig. 7. Although at times the sediments may be more or less mixed or interbedded, above those mentioned come crystalline limestone that is essentially magnesian, and finally crystalline limestone that is essentially non-magnesian. No unconformity has been observed within the Grenville.

While it seems likely that erosion of part of the surface of the Keewatin preceded or accompanied the deposition of the Grenville sediments, an unconformity has not been proved to exist between the latter and the Keewatin lavas.

It is also not unlikely that sedimentation and the outpouring of lava took place partly contemporaneously. Sediment, especially the finer fragmental material, from submarine lavas is difficult to distinguish, under conditions in which the Grenville rocks are now found, from land-derived sediment. It is believed by most authorities that clays and certain other materials in the deeper parts of the ocean are formed, by decomposition in sea water, from fragments of submarine lavas and from other inorganic material transported from a distance. If such sediments were submitted to the extreme metamorphism that the Grenville rocks have undergone, they would, in all probability, be indistinguishable from ordinary land-derived material.

(3) Granites of two ages have been recognized. The older of the two (Laurentian) which is gneissoid in character, intrudes both the Keewatin and the Grenville, but is older than certain pre-Cambrian conglomerates and other sediments of the region. The younger granite intrudes all the sediments. Granites of both ages are extensively developed, and, heretofore, they have not been differentiated as regards their age.

(4) Conglomerates and other pre-Cambrian fragmental sediments of the region were at one time grouped with the less highly metamorphosed, or blue, crystalline limestones, and the name Hastings was applied to them. We place most of the blue limestones in the Grenville and restrict the name Hastings to the conglomerates, with some limestones, and other sediments that we have proved to be post-Laurentian in age. The Hastings rocks, as here defined, have been found at various places across a strip of country sixty-five miles in length, from the township of Belmont in Peterborough county on the southwest to the township of Palmerston in Frontenac county on the northeast. On following pages reference is made to the views that have been held concerning the Hastings and Grenville series.

(5) Intrusives, later in age than the Hastings sediments, are represented by gabbro with extrusive facies (basalt and tuff), and granite.

(6) The crystalline limestones and other Grenville sediments in southeastern Ontario constitute a series of great thickness, and are found to be of pre-Laurentian age. The great volume of the sediments older than the Laurentian appears not to justify the separation of the Laurentian and earlier rocks from those of later pre-Cambrian age. In other words, a dual subdivision of the pre-Cambrian into an upper characteristically sedimentary group above the Laurentian and a lower igneous complex, including the Grenville, is not logical. Hence the writers do not make use of the terms Algonkian and Archean, or Proterozoic and Archeozoic, employed by many authors.

AGE CLASSIFICATION OF THE ROCKS OF THE REGION

The following table gives the classification of the rocks, according to their age relations, employed in this report and on the accompanying maps:—

Pleistocene	
GLACIAL AND RECENT	Boulder clay, sand and gravel.
Paleozoic	
ORDOVICIAN	Blac' River limestone and basal sandstone.
(Great unconformity)	
Pre-Cambrian	
POST-HASTINGS INTRUSIVES	Granite, gabbro, diabase, basalt.
(Intrusive contact)	
HASTINGS (TEMISKAMING?) SERIES	Conglomerate, greywacké, quartzite, slate, thin beds of crystalline limestone, and the metamorphosed equivalents of these rocks.
(Unconformity)	
LAURENTIAN	Gneissoid granite and syenite.
(Intrusive contact)	
GRENVILLE SERIES	Crystalline limestone, iron formation, slate, quartzite, greywacké, largely altered to various schists and gneisses.
KEEWATIN COMPLEX	Green schists, pillow lavas, basic gneiss and other rocks.

COMPARISON WITH NORTHERN AND NORTHEASTERN ONTARIO

From the preceding table it will be seen that the geology of southeastern Ontario is much like that of the northeastern part of the Province, e.g., Cobalt and surrounding region, distant two hundred miles or more. The Keewatin is present in large volume in both regions, but the Grenville sediments have a much greater thickness in the southeastern than in the northeastern region, owing to greater erosion in the latter. The Laurentian in one region possesses similar features to those of the other. The Hastings series in character and relations appears to be comparable to the Temiskaming series of the region surrounding Cobalt. The later granite, Moira, resembles in character and relations the Lorrain granite of Cobalt. The post-Hastings basic intrusives, marked on the maps as being doubtfully of Keweenawan age, are more altered or decomposed than the Nipissing diabase of Cobalt, and may be of about the same age as the lamprophyre dikes of Cobalt and the pillow lavas, post-Sudbury series, of Sudbury. Fragmental rocks, comparable in age with the rocks to which the name Cobalt is applied, have not been recognized in the southeastern region.

The two regions are separated by a territory which is underlain chiefly by granite and granite gneiss, and in which pre-Cambrian sediments later in age than the Grenville series are not known to occur.

Following the nomenclature usually employed in the description of fragmental rocks next younger than the Laurentian, both the Hastings and Temiskaming series might be called, provisionally, Lower Huronian.

In the appendix to this report is given a comparative table of the age relations of the pre-Cambrian rocks of all the areas in Ontario that have been mapped systematically.

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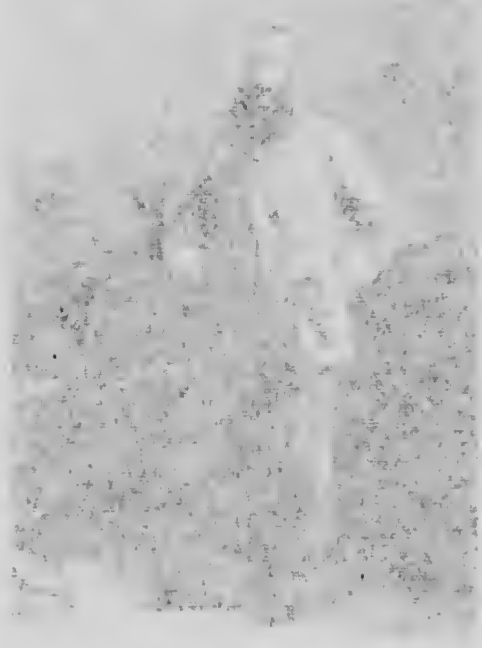
W. E. Logan

(1798-1875).

Sir William Edmond Logan, F.R.S., Provincial Geologist of the Province of Canada (Ontario and Quebec), 1843-1867, Director of the Geological Survey of the Dominion of Canada, 1867-1869.

(From the painting in the Canadian Institute, Toronto, by Berthon, 1856.)



GEOLOGICAL LITERATURE ON THE DISTRICT

As the table on a preceding page shows, the rocks of the district, exclusive of the Pleistocene, fall naturally into two groups: the Paleozoic and pre-Cambrian. While notes on the former group are given in the description of the various areas, no detailed study has been made of it by the authors. This report, therefore, deals essentially with the pre-Cambrian rocks. From the time the rocks were first studied in southeastern Ontario and adjacent areas, in the fifth decade of the last century, until its last decade, the name Laurentian was applied to all of them. They included granites and granite gneisses, crystalline limestones and other rocks, together with what was called the Upper Laurentian or Norian. Papers by Logan, Murray and other authors of the earlier period, and those by Vennor, Selwyn, Adams, Barlow, and Ells during the last quarter of the century, and more recently, show the views that have been held, and the discussions that have taken place concerning the so-called Laurentian of this region.

Alexander Murray, C.M.G.
(1810-1884).

Mr. Murray was Assistant Provincial Geologist of Canada (Ontario and Quebec) from 1843 to 1864, and Director of the Geological Survey of Newfoundland from 1864 to 1883. He was Sir William Logan's co-worker in the Canadian pre-Cambrian. The picture is from a photograph taken in 1865.

On following pages, extracts from papers and reports give the opinions of various authors in the past concerning the character and relations of the rocks of the district.

All the literature on the district up to 1908 has been summarized by Van Hise and Leith.*

Views Held in 1897 and Earlier

In 1897, the late Dr. Geo. M. Dawson, then Director of the Geological Survey of Canada, gave an excellent summary of the literature, and of the opinions then held, of the nature and relations of the more ancient rocks of North America.† The following quotations are taken from Dr. Dawson's address:—

"It was along the Ottawa valley, in 1845, that the rocks subsequently classed under

* Pre-Cambrian Geology of North America, U. S. G. S. Bulletin, No. 360, pp. 448-483.
† Presidential Address, Section C, Brit. Ass. Ad. Science, 1897.

the Laurentian and Huronian systems were first examined in some detail.* In that year Logan met with and accurately described, severally, rocks which we now refer to (1) The Fundamental Gneiss; (2) The Grenville Series; and (3) The Huronian. He speaks of the rocks of the first class as being in the main syenitic gneisses 'of a highly crystalline quality, belonging to the order which, in the nomenclature of Lyell, is called metamorphic instead of primary, as possessing an aspect inducing a theoretic belief that they may be ancient sedimentary formations in an altered condition.' In what we now call the Grenville Series, he describes the association of crystalline limestones and interbedded gneisses, adding that it appeared to be expedient to consider this mass as a separate metamorphic group, supposed to be newer than the last. Of the Huronian, the relations were at that time left undetermined, although it is observed that its beds hold pebbles of the underlying rocks, here the Fundamental Gneiss.

. . . .

Henry G. Vennor, F.G.S.
(1840-1884).

Mr. Vennor was a member of the staff of the Geological Survey of the Province of Canada (Ontario and Quebec) from 1860 to 1867, and of that of the Dominion of Canada from 1867 to 1881. The most of his work was in connection with the pre-Cambrian rocks of southeastern Ontario and the adjacent part of Quebec. The picture is from a photograph taken about 1876.

"In the Report for 1852-53 (published 1854), the name Laurentian was adopted for what had been previously designated merely as the 'metamorphic series,' and in the geological sketch printed in Paris in connection with the Exhibition of 1855 (which follows next in order of publication), this system is stated to consist almost exclusively of much altered and disturbed sedimentary beds. It is also, however, made to include some recognized intrusives, such as granite and syenites, forming parts of the mass, as well as the Labradorite rocks, which were afterwards for a time named Upper Laurentian, and to which further allusion will be made in the sequel.

. . . .

* The Huronian rocks were found on Lake Temiskaming, an expansion of the upper part of the Ottawa river, in northeastern Ontario. This lake is beyond the region under review in the present report. M. & K.

Very truly yours
Edw. J. Chapman

(1821-1904.)

E. J. Chapman, Ph.D., LL.D., Professor of Mineralogy and Geology in the University of Toronto and University College, 1853 to 1895, and the author of many papers on the Mineralogy and Geology of Ontario.

(From a photograph taken about 1891.)

"In the summary volume of 1863 . . . . the existence of an Upper Laurentian, Labradorian or Norian Series was first tentatively indicated in a supplementary chapter. It is unnecessary to follow here the history of the rocks so classed, for the supposed series has not stood the test of later discussion and research, due chiefly to Selwyn and Adams. The apparently stratified rocks often included in it are now understood to be foliated eruptives. The recognition achieved by this and by other more or less hypothetical series about this time may be traced to the brilliant chemico-geological theories advanced by Hunt, previous to the general acceptance of modern petrographical methods.

"In a similar manner, and very justly so, Logan, as a field geologist, was influenced by the views held by Lyell in the early editions of his 'Principles' to accept without reservation the foliation of crystalline rocks as indicative of original bedding.

. . . .

"No reference has so far been made to the development of Archæan [pre-Cambrian] rocks, known as the 'Hastings Series.' The rocks thus named occupy considerable tracts to the south of the Ottawa River, west of the City of Ottawa. They were originally classed by Logan and Murray with the Grenville Series of the Laurentian, although Murray soon after insisted on their peculiar features, and they came to be recognized by the above geographical name during subsequent discussions as to their systematic position, by the authors above referred to, and by Hunt, Vennor, and Macfarlane. These rocks are particularly alluded to now, because later work seems to show that both the Grenville Series and the Huronian are represented in the district—in so far, at least, as lithological characters may be depended on. They include a preponderance of thinly bedded limestones and dolomites, finer in grain and usually less altered than those of the typical Grenville Series, associated with conglomerates, breccias and slates still retaining complete evidence of their clastic origin.

. . . .

"Reverting to the original classification of the Archæan [pre-Cambrian] of the Canadian Survey, as developed in the field by Logan and his assistants, we may now enquire—In how far does this agree with the results of later work above outlined? In the main, this classification still stands substantially unaltered, as the result of all honest work carefully and skillfully executed must. The nomenclature adopted is still applicable, although some of our conceptions in regard to the rocks included under it have necessarily undergone more or less change.

"The Laurentian is still appropriately made to include both the Fundamental Gneiss and the Grenville Series; although at first both were supposed to represent 'metamorphic' rocks, it was even then admitted (1855) that these embraced some plutonic masses practically inseparable from them. Later investigations have increased the importance of such plutonic constituents, while at the same time demonstrating the originally supposed sedimentary origin of the characteristic elements of the Grenville Series; but the admission of so large a plutonic factor necessarily invalidates in great measure the estimates of thickness based upon the older reasoning, under which any parallelism of structure was accepted as evidence of original bedding.

. . . .

"The subsequently outlined Labradorian [Norian or Upper Laurentian] has been eliminated as a member of the time-series, and the rocks of the so-called 'Hastings Group' remain yet in a doubtful position, but with the promise that they may afford a clue to the true relations of the Grenville Series of the eastern and the Huronian of the western province of the Protaxis."*

Conclusions of Adams in 1901

For several years Messrs. F. D. Adams and A. E. Barlow were engaged in mapping and working out the geological structures of the Haliburton and Bancroft areas, which include about 4,200 square miles. The work having been completed in 1901, the results were summarized by Dr. Adams in the following words:—†

"With the completion of this work it may be appropriate to state very briefly what has been accomplished.

. . . .

"The survey has shown that the northern half of the area mapped consists almost exclusively of granite-gneisses of igneous origin which would in all probability have been classed by Logan as Fundamental gneiss. The southern half of the area, on the other hand, consists chiefly of a series of very ancient sedimentary rocks, largely limestones, which rests upon the gneissic series, but which has been invaded and altered by it. Large areas of the sedimentary series have been so shattered and penetrated by the granite-gneiss that a sort of breccia on an enormous scale has resulted. Great bathylites of the granitic rock arch up and break through the sedimentary series elsewhere, the latter being wrapped around the bathylites in great sweeping curves.

* In the Geol. Sur. Report for 1877-78, p. 10A, the conclusions concerning the relations of the Hastings and Grenville series are summarised by Dr. A. R. C. Selwyn.

† Geol. Sur., Canada, Vol. XIV, 1901, pp. 148-149A.

"The same bathylite structure is observable in the northern gneisses also, and can b traced by the curving strikes of the foliation of the gneiss, but here the limestones hav been swept away by erosion.

"In the south-eastern portion of the area the limestones are found in a comparativel unaltered condition and are associated with great volumes of amphibolite and othe foliated rocks, as well as with occasional bands of conglomerates—some of which, a least, have been shown by Dr. Barlow to be of autoclastic origin. The amphibolites ar in part altered volcanic tufas."

International Committee's Conclusions, 1906

In 1906 an international committee, consisting of Canadian and United States geolog ists, representing the federal surveys of the two countries, was appointed to conside the "Correlation of the pre-Cambrian Rocks of the Adirondack Mountains, the 'Origina Laurentian Area' of Canada, and Eastern Ontario." The following extracts, from th report made by the committee, show the conclusions to which it came.*

"The committee considers that over the whole area covered by their investigations— namely, the Adirondack Mountains, that portion of Eastern Ontario which they examined the 'original Laurentian area' in the province of Quebec and its continuation to the eas as far as the river St. Maurice—the pre-Cambrian sedimentary development is repre sented by one great series. This series is essentially identical in petrographical char acter throughout the whole region.

"The only locality where the possible (Coleman would say probable) existence of a second unconformable sedimentary series was suggested by the facts observed, was tha on the Queensboro road, east of Madoc, Ontario. It is, however, still a matter of un certainty as to whether the conglomerate here developed marks the base of an overlying infolded, unconformable series or not.

"In Logan's original classification of the Laurentian this term—apart from the Upper Laurentian which was proved to be composed essentially of anorthosite intrusions —included two series differing in character, namely, the Lower Orthoclase (Fundamental) Gneiss and the Grenville series. Now that investigations have shown that these two series differ in origin, one being essentially a great development of very ancient sediments, and the other consisting of great bodies of igneous rock intruded through them, it be comes necessary to separate these two developments in drawing up a scheme of classi fication.

"As the great intrusions of gneissic granite, forming what has been termed the 'fundamental gneiss' have an enormously greater areal development than the overlying sedimentary series, constituting, as they do, a very large part of the whole northern protaxis, the committee recommend that the term 'Laurentian' be restricted to this great development of igneous gneisses. The nomenclature suggested for the pre-Cam brian rocks of this eastern region will thus conform, so far as the use of this term is involved, with that suggested by the Special Committee for the Lake Superior region.

"For the overlying sedimentary series the committee recommend the adoption of the name 'Grenville series,' as it is the name originally given by Logan to the series as typically developed about the township of Grenville in the 'original Laurentian area' on the north shore of the Ottawa river, in the province of Quebec, between the cities of Montreal and Ottawa. The term 'Hastings series' in the opinion of the committee should be abandoned as a serial name, seeing that the development to which this name was applied by Logan is merely the Grenville series in a less altered form, as Logan in giving the name had conjectured was probably the case. The committee, however, think that it may in some cases be advantageously employed as a qualifying term to designate the less highly altered phase of the Grenville series, which may thus be referred to as the 'Hastings phase' of the Grenville series.

"In Canada this Grenville series everywhere on going north is invaded by and frays away into the great Laurentian bathyliths, while in the Adirondacks it is cut to pieces by the great intrusions of that area which, when worked out in detail, may prove also to have a more or less similar bathylithic form.

"The following succession in this region is therefore recognized and adopted by the committee:

"CAMBRIAN— Potsdam sandstones, etc.
(Unconformity)
"PRE-CAMBRIAN—
Grenville series
(Intrusive contact)
Laurentian.

"The committee consider that it is inadvisable in the present state of our knowledge to attempt any correlation of the Grenville series with the Huronian or Keewatin, so

* Journal of Geology, April-May, 1907, pp. 191-217.

extensively developed in the region of the great lakes. The Grenville series has not as yet been found in contact with either of these, and until this has been done and the relation of the several series have been carefully studied, their relative stratigraphical position must remain a mere matter of conjecture."*

Conclusions of Miller and Knight, 1907

In 1907, the authors prepared a brief paper on the district under review.† In that paper, conclusions given as to the age relations of the rocks were practically the same as those in the present report. It was shown that the Grenville series had a basement, Keewatin rocks having been found to occur in the district. The iron formation, which was discovered in that year, was placed with the Grenville sediments. Conglomerate and other rocks were definitely separated from those sediments, the name Hastings being retained for them.

Since the paper was written, a larger territory has been examined and a more complete knowledge of the character of the Grenville sediments, and their relations one to another, has been obtained. The age relations of the various intrusives have been determined, and the discovery of numerous erosive contacts between Hastings conglomerate on the one hand, and granite-gneiss, Keewatin rocks and various members of the Grenville series on the other, has enabled a more complete geological history to be written.

More Recent Publications

While the papers and reports issued within the last six years add nothing to our knowledge of the age relations of the rocks, during this period, one of the most important and detailed reports has been published that has yet been written on the pre-Cambrian of any Canadian area.‡ The authors are F. D. Adams and A. E. Barlow, and the

* Notes by M. & K.—The following notes and extracts show that the conglomerates and their limestone pebbles were known to early workers in the field. The stratigraphical relations of the conglomerates were, however, left in doubt, as they were by the International Committee report, quoted above.

In the Report of the Geological Survey of Canada for 1852-53, Murray described the conglomerate on the Queensboro road and the limestone pebbles that are to be found in it. He also mentions the occurrence of conglomerate near the village of Madoc and at Belmont lake.

Macfarlane, in the Report for 1863-66, page 93, said: "Conglomerates, consisting of pebbles, generally of quartzite, in a schistose matrix, and lithologically not unlike some of the Huronian rocks, are frequently met with in Madoc." In a footnote to this statement, Logan does not agree with Macfarlane's suggestion that the rocks are Huronian. He says "The rocks of Marmora, Madoc, and other townships in Hastings, have provisionally been classed with the Laurentian series, with which they appear to be conformable, and in common with which they hold *Eozoon Canadense*, in which, however, the canals and interspaces of the fossil are filled with carbonate of lime instead of any of the silicates filling them in other parts. These Hastings rocks may be a higher portion of the Lower Laurentian series than we have met with elsewhere. It is not to be inferred from the presence in them of a schistose conglomerate that therefore they are Huronian. As shown in the Geology of Canada, p. 31, conglomerates occur in the Laurentian, as well as in the Huronian series."

The conglomerates and their limestone pebbles are also described by Mr. H. G. Vennor in the Report for 1866-69, pp. 143-171. In the Report for 1869-70, the same author regards the conglomerates as probably of Huronian age.

From 1866, for about twelve years, Mr. H. G. Vennor was engaged in studying the Laurentian system, which then included the Grenville and Hastings series, in southeastern Ontario and the adjacent part of Quebec. His conclusions, after these years of study, are given by Dr. A. R. C. Selwyn, at that time Director of the Geological Survey. In the Report for 1877-78, p. 10A, Dr. Selwyn said: "Since 1866, Mr. H. G. Vennor, of the Geological Corps, has been occupied in a careful examination of the stratigraphical relations of the Laurentian rocks. . . . . Thus, at the commencement of Mr. Vennor's investigation in 1866, it was supposed that the limestones and calcareous schists of Tudor and Hastings holding *eozoon* together with certain associated dioritic, felsitic, micaceous, slaty and conglomerate rocks, were a newer series than those already examined and described by Sir W. E. Logan, and they were accordingly designated in the report published in 1870, the *Hastings series*, and it was further supposed, from its apparent stratigraphical position and from certain lithological resemblances, that it might be of Huronian age. The gradual progress of the work, however, from west to east, has now, I think, conclusively demonstrated that the Hastings group, together with the somewhat more crystalline limestone and gneiss groups above referred to, [i.e., Grenville series], form one great conformable series."

From this quotation it will be seen that the conclusions arrived at by Selwyn and Vennor on the work between 1866 and 1878, and the conclusions of the International Committee in 1906, on the work done after 1892, are the same, viz.: that the Hastings and Grenville form one conformable series.

† Ontario Bureau of Mines, Vol. XVI., Part I, pp. 221-223.

‡ Geological Survey of Canada, Memoir No. 6, 1910. Geology of the Haliburton and Bancroft areas, by Frank D. Adams and Alfred E. Barlow.

report describes the geology of the Haliburton and Bancroft areas, which lie to the nor and northwest, almost beyond the limits of the district we have examined. The fie work on which the report is based was done chiefly between the years 1892 and 1902.

The authors say, pp. 49-51:

"The geological history of the area may be briefly summed up as follows:—

"The district was, in pre-Cambrian times, covered by a sea, in which there w deposited an immense series of sediments aggregating many thousand feet in thickne The thickness of the series shows that the period of deposition was a long o and the prevailing calcareous character of the sediments shows that it was probably marine origin. That there was land, however, in the vicinity, is shown by the fact th a certain amount of argillaceous and arenaceous sediment found its way into this se It was deposited at a time of violent volcanic activity, for there is reason to belie that a large part of the great volume of amphibolite interstratified with the norm sedimentary material represents volcanic ashes and other clastic material of volcan origin, which was, from time to time, thrown out into the sea in which normal sed mentation was going forward. There are also flows of porphyritic lava, and bosses plutonic rocks, probably representing the deeper parts of volcanic centres.

"Concerning the nature of the basement upon which this immense accumulatio of sedimentary material was laid down we have no certain knowledge, for no part of can be recognized at the present time as the original floor.

"This great series was then folded in a general direction, N. 30° E., and probab contemporaneously with the folding, was invaded by an enormous body of granite This granite slowly rose in the form of great batholiths, into the overlying series, di integrating it and becoming filled with countless fragments of the invaded rock. I the case of the limestones this granite not only disrupted them, but changed them int amphibolite. The amphibolite produced in this way, as well as that referred to abov as occurring interstratified with the limestones, and of different origin, was, in man places, dissolved by, or incorporated into, the substance of the granite, taking the for of basic streaks or schlieren.

"While in the southeast corner of the area the sedimentary cover is thick, an almost continuous, on going toward the northwest it becomes, as the result of mor intense erosion, progressively thinner, while the volume of granite breaking up throug it gradually becomes greater until the northern limit of the Bancroft sheet is reache where the sedimentary series is fretted away, and is represented only by occasiona shreds and patches of amphibolite scattered through the batholiths of gneiss, an arranged in lines conforming to the strike of the foliation of the latter. The erosio to the north has thus cut down into and laid bare a deeper part of the section, wher all the rocks, both invaded and invading, everywhere show indisputable evidence o great movement while in a soft or plastic condition.

"Here are displayed the roots of the mountains. From what has been said it wil be seen that there are presented in this great area precisely the same phenomena a those seen elsewhere in North America, and the evidence available seems to indicat that this statement may be extended to all parts of the world. Where the oldest strati fied, or stratiform formations are exposed, these rest upon great bodies of granite usually gneissic in structure, which penetrate them in great batholithic masses the contact being an intrusive one. Thus the Keewatin, which in the region o the Great Lakes, on the border of the Canadian shield, is the oldest series, and which, although containing a large amount of volcanic material, abounds also in ordinary sedimentary deposits in many districts, rests upon granite which is intruded through it. Farther to the east, all along the border of the same shield or protaxis in Ontario and Quebec, as well as in the Adirondack mountains, the Grenville, which forms the base of the sedimentary series, shows precisely the same relations."

*Note by M. & K.—The intrusive character of granite in other parts of southeastern Ontario, has been referred to by various writers. For instance, in speaking of part of the Madoc-Marmora area, Coste says: "Fiftee large igneous masses and numerous smaller ones are to be found there in an area of 500 square miles. They have cut the Archæan or primitive rocks to pieces and have completely metamorphosed large areas of the rocks of that system, so much so, that I estimate these metamorphosed rocks (principally metamorphosed by injection) and the igneous masses to occupy about half the area of the Archæan of that part of the country." Report Geol. Surv., Can., 1886, p. 20A.

THE ROCKS OF THE DISTRICT

The following notes on the rocks supplement those in the summary on a preceding page:—

The Keewatin.—The most ancient rocks which have been recognized consist essentially of green schists. It can be shown that they are of igneous origin, because they sometimes pass gradually into altered basalts which still retain ellipsoidal structures, Fig. 20, and because chemical analyses prove that their composition is similar to basic lavas. The rocks have been correlated or classed with the Keewatin, mainly for two reasons: (*a*) They have the same mineral composition and appearance as many of the Keewatin schists in Northern and Northwestern Ontario, and are, in part, altered pillow lavas. (*b*) They occur in the same stratigraphic position as these rocks, namely, at the base of the geological column.

In other parts of Ontario the Keewatin period is considered to have been one of great volcanic activity, during which enormous quantities of lavas were erupted, probably largely under the surface of the ocean. It is not known upon what kind of rocks these lavas originally rested.

Owing to rock decay, and especially to migrating solutions from the limestones, the Keewatin and other members of the pre-Cambrian are often highly impregnated with calcite and dolomite.

The Grenville Series.—The volcanic activity of the Keewatin was succeeded by a period during which sediments, known as the Grenville series, and now represented by crystalline limestone, greywacké, quartzite, slate and iron formation, were deposited. It has not been proved that contemporaneous lava-flows occurred during the deposition of the Grenville sediments. Such, however, may have been the case, as the intense volcanic activity of the Keewatin would not probably abruptly change to a long-continued era of sedimentation. If interbedded flows of lava do occur it may be difficult to distinguish them from the basement flows, Keewatin, on which the Grenville sediments rest.

These rocks are of great thickness, and are considered by some authors to be the thickest pile of sediments known on the earth's crust, having been estimated by Vennor* at 50,000 to 60,000 feet, and later by Adams at 94,406 feet.† The present writers, however, believe that certain Keewatin lavas have been included in these measurements, thus giving to the Grenville series too great a thickness. At Madoc the thickness appears to be at least half a mile.

Generally speaking, the base of the Grenville series, where seen in contact with the Keewatin, consists of greywacké, Fig. 21, and quartzite, which pass upwards into limestone. We have not been able to prove that the surface of the Keewatin was eroded before the deposition of the Grenville, but the presence of quartzite and greywacké beds would seem to indicate that there was a land surface. A striking characteristic of the Grenville sediments is the absence of coarse material.

The iron formation, which is very subordinate, consists of pyritiferous schist, and of granular or cherty quartz, jaspilyte, grey to red in color, and containing sometimes considerable iron oxides. The jaspilyte is regarded as a chemical precipitate.

It is believed that the Grenville sediments were deposited in part on the ropy surface of sub-marine lavas belonging to the Keewatin.

The Laurentian.—After the deposition of the limestones and other sediments of the Grenville series, both the Keewatin and Grenville rocks were invaded by vast masses of granite and syenite. The intrusion caused the older rocks to become folded, crumpled and altered to schists and gneisses. Thus their bedding or schistose planes now rest in vertical or highly inclined positions. The invasion of the granites also appears to have destroyed, in many areas, the Keewatin lavas, so that the basement on which the Grenville sediments originally rested is frequently not seen, or, at least, not recog-

* Geological Survey of Canada, 1876-77, pp. 299-300.

† Geology of the Haliburton and Bancroft areas, Province of Ontario, Memoir No. 6, p. 36, Geological Survey of Canada. Journal of Geology, Vol. XVI, 1908, p. 630.

nised. Further, it is conceived that masses of the granite magma forced their way thr great cracks or channels of the Keewatin rocks reaching up into the Grenville ments; hence the latter now rest directly on the granite with irruptive contact. other cases where the sediments rest on the granite with irruptive contact it ma that the Keewatin basement was absorbed by the granite magma.

A characteristic feature of the Laurentian gneisses is that they are often mor less strikingly banded, due to alternate layers of dark or light-colored material. It frequently be shown that the dark bands were originally fragments of the Keew or Grenville series which were caught up by the molten granite magma and flatte out into long lenses by pressure. The banded structure has also been caused by intrusion of narrow parallel tongues or dikes of the granite between the schistos bedding planes of the older rocks.*

The granites composing the Laurentian complex were probably intruded at vari times during the Laurentian period. For instance, west of the village of Flinton, Addington county, the granite-gneiss invades a mass of syenite. This occurrenc described in following pages.

The Hastings Series.—Movements connected with the invasion of the Laurent granites into the Keewatin and Grenville are thought to have raised these rocks ab sea level and formed mountain ranges. Erosion of the mountains took place. T weathering and denudation thus begun must have been deep and long continued, over vast areas were removed the overlying Keewatin and Grenville rocks, exposing view the deep-seated granites and gneisses. This period of erosion was followed by to or partial submergence of the land surface below the ocean, and beds of conglomera Fig. 10, and quartzite—holding pebbles of Keewatin, Grenville, Fig. 11, and Laurenti rocks—were deposited. Remnants of these Hastings sediments occur here and the throughout a stretch of country 65 miles long, in the form of narrow lenses or ban closely infolded with the older rocks. The conglomerates and quartzites are schistose; fact, in many places they are altered to schists which are indistinguishable from schists of the older Grenville series. It is obvious that the forces which acted on conglomerates and quartzites of the Hastings series, causing them to become schisto must also have acted on the older granites and syenites of the Laurentian, causing latter to assume gneissoid structures. It is believed also that the gneissoid structures the granites and syenites were formed in part when the granite was still in a plas state.

Conglomerates and other fragmental rocks of the Hastings series occur in par of the district, outside of the area mapped, viz., near Sulphide, a station on the Canadi Pacific Railway east of Tweed, and near the crossing of the Madoc-Marmora wagon ro over the Moira river, east of Deloro. The conglomerate, southeast of the Actinoli Cloyne area, in the Bald mountains, near the Addington road, is described on a follo ing page. Its relations to the granite-gneiss are instructive.

From what has been said in preceding paragraphs, it will be seen that the ter "Hastings series" is used in a more definite and a more restricted sense in this repo than it has been by other writers. In earlier reports the term covered the blu crystalline limestones, most of which we place with the Grenville, together with co glomerates and other sediments. We thus employ the term to cover part of the rock to which it was formerly applied, but not all of them. In the same way the nam Laurentian, for example, now stands for only a part of the rocks to which it wa applied by Logan and the earlier field men, the Grenville and Norian now not bein included in the group.

* It has already been stated that Sir William Logan, in the early days of the Canadia Geological Survey, mistook this banded structure for bedding planes. British geologist at the time held the same opinion concerning the banded and foliated rocks in the Highland of Scotland. (*See* Memoirs of the Geological Survey of Great Britain.—The Geologica Structure of the North-West Highlands of Scotland, page 13.).

Post-Hastings Intrusives.—The youngest pre-Cambrian rocks include granite, diabase and basalt. The Moira granite at Moira lake, Hastings county, and the diabase-basalt at Belmont lake, Peterborough county, are examples of these later intrusives. The massive structure of the granite helps to distinguish it from the older Laurentian granites, which are generally gneissoid; but where the Hastings conglomerate is absent it may be difficult or impossible to separate the older from newer granites.

The intrusion of these younger rocks probably rendered the Hastings sediments schistose and tilted them into vertical position.

Paleozoic System.—After the invasion of the post-Hastings granites and more basic rocks, the surface of the earth again fell below sea-level, and limestone, sandstone and shale of the Paleozoic system were deposited. These rocks, since their elevation to land surface, have remained in a practically undisturbed state to the present day. Faults with small throw are, however, occasionally found.

Fig. 2a. Fragment of eozoon-like material from Big Island, Belmont lake. Natural size

TOPOGRAPHY

Mr. W. R. Rogers, topographer of the Bureau of Mines, has written the follo description of the topography of southeastern Ontario:

Introduction.—Southeastern Ontario presents a great variety of topographic fea which are to a certain extent expressions of the intricate geological structure of region. What is true of the particular localities embraced by the isolated map sh the positions of which are indicated on the accompanying key plan, Fig. 1, is applic in a general way to adjacent areas.

Pre-Cambrian rocks occur to the north of a line joining the south end of Geor Bay and the east end of Lake Ontario. That part of the Province of Ontario lyin the south of this line is underlaid by undisturbed Paleozoic formations, dipping at angles away from the old land to the north. Granitoid gneiss is the predominant to the north, limestone to the south. It is on the border line of these two main divis that the larger mapped areas lie, and, in consequence, areas embraced by the geolog sheets accompanying this report possess physiographic features common to both the Cambrian and the Paleozoic.

The main line of the Canadian Pacific Railway, Toronto to Montreal via Pe borough, traverses the southern part of the areas embraced by the Belmont and Act lite-Cloyne sheets.

Near the southwest end of the latter are situated three small areas, namely, Ma Hazzard's Corners and Queensboro. The Gilmour and Ompah areas are respectiv 26 and 18 miles north of the above-mentioned railway line. Gilmour station, on the of the Central Ontario Railway, has a high elevation, 1,018 feet above the sea, or feet above Lake Ontario. Immediately to the east of the Ompah area, and one an half miles south of Lavant station on the Kingston and Pembroke Railway is the s mit, elevation 905 feet. These two areas are situated in the Ontario Highlands on height of land between Lake Ontario to the south and the Ottawa River to the north.

It is to the five southern sheets that this topographic description applies more p ticularly, as the writer did not visit either the Gilmour or Ompah areas.

A few high hills of rock, that have resisted glacial action to a greater ext than the surrounding country, stand out in bold relief, and have been utilized by Dominion Geodetic Survey for the location of primary triangulation stations. One these observation towers is situated on the Bald mountains, about three miles west Kaladar station on the Canadian Pacific railway. Another, about ten miles northe of Queensboro, is located on the highest point of Mount Maria, lot 23, concession township of Grimsthorpe. There is also a tower situated near the Ompah ar about two miles east of Lavant station on the Kingston and Pembroke railway. Th triangulation towers are prominent landscape features, visible for many miles fr elevated points where a clear view is obtainable.

The region has been the scene of lumbering operations for a number of decad until practically all the valuable timber has been removed, including both conifero and hardwood varieties. Fires also have destroyed much valuable forest from ti to time. Many of the rough, broken, or sandy areas, where settlers now barely e out a livelihood from agricultural pursuits, if placed under government control cou be reforested. A national asset would be created in this way, and, in addition, gener climatic advantages would ensue.

Survey lines, marking township, concession and lot boundaries have become obliterated that it is a difficult matter to retrace the original surveys, many of whi were made about 100 years ago. In consequence it was found necessary to traver practically all the roads and tie in the old surveyed lines wherever possible in ord to secure a topographic base for the accompanying geological maps, more particularly th Actinolite-Cloyne, Belmont and Queensboro sheets.

Pre-Cambrian.—Pre-Cambrian topography is remarkably uniform throughout Ontario, and has been described by many writers. Various terms—Canadian shield, Laurentian peneplain, and Archean protaxis—have been applied to designate this outstanding physiographic province, the backbone of central Canada.

The singularly even sky-line, perhaps the most characteristic topographic feature, may be noted from almost any prominent hill where a clear view can be obtained. Only in this way will the casual observer note the plain-like character of the upland surface, interrupted occasionally by greater elevations standing out in relief. Very rarely does an elevation exceed the height of the adjacent depression by more than 200 feet.

In detail the pre-Cambrian peneplain is rough, and towards the margins is more rugged. Rolling areas are the rule, hummocky ones the exception. Monadnocks are infrequent. In most cases the surface elevations present a rounded appearance, devoid of overburden, and plainly show the results of glacial sculpturing.

The region presents a perfect network of lakes connected by streams that are noted for rapids and waterfalls. In parts the water area approaches 25 per cent.* of the whole. In fact all the characteristics, including imperfectly developed drainage, are indicative of a youthful stage in the present cycle of erosion.

Throughout Canada the average elevation of the pre-Cambrian is approximately 1,000 feet, and, so far as is known, the maximum elevation in Ontario is in the neighborhood of 2,100 feet above sea level.

Paleozoic.—Paleozoic topography, in contrast with pre-Cambrian, presents an entirely different aspect The general character of the country is rolling and drift-covered for the most part. Drainage is better developed, and agriculture is the chief industry.

The present line of contact between pre-Cambrian and Paleozoic is intricate. Flat-lying sedimentary outliers are numerous. Sometimes these are separated by many miles from the main Paleozoic mass to the south. Consequently the topography of the areas embraced by the accompanying map sheets is varied, partaking partly of pre-Cambrian and partly of Paleozoic characteristics.

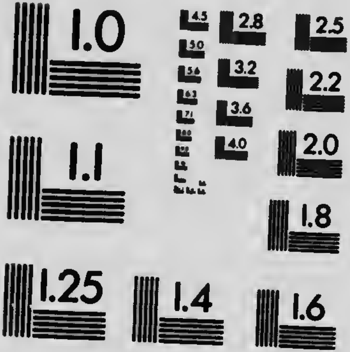
Through the counties of Northumberland and Hastings the main lines of the Grand Trunk and Canadian Pacific railways parallel one another and both traverse the Paleozoic areas. The former follows the shore of Lake Ontario, while the latter is inland a distance varying from twenty to twenty-five miles. The average elevation of the lakeshore railway is 50 feet above Lake Ontario while that of the inland line is 450 feet above the lake. Thus we have a gradient of 15 feet to the mile towards the south. Railways usually follow lines of depression, yet, in the absence of contoured topographic maps of this area, the above data are the best available to represent the surface gradient. It is also worthy of note that the entire southern watershed from Gilmour to Lake Ontario, embracing both the pre-Cambrian and Paleozoic formations, has a uniform surface gradient.

Topographically, the most important feature in connection with the Black River limestones is the cuesta whose escarpment front extends along the entire northern boundary of the Paleozoic. Through the counties of Hastings and Addington the cuesta is only partly visible owing to drift deposits. One prominent outcrop marks the southern shore of Moira lake where the plateau rises to an elevation of 150 feet above the wide valley to the north. This limestone escarpment has a talus slope reaching well up towards the crest. Another exposure of the cuesta occurs two and one-half miles north of Tweed, lots 8 and 9, concession XII., Hungerford township. On the Belmont sheet there is a precipitous cliff, 70 feet high, with talus slope abutting the southern shore of Round lake.

*Physiography of the Archean areas of Canada, by A. W. G. Wilson. Eighth International Geographic Congress.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



Paleozoic Outliers.—Outliers of flat-lying sediments are numerous and vary gre in size. The large ones are marked usually by an escarpment front with ta slope facing the direction from which the thrust of the glacier came. In most ca the lateral faces have had the talus débris worn away, while the lea side is usu marked by the presence cf more or less rectangular blocks trailing away in southwesterly direction.

From an agricultural standpoint these Paleozoic outliers mark oases in the rug and unproductive pre-Cambrian, supporting farming communities where dairying the specialty.

On the Queensboro sheet there is only one small erosion remnant. On Actinolite-Cloyne sheet there are four very small Paleozoic outliers to the northe of Moira Lake; another, somewhat larger, is situated on lots 10 and 11, concession Elzevir township. On the Hazzard's Corners sheet a larger area, showing a promin escarpment, occurs on lot 14, concession VII., Madoc township. Another outlier, thr quarters of a square mile in area, shown on the Belmont sheet, is known locally as Round Lake settlement.

Pleistocene.—About two miles northwest of Havelock, concession X., Belmont, the is an occurrence of narrow sand and gravel ridges, evidently of glacio-fluvial origin, ha ing a general northeast and southwest axial direction. These narrow hog's-backs, pr ably eskers, rise quite steeply to 20 or 30 feet above the surrounding plain, the altitu of which is approximately 725 feet above sea level. The same broken ridges are sa to extend southwesterly to Peterborough.

The most striking feature in proximity to these ridges is the prevalence of sma rounded kame-like domes, in some cases rising as high as the ridges above the lev plain.

Another prominent morainic ridge occurs near the southeast corner of the Belmo sheet, three-quarters of a mile north of the Canadian Pacific Railway. The ma travelled road from Havelock to Marmora follows its summit for a distance of one-ha mile.

Near the boundary of Belmont and Seymour townships, a couple of miles south the Belmont sheet, W. A. Johnston describes a drift-covered area which is a remarkab jumble of limestone boulders and boulder clay ridges, probably morainic in characte A short distance farther south, near Healy Falls on the Trent river, is the farthest poi to the northeast that a well-developed beach of glacial lake Iroquois has been definitel recognised.

Physiographic history.—The pre-Cambrian series of crystalline rocks occupies a larg part of the district embraced by the map sheets. These formations, comprising rock in greatest variety, have experienced intense metamorphism and a complicated foldin chiefly in a northeast and southwest direction. As a result of this folding mino valleys and ridges trending in the above direction are the dominant features of th upland topography. The Actinolite-Cloyne sheet demonstrates this point in an ocula manner. Frequently swamp areas of considerable extent are found between the rock ridges, e.g., the Boundary swamp between the townships of Kaladar and Barrie.

Pre-Cambrian areas which have been uncovered most recently near the Paleozoi escarpment represent very nearly the old pre-Paleozoic floor. Erosion probably too place continuously for a relatively long period during which the Paleozoic sediment were worn down and the pre-Cambrian boundary shifted southerly, leaving behind numerous limestone outliers. Recent dissection, including the forces of normal erosion and glacial scouring, has accentuated the roughness by further incising the old valleys. Belmont lake probably owes its existence to the erosion of softer sediments by glacial action.

However, the present land surface is essentially pre-glacial in origin. All the evidence points to the minor part played by the ice invasion in shaping and modifying the topography. The escarpment which fronts the old pre-Cambrian land is largely the result of normal drainage development along the northerly edge of alternately hard and soft strata dipping away from the old land to the north.

The general gradient of the pre-Cambrian interior rarely exceeds 4 feet per mile.* Near the margin the dip increases to as much as 20 feet per mile toward the Paleozoic sediments. North of Lake Ontario the pre-Cambrian floor on which the Paleozoic rocks rest, has an average southeasterly gradient of 23.7 feet per mile. From data which Mr. Wilson furnishes, this Paleozoic basement gradient in Hastings county amounts to 25 feet per mile dipping from north to south. More recent work in the Peterborough and Simcoe regions has verified the dip of the limestones.** This dip is S.S.W. on the average, amounting to about 25 feet per mile, but varied somewhat by slight undulations, folds, and occasionally steep dips near the pre-Cambrian boundary where the thickness of the limestones is slight. The limestones, however, are rarely faulted.

A study of the beaches of glacial lakes †Algonquin and ‡Iroquois shows that the region along the pre-Cambrian southern boundary has experienced differential uplift during and subsequent to the existence of these ancient lakes. The warped beaches exhibit a decided increase in uplift towards the N.N.E. The Algonquin beach uplift amounts to 6 feet per mile in the vicinity of Orillia, and the Iroquois beach differential elevation is as much as 5 feet per mile in Huntingdon township about 10 miles south of the Madoc sheet.

It is still believed by many that the uplift since glacial times was an isostatic movement due to relief from the burden of the ice sheet. In this connection§ F. B. Taylor, who has studied the Pleistocene of southern Ontario for several years, sounds a note of caution. He states that the relations between the boundaries of the ice and the uplifted lands are somewhat discordant and that the preponderance of evidence only slightly favors the idea of resilience following depression by the ice weight. The other hypothesis of such deformation and uplift incident to creeping movements is regarded as more tenable.

Many interesting problems await solution which cannot be intelligently studied until contoured topographic maps are available. At present topographic mapping is being carried on in Eastern Ontario by the Department of Militia and Defence, Ottawa. The sheets already published are on a scale of one and two miles to the inch, and show all the topographic features, viz.: hydrography, hypsography and culture.

DESCRIPTIONS OF THE AREAS

On following pages are given descriptions of each of the seven areas that have been mapped by the authors. The most western area, that of Belmont lake, is first described. This is followed by the descriptions of the Actinolite-Cloyne and the other areas that are shown on the index map, Fig. 1.

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*Physical Geology of Central Ontario, by A. W. G. Wilson. Transactions Can. Inst., Vol. VII, Part I.

**W. A. Johnston, Summary Reports, Geol. Survey, 1906-11.

† J. W. Goldthwait, Memoir No. 10, Geol. Survey, 1910.

‡ A. P. Coleman, Bureau of Mines' Report, Vol. XIII, 1904.

§ F. B. Taylor, Glacial and post-glacial lakes of the great lakes region, Smithsonian Report, pp. 291-327, 1912.

THE BELMONT LAKE AREA

INTRODUCTION

This area, in Belmont township, Peterborough county, contains within its bor both Belmont and Round lakes. Havelock station, a divisional point on the Cana Pacific Railway, one hundred miles east of Toronto, lies in the southwest corne the map sheet which covers approximately 50 square miles.* Belmont lake occupi depression in the pre-Cambrian rocks near the northern edge of the Paleozoic which stretches southward to Lake Ontario, distant 35 miles.

In addition to its interest from the geological point of view, the area posse other characteristics that make it worthy of being mapped in more detail tha had been up to the time that our work began. The two lakes possess attract for summer visitors and campers. On the shores of both, a number of cott have been built. Bass and "lunge," or maskinonge, fishing is good. During of three years small-mouthed black bass, caught in Belmont lake, have taken first prize, offered by certain sporting journals and newspapers for the fish of class of the greatest size. Fish have been sent in competition with those from lake not only from many parts of Ontario, but from the northern United State well. A few of the smaller streams have been stocked with speckled trout. B so conveniently situated for visitors from Toronto and other centres of population, area cannot fail to grow in popularity as a tourist resort.

Moreover, the area possesses attractions for the student of forestry and arb culture. The writers have seen no better examples of the conditions requisite the seeding and growth of pines than are shown on the point of Belmont lake the north end of Wilson bay. Years ago the area was visited by heavy fires wi destroyed all but a few of the pine trees that were numerous and made the important for its timber. On the part of the lake referred to, a few red pines one or two white ones escaped the fire and were left as seed trees. Poplars h since grown up and now have a height of fifty or sixty feet or more. Back from shore where the seed has been blown, in the shade of the poplars, there is no pretty growth of young pine trees four or five feet in height.

The area is deserving of more attention than it has received as a site for a orchards. Much of the land is rough, and, not being well adapted to the growth ordinary crops, it can be bought at a low price. Apple trees, in spite of the that they do not receive the attention given to orchards in established fruit distri do well. In 1912, the trees were loaded with fruit, without the aid of fertili or spraying solutions.

Within the area, at the present time, there are being worked the gold m at Cordova, the iron mine on the property adjacent to the south, and the t quarry of the Ontario Rock Company, whose plant, with a nominal capacity of tons a day, is on a spur of the railway, about three miles east of Havelock. Additio notes will be given on these industries on later pages.

* Map No. 22a. A careful topographic survey of the lake and islands was made by W. R. Rogers; the islands, which are numerous, have been numbered from south to nort

ROCKS OF THE AREA

The rocks of the Belmont Lake area are classified, by the authors, as follows:—

Pleistocene

GLACIAL AND RECENT	Boulder clay, sand and gravel.

Paleozoic

ORDOVICIAN	Black River limestone with basal sandstone and conglomerate.

(Great unconformity.)

Pre-Cambrian

POST-HASTINGS INTRUSIVES	Belmont amygdaloidal basalt and tuff. Belmont gabbro-diabase.
(Igneous contact.)	
HASTINGS (TEMISKAMING?) SERIES	1. Slate, quartzite and greywacké, thin beds of conglomerate and limestone. 2. Conglomerate and subordinate beds of slate.
(Unconformity.)	
GRENVILLE SERIES	1. Blue and white crystalline limestone, essentially non-magnesian, together with subordinate beds of fine-grained quartzite or chert. 2. Quartzose, dolomitic, crystalline limestone and sedimentary material lying between limestone and Keewatin. 3. Iron formation (banded chert, jasper, or granular quartz.) 4. Rusty quartz-mica schist. 5. Fine to medium-grained, quartz-feldspar gneiss of doubtful origin.
KEEWATIN COMPLEX	Hornblende and chlorite schists essentially of submarine volcanic origin.

The rocks, beginning with the oldest series, will be described in the following paragraphs:—

THE KEEWATIN COMPLEX

A belt of green schist, striking N. 15°E. and dipping steeply to the east, occurs along the west side of Belmont lake. The schist, which is fine to medium in grain, consists of green hornblende, chlorite, epidote, zoisite, biotite, feldspar, calcite, quartz and magnetite. Here and there in the rock occur round or oval masses, made up largely of epidote and over a foot in diameter. These masses are probably bombs. The following analysis shows the schist to have the composition of a basalt, and to be, therefore, of igneous origin. The sample analyzed was a composite one taken at various points along the west short of Belmont lake.

SiO_2	44.85
Al_2O_3	20.53
Fe_2O_3	5.45
FeO	12.96
MgO	2.45
CaO	9.88
Na_2O	2.16
K_2O	.35
H_2O	1.35
	99.98

A second belt of greenstone schist extends northerly from the northeast Round lake. In places the rock is a coarse hornblende-schist. On lot 25, sixth concession of the township of Belmont, beyond the northern boundary of th it is a fine-grained hornblende-schist consisting for the most part of green horn blades, together with lesser amounts of clear grains of quartz or feldspar, epido calcite. At the northwest corner of this lot, 100 feet from the corner post, the still retains numerous amygdules, about one-eighth of an inch in diameter, filled epidote and calcite, Fig. 15.

Like the Keewatin of northern Ontario, this schist is associated with iron forr or jaspilyte, described on following pages.

THE GRENVILLE SERIES

(1) *Blue and white crystalline limestones, essentially non-magnesian, togethe subordinate beds of fine-grained quartzite or chert.* Those crystalline limestones,

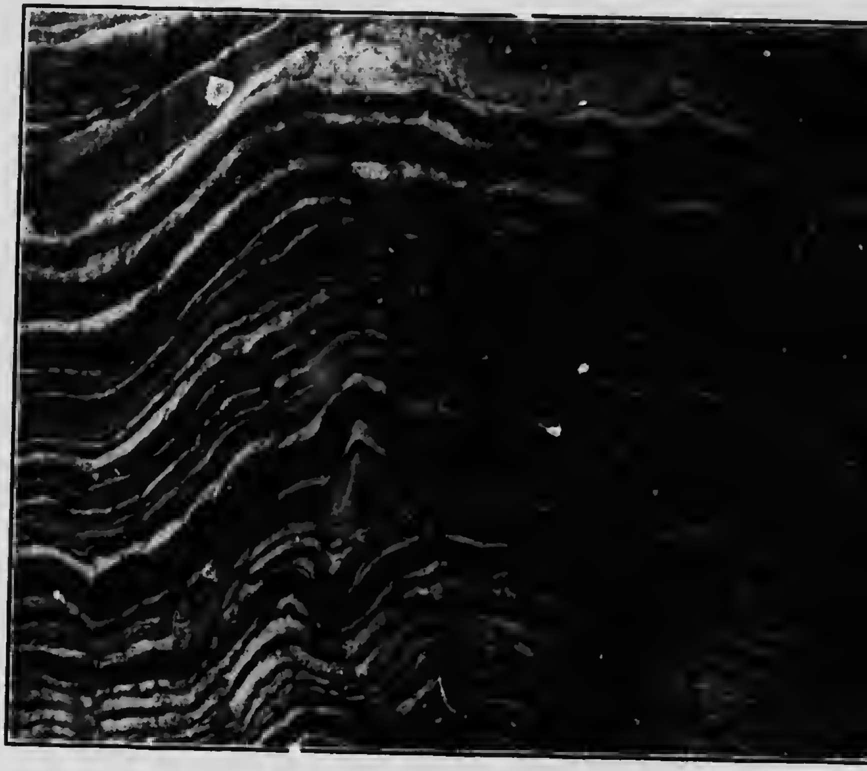

Fig. 3.—Contorted crystalline limestone of the Grenville series, Belmont lake. The dark beds consist of quartzitic or cherty material; the light colored beds are limestone.

contain low amounts of magnesia, occur for the most part on the east side of lake and on some of the islands, and also in minor beds on the west side. have a light, bluish grey, drab, or white color, and have been called "blue" limest by other writers. Banding, or bedding, due to the alternation of bands of slig different color, is commonly found, but the banded structure is also due to the sence of beds of slaty quartzite or chert which vary from a fraction of an to several feet in thickness, Fig. 3. It is difficult, at times, to distinguish these from the quartzite and slate of the Hastings series.

The limestones, as will be seen from the following table, are characterized by lime and low magnesia content. Good examples occur to the east of the north en Belmont lake, especially along the road to the Cordova gold mir

Table Showing Composition of Blue and White Crystalline Limestones on East Side of Belmont Lake and on Islands in Lake

No.	CaO.	MgO.	Al_2O_3 Fe_2O_3	Insoluble.	Loss on Ignition.	Graphite.	Total.
1	51.21	1.02	3.04	4.83	40.08	....	100.18
2	50.27	2.90	0.44	4.84	41.77	....	100.22
3	43.84	1.81	1.38	16.38	35.94	....	99.35
4	7.60	1.08	2.98	76.90	7.08	4.12	99.76
5	21.30	2.25	2.04	54.66	19.45	....	99.70
6	34.30	1.16	2.40	33.54	28.42	....	99.82

1. Deer bay, northeast corner of Belmont lake.
2. Green island, Belmont lake.
3. East shore Belmont lake, opposite north part of Green island at boat house.
4. Graphitic limestone, 50 feet south of No. 3.
5. Saw-mill bay, southeast end of Belmont lake, small patch of micaceous, crystalline limestone at water's edge.
6. Ten chains east of Saw-mill bay, southeast end of Belmont lake; patch of grey limestone, 25 feet long, resting in porphyritic phase of basalt. Not shown on map.

Subordinate beds of blue limestone also occur on the west side of Belmont lake, at times interbedded with magnesian limestones. The following table shows their composition.

Table Showing Composition of Blue and White Crystalline Limestones on West Side of Belmont Lake

No.	CaO	MgO.	Al_2O_3 Fe_2O_3	Insoluble.	Loss on Ignition.	Total.
1............	37.88	2.25	3.70	27.80	28.00	99.63
2............	51.62	1.23	0.20	4.40	42.25	99.70
3............	52.32	1.32	0.92	3.42	42.20	100.18
4............	46.40	5.58	1.10	4.48	42.16	99.72
5............	48.66	4 78	0.70	1.40	44.15	99.69
6............	51.31	0.72	0.41	7.30	40.10	[illegible]84
7............	35.29	1.35	0.63	33.14	29.26	99.67
8............	52.10	1.41	0.30	2.36	....	....
9............	50.06	1.27	0.80	7.10	40.39	99.62
10............	45.22	1.56	0.64	15.00	37.72	100.14
11............	41.13	1.56	1.66	21.88	33.46	99.69
12............	49.09	1.34	1.22	7.75	40.07	99.47

1. Northwest corner of Belmont lake at shore; contains sl[illegible]e laminæ.
2. Same part of lake as No. 1, about 150 feet west of sho[illegible].
3. First point north of Deer river, northwest part Belmont lake.
4. First point west of Squaw point, at mouth of North river.
5. Same place as No. 4.
6. Roddy bay, south of the mouth of North river, Belmont lake; bluish white, medium-grained limestone, one foot from contact of schist.
7. Same place as No. 6.
8. Taylor island at mouth of North river, Belmont lake.
9. Schooner island, west side of Belmont lake; greyish white, medium-grained limestone.
10. Same place as No. 9.
11. North end of Breckenridge bay, Belmont lake; blue limestone.
12. Limestone on east side of small band of iron formation about 150 feet east of bridge over Deer river, north of Belmont lake: pale, flesh-colored limestone.

(2) *Quartzose, dolomitic, crystalline limestone, and sedimentary material lying tween limestone and Keewatin.*—The limestone included in this group is a fin medium-grained, greyish brown rock containing more magnesia than the "blue" t It is often lacking in banded or bedded structures, and in places contains m granular quartz, Figs. 4 and 6.

The quartz in the limestone sometimes occurs in banded or laminated structu shown in Fig. 4, which are suggestive of "eozoon" forms, Fig. 2. The banding is du alternate, parallel layers of quartz and calcite or dolomite. These forms, which

Fig. 4.—Eozoon-like forms contained in crystalline limestone of Grenville series, Belmont lake.

found on the west part of Big island and at the northeast part of the lake, are of impo ance in a stratigraphic way because pebbles and boulders of them have been found the overlying Hastings conglomerate, Fig. 5, proving the unconformity between the cr talline limestone and the conglomerate.

The dolomitic limestone, which occurs largely on the west side of Belmont lake, also found on some of the islands, including Big island, and at the northeast part of t lake. The following table shows the composition of specimens; it will be noted th many of them have almost the theoretical composition of dolomite.

Table Showing Composition of Dolomitic Crystalline Limestones at Belmont Lake

No.	CaO	MgO	Al_2O_3 Fe_2O_3	Insoluble	Loss on Ignition	Total
1	30.42	21.64	1.10	0.48	46.76	100.40
2	30.12	18.15	1.00	8.60	41.48	99.35
3	30.62	17.78	4.90	3.50	43.03	99.83
4	30.22	20.85	0.98	1.82	45.89	99.76
5	29.78	21.54	0.84	1.74	46.46	100.36
6	29.82	19.57	0.80	6.70	43.38	100.27
7	30.70	17.89	0.66	7.10	43.46	99.81
8	31.78	19.81	1.20	0.88	45.96	99.63
9	30.14	21.06	1.76	1.28	46.30	100.54
10	27.65	17.90	2.80	11.60	40.12	100.07
11	30.19	20.80	1.58	1.24	46.06	99.87
12	7.20	4.34	0.60	77.88	9.58	99.60
13	25.34	16.50	0.50	20.08	37.96	100.38
14	23.02	17.05	0.50	23.46	36.11	100.14
15	19.66	13.75	0.84	36.46	29.56	100.27
16	31.50	20.87	0.74	0.28	46.90	100.29
17	28.70	19.13	......	6.28	43.22	......
18	29.74	20.67	......	2.73	44.48	......
19	30.60	20.38	1.14	1.20	46.56	99.88
20	30.50	21.35	0.70	0.30	47.10	99.95
21	28.40	18.12	1.70	8.76	42.85	99.83
22	12.42	8.77	0.80	59.70	18.10	99.79

1. Northwest corner of Belmont lake, about 75 feet west of shore; fine-grained, yellowish brown limestone.
2. Same locality as No. 1, but sample was taken about 200 feet from shore; fine-grained, yellowish brown.
3. West shore Belmont lake, south of Deer river; fine-grained, light brown limestone.
4. West shore Belmont lake, northwest of Twin islands; fine-grained, greyish yellow limestone.
5. West shore Belmont lake, southwest of Twin islands; fine-grained, pink or flesh-colored limestone.
6. North end of Breckenridge bay, Belmont lake; fine-grained, greyish brown limestone.
7. First point north of King bay, southwest end of Belmont lake; pale, flesh-c[illegible]ored limestone.
8. E[illegible]st side of Belmont lake, opposite Sammy island; long, narrow belt of limestone [illegible] to a brown or yellow color, but having a bluish grey appearance on fresh [illegible]
9. [illegible]me belt as No. 8.
10. [illegible]e belt as No. 8.
11. [illegible]ast shore Belmont lake, second outcrop of limestone north of Crow river; grey [illegible].
12. Same place as No. 11.
13. Big island, Belmont lake, west side of island, 200 feet from shore on knoll; grey limestone.
14. West side of Big island, Belmont lake, on shore; grey limestone.
15. Centre of east shore of Big island, Belmont lake; yellowish brown limestone.
16. First point west of Squaw point at mouth of North river, Belmont lake.
17. Same place as No. 13.
18. Same place as No. 13.
19. West Twin island, Belmont lake, fine-grained, grey limestone.
20. East side of Birch island, Belmont lake.
21. East side Birch island, Belmont lake; fine-grained, yellowish brown limestone.
22. East side Birch island, Belmont lake; fine-grained, yellowish brown limestone.

On the west side of Belmont lake calcareous, quartz-mica schist intervenes between the Keewatin greenstone schist and the Grenville dolomitic limestone. This quartz-mica schist is probably an altered quartzite or greywacké, corresponding in stratigraphic position to similar rocks in the Actinolite-Cloyne area, which resemble the Couchiching of northwestern Ontario. At the southwest part of Belmont lake, in Contact bay, this

Fig. 5.—Conglomerate of Hastings series, holding a boulder, below the pick, of so-called "eozoon", near Crow River point, Belmont lake.

Fig. 6.—Quartzose, magnesian, crystalline limestone of the Grenville series. The white parts and veinlets are quartz. Big Island, Belmont lake.

schist is about two hundred feet wide, measured across the schistosity, while in Roddy bay, near the mouth of the North river, the schist is very much thinner. There appears to be a gradual transition, in ascending order, between the greenstone schist, quartz-mica schist and limestone.

(3) *Iron formation (banded chert or granular quartz).*—The iron formation has been so-called on account of its resemblance to certain cherty rocks of the iron ranges in the Vermilion district of the Lake Superior region and elsewhere. In the Belmont lake area three belts have been found, viz.: (a) One hundred feet east of the bridge over Deer river at the north end of Belmont lake, a belt about twenty feet wide and two hundred feet long is exposed. It is made up of dark red, coarse chert, or granular quartz, interbanded with calcite. The cherty bands are from an inch to two feet thick, each band sometimes showing alternate lines of darker and lighter chert. Thin sections show

Fig. 7.—Iron formation (jaspilyte), Grenville series. About one-half mile west of Deer bay, Belmont lake.

the material to be made up of interlocking grains of quartz which form the base. Magnetite and hematite grains occur disseminated among the quartz grains, without showing any tendency to surround individual grains. The octahedra of magnetite can occasionally be detected with the naked eye, but they are for the most part in minute grains. The hematite can be recognized with high powers of the microscope in blood-red grains, but it occurs also in thin layers which lie roughly parallel to the strike and dip of the rocks in general in this area. It is the hematite in dust-like condition that gives the chert its reddish, jasper-like color while hematite and magnetite together produce a dark purple effect. Two analyses for metallic iron gave 11.8 and 15 per cent. respectively, the former probably being nearer an average. (b) About half a mile southwest of the outcrop described there occurs a larger exposure of iron formation, Fig. 7. It rests on the Keewatin schist with sharp contact and is about a quarter of a mile long by fifty or sixty feet wide. It has the same microscopic character as that just described but carries little or no carbonate, and at the north end of the exposure more of the iron oxides is present. In some cases the bands of iron oxides are a quarter of an inch wide. An analysis of this part of the iron formation gave the following percentages: metallic iron, 24.06; sulphur, .024; phosphorus, .126. There is, however, very little of this richer zone exposed, since this end of the formation disappears under the swamp to the north. (c) On lot 25 in the sixth concession of Belmont, north of Round lake, a third patch or remnant of iron formation was discovered. It lies just to the north of the colored part of the map, and has a width of 250 feet, but can be traced a distance along its strike of only 150 feet. It rests in the green schist.

It may be added that a little of the iron formation is to be seen in the Keewatin at other places, e.g., near the boat landing on King bay.

(4) *Rusty quartz-mica schist.*—A band of rusty quartz-mica schist runs northerly from the northeast corner of Round lake. It rests in Keewatin green schist into which it gradually passes. Exposures of the rock occur at the power house on the North river. A thin section of the rock from this place shows it to be composed largely of grains of quartz, in the interstices of which lie minute plates of biotite; calcite is present in small quantities. The rusty color is due to iron oxides resulting from the decomposition of iron pyrites or other sulphides.

(5) *Fine-to-medium-grained quartz-feldspar gneiss of doubtful origin.*—To the north and northwest of Round lake the map shows a considerable area of rocks grouped with the Grenville series. They are quartz-feldspar gneisses, generally fine-grained and with a grey to pinkish-grey color. They often contain calcite, while in places calcareous bands two or three feet wide occur, as may be seen at the first falls one mile north of the iron bridge on the North river, in the eighth concession of Belmont township. In places, too, the gneisses are quartzose and garnetiferous. The following results of a chemical analysis of the gneiss point to a sedimentary origin.

SiO_2	75.78
Al_2O_3	12.91
Fe_2O_3	.83
FeO	4.07
MgO	.53
CaO	1.63
Na_2O	1.67
K_2O	1.10
H_2O	1.51
CO_2	.57

THE HASTINGS (TEMISKAMING ?) SERIES

The Hastings series consists of conglomerate, quartzite, greywacké, slate and limestone. The rocks are all more or less schistose, and the pebbles of the conglomerate have generally been elongated by pressure, Fig. 10. The series appears to be a conformable one, no evidence of a break having been observed. On the west side of Big island, just to the south of a knoll of crystalline limestone, original bedding is still clearly preserved, showing a gentle d[illegible] the southwest. The bedding may be recognized by the alternation of fine and coarse pebbly bands; the schistosity here occurs at right angles to the bedding planes. On the east shore of Belmont lake, opposite island number 29, and at the northeast corner of the lake, bedding may also be recognized, Fig. 12; at the latter place delicate cross-bedding was observed. On the map the Hastings series has been divided into two groups: (a) That composed largely of conglomerate, and (b) that composed largely of slate. The limestone is present in thin bands or laminæ, interbedded with the slate or conglomerate. While it is probable that the Hastings series in the district is of considerable thickness, extending, as it does, along a stretch of country 65 miles in length, nevertheless but little is known regarding its actual thickness.

Fig. 8.—Island 27, Belmont lake, Peterborough county. Crystalline limestone of the Grenville series on right. Hastings slate on left. A few pebbles occur near the contact.

Fig. 9.—Part of Belmont lake, looking north towards Sidonia Island.

Conglomerate

The pebbles of the conglomerate are water-worn, and consist of quartz-porphyry, feldspar-porphyry, granite-porphyry, felsite, fine-grained greenstone, fine-grained grey or greenish grey schist, crystalline limestone, Fig. 11, chert varying from fine to coarse in grain and from greyish white to red in color (jaspilyte), white quartz and "eozoon" fragments.

The porphyry pebbles are grey to pink in color, and consist of a fine-grained matrix of quartz, feldspar and biotite in which are set phenocrysts of the first two minerals which are often remarkably well preserved. Sometimes these phenocrysts of feldspar show albite twinning lamellæ. The porphyry pebbles are of common occurrence and may be observed in the conglomerate on several of the islands of Belmont lake, including Sidonia and Big islands.

The fine-grained greenstone pebbles are seen under the microscope to consist of a network of plagioclase rods, green mica and magnetite, in which matrix are set phenocrysts of feldspar and subordinate blades of hornblende.

Pebbles of crystalline limestone that have been found in the conglomerate on the east and west side of Big island, have the same composition as the magnesian crystalline limestone which is exposed in several places on the island. Limestone pebbles also occur in the conglomerate on Sidonia island, Fig. 11, and elsewhere around the lake. The following table shows the composition of three of these limestone pebbles from Big island:

CaO	MgO	Fe_2O_3 Al_2O_3	Loss on Ignition.	Insoluble.	Total.
29.13	18.22	2.92	44.30	5.68	100.25
29.19	19.98	2.76	44.21	4.24	100.38
29.04	15.08	18.54	36.26	0.72	99.64

Pebbles of chert or granular quartz are commonly found in the conglomerate, and those having a red color (jasper) at once attract attention. A thin section of one of the jasper pebbles consists of interlocking grains of quartz scattered through which are magnetite or hematite specks. Several pebbles of what, for convenience of description, have been called "eozoon" were observed in the conglomerate. One of these, which is shown in Fig. 5, occurs about one hundred yards south of Crow River point, on the east side of Belmont lake.

On the northeast side of Deer bay, at the boat landing, the rock at the water's edge is crystalline limestone. Overlying it is conglomerate which contains well rounded pebbles an inch or two in diameter set in a limestone matrix. The pebbles are rather uniform in size and consist essentially of cherty material.

It may be of interest to note that the conglomerate at Belmont lake was described by Mr. Alexander Murray in the middle of the last century. Mr. Murray said:

"On the east side of the largest of the islands and on a small one to the N.N.E. there occur beds of conglomerate, which according to the dip, would overlie the previous rocks; they are interstratified with talcose slate, and the matrix of the conglomerate exhibits a slaty structure and talcose character, at the same time that it is calcareous or dolomitic . . . . The general color in fresh fractures is greenish or reddish white, but the external surface weathers a dark brown. The pebbles are distinctly rounded or flattened, the flat sides usually but not always lying parallel with the bedding. They are of various sizes, the largest being about five or six inches in diameter, while the smallest do not exceed the size of a snipe shot. The prevailing color of the pebbles is a very dark grey; they have a flat conchoidal fracture, with a very close impalpable grain; they are harder than steel and appear to be a quartz rock."*

Quartzite, Greywacké and Slate

Quartzite and greywacké are associated with the conglomerate on Big island and at other points. At the northeast corner of Belmont lake, impure quartzite, or greywacké, having a peculiar greyish green color, is well exposed and often shows distinct bedding planes, Fig. 12. A thin section shows the rock to be made up of angular fragments of quartz and feldspar together with many scales of brown mica; the feldspar sometimes

* Report Geol. Sur., Can., 1852-3, pp. 104-107.

Fig. 10.—Hastings conglomerate showing pebbles elongated by pressure. Sidonia island, Belmont lake.

Fig. 11.—Pebbles of Grenville crystalline limestone in Hastings conglomerate. Sidonia island, Belmont lake.

shows twinning lamellæ. On the east shore of the lake, north of Wilson bay, there is a bed of quartzite or greywacké about 100 feet wide. It has a pinkish brown color, and consists of angular fragments, one-eighth of an inch in diameter, of blue quartz, orthoclase and plagioclase set in a fine-grained matrix of the same minerals together with a little calcite, sericite and iron oxides. The rock passes to the east into a dark grey, finely banded slate, consisting largely of greenish brown mica and subordinate quartz, epidote, calcite, zoisite and iron oxides. This rock then passes into a conglomerate, the position of which is shown on the map.

Slate-like rocks occur on the east shore of Belmont lake between Green island and Crow river. They appear to be a fine-grained facies of the greywacké and are often very finely banded or bedded, the bedding being due to interbanding of coarse and fine material. Thin sections show the slate to be made up of a fine-grained matrix of dark-colored mica, quartz, feldspar, calcite, and iron oxides. In this matrix angular fragments of quartz and feldspar occur. The conglomerate on Big island is sometimes interbedded with slate, but it has not been found practicable to show it with a separate color on the map. Along the northwest shore of this island the slate is well exposed, and consists

Fig. 12.—Greywacké, Hastings series, showing bedding. Belmont lake.

of brown mica, muscovite, quartz, chlorite and iron oxides. On the east shore of Belmont lake, one hundred yards south of Crow River point, a narrow band of blackish brown slate is interbedded with coarse conglomerate, the latter containing a light-colored boulder of "eozoon," Fig. 5; the conglomerate here was referred to in a preceding paragraph. This interbedding of coarse boulder conglomerate and slate shows that conditions of deposition must have rapidly changed during Hastings time. The slate on the west part of Island No. 27, one of the Twin islands, is very fine-grained and compact, and consists of grains of quartz and feldspar together with considerable brown mica scales, iron oxides and a little calcite. The map does not show this bed on account of the small size of the island, but Fig. 8 is a photograph of the slate, showing its contact with magnesian, crystalline limestone of the Grenville series. On the west part of Birch island there occur calcareous slates which have been provisionally classed with the Hastings series; it is possible, however, that they should be grouped with the Grenville sediments.

The slate on the east side of the lake, north of Crow river is often impregnated with rhombohedra of ferruginous carbonate.

Limestone

Limestone does not appear to have formed an important part of the Hastings sediments at Belmont lake but three places where it occurs may be mentioned; (1) At several points on the east shore of the lake, north of Crow river, the slates are interbedded with limestone bands about an inch in thickness; (2) The map shows, at the northeast corner of the lake, near Deer bay, a bed of blue limestone lying in the Hastings greywacké. The relation of this limestone bed to adjacent rocks is not clear. It may be interbedded with the greywacké, which seems the most obvious explanation; or, it may be a long ridge of the Grenville basement on which the Hastings greywacké was deposited; or, it may be a slice of the Grenville limestone faulted against the greywacké; (3) A band of yellowish brown limestone 15 inches wide appears to be interstratified with the conglomerate and calcareous schist at the north end of Big island, though this may not be the true relationship. An analysis showed this band to have the following percentage composition: insoluble, 9.54; Al_2O_3 and Fe_2O_3, 2.78; CaO, 27.75; MgO, 18.63; loss on ignition, 41.48.

Certain narrow bands of limestone in the Hastings fragmental sediments, lying parallel with the strike or schistosity, are clearly of secondary origin.

Fig. 13.—Amygdaloidal basalt, post-Hastings age. Belmont lake.

POST-HASTINGS INTRUSIVES

The series consists of gabbro-diabase, basalt with associated ash beds, and basic and acidic dikes.

On the map the rock that is more of the plutonic type is shown in a deeper color than that which possesses volcanic characteristics.

The coarse-grained rock at the Cordova gold mine, at the northeast corner of the map, has sometimes the texture of a diabase and sometimes that of a gabbro, one facies passing gradually into the other. It has been, therefore, called the Belmont gabbro-diabase, the word "Belmont" referring to the lake or township of the same name. The feldspar, which is labradorite, is partly decomposed to saussurite and other secondary materials. The other chief constituent is pyroxene, and it is frequently altered to chlorite and green hornblende. Pyrite, apatite and titaniferous magnetite or ilmenite are present in the usual subordinate quantities.

The Belmont basalt is a dense green rock, frequently amygdaloidal, Fig. 13, and more rarely scoriaceous or ropy, Fig. 17, showing its volcanic or surface origin. It is almost always fine-grained, but, at times, as for example, in the hills east of Wilson bay and Sawmill bay, on the east side of Belmont lake, it becomes coarsely porphyritic, containing phenocrysts of feldspar an inch or more in length, having both tabular and lath-like outlines. Generally it is too fine-grained to distinguish any of the minerals with the naked eye. Under the microscope specimens seem to consist essentially of plagioclase feldspar, hornblende and magnetite. A mineral with a green color appears to be mica, and is subordinate in quantity. The feldspar is more or less decomposed, but some of it is comparatively fresh. The amygdules average perhaps less than a quarter of an inch,

Fig. 14.—Bombs in ash beds. Belmont lake.

but some are microscopic while others are an inch in diameter. The minerals filling the amygdules are quartz, epidote, chlorite, calcite, magnetite and rarely biotite. Quartz and epidote are most common.

Associated with the basalt there are restricted areas of volcanic tuff or breccia, the fragments of which are angular or sub-angular and are made up of fine-grained basic lavas or more acid fine-grained rocks. Some of these fragments, a foot or more in diameter, shown in Fig. 14, are bombs; they are round or oval in outline, possessing a pistachio-green color, and are made up largely of epidote, together with small quantities of biotite, calcite and magnetite.

Along the east shore of Belmont lake, a short distance north of Sawmill bay, the best exposure of the fragmental facies of the lava, observed in the area, is to be seen. It consists of consolidated ash beds or tuff, containing bombs a foot or more in diameter, Fig. 14. Large boulders of the tuff lie near the shore and similar material in place is to be seen in a wooded hill near at hand.

Generally speaking the basalt and gabbro are distinctly massive, but attention may be called to the fact that they have been rendered schistose in places. The gabbro-diabase at the Cordova mine has in a few cases a gneissoid structure.

The contact between the gabbro-diabase and the basalt is of interest. One rock passes gradually into the other in a distance of two or three hundred feet, but the transitional facies and also the normal gabbro-diabase and basalt have been much brecciated, and the cracks have been filled with aplite and micropegmatite. It would seem that this acidic material represents the last phase of the cooling gabbro-diabase-basalt mass. The aplite, which is really at times a medium-grained granite, is often dark in color, due to the presence of hornblende. Several of these acid dikes are shown on the map. A well exposed contact showing the relation between the gabbro-diabase and the basalt occurs on lot 17 in the second and third concessions of Belmont township.

The gabbro-diabase solidified at some distance below the surface of the earth and is merely a deep-seated part of the basalt.

The following table shows the composition of a sample of the basalt, or "trap" rock as it is commercially known.

SiO_2	47.14
Al_2O_3	14.08
Fe_2O_3	10.84
FeO	12.02
MgO	2.65
CaO	9.67
Na_2O	1.60
K_2O	1.07
H_2O	1.50
	100.57

Three silica determinations were also made of other parts of the basalt, giving 42.00, 43.76 and 46.54 per cent., thus showing the basic nature of the rock.

The map shows several diabase or other basic dikes, which cut the conglomerate, crystalline limestone and Keewatin green-schist. One of these on the west side of Big island is dark green, medium in grain, and contains glistening flakes of mica. Under the microscope it is seen to be made up essentially of biotite, and calcite, together with muscovite, quartz and some feldspar; many of the minerals appear to be secondary. Other dikes are fresher than this. One on the west shore of Belmont lake is fine-grained and dark green in color and shows a diabasic texture. Under the microscope it is seen to consist largely of green pleochroic hornblende. Plagioclase occurs in rods and stout prisms and has crystallized out before the ferro-magnesian mineral. There is also present epidote, brown mica, serpentine, and ilmenite partly altered to leucoxene. Another specimen has about the same composition but does not show the ophitic texture.

The gabbro-diabase series is important from the economic point of view, as in it at Cordova are the auriferous veins of the Cordova mine. Moreover, at two or three places, where the gabbro-diabase has intruded the crystalline limestones and associated rocks, there occur bodies of magnetite, such as those at the Blairton mine on the shore of Crow lake, to the east of the borders of the map of the Belmont lake area, and at the Belmont iron mine, immediately south of Cordova. The finer-grained variety of the rock makes good road material.

PALEOZOIC SYSTEM

The Paleozoic system is represented by horizontal beds of Ordovician, Black River, limestone, with usually, at the base, calcareous sandstone often of a red color due to the presence of iron oxides. At other times the pure limestone rests directly on the pre-Cambrian rocks and holds a few angular fragments of them.

Analysis of Paleozoic Limestone

A sample of limestone from a small quarry just east of Havelock was found to have the following chemical composition, showing it to be, like most Black River limestones, low in magnesia:*

Lime	51.22
Magnesia	0.70
Alumina	2.37
Ferric oxide	0.61
Sulphur trioxide	0.24
Carbon dioxide	40.75
Loss	2.39
Silica	1.96
Total	100.14

Fig. 18.—Greenstone of Keewatin series in which the amygdules are still preserved. Lot 28, concession 6. Belmont township.

Relationships

Relation of Grenville series to the Keewatin.—The Keewatin green schists, originally essentially volcanic rocks, are considered to form the basement. On the ropy, tufaceous and uneven surface of the Keewatin were deposited sediments now represented by calcareous quartz-mica schist, iron formation, dolomitic limestone, and finally by pure limestone. No erosion unconformity preceding that immediately below the Hastings series has been observed. The deposition of the older sediments, including the iron formation and dolomitic limestone, probably closely followed the submarine lava flows of the Keewatin. The purer or non-dolomitic limestone is the youngest of the pre-Hastings

* Ont. Bur. Mines, Vol. XIII, Part 2, p. 98.

sediments, and was deposited towards the close of a prolonged period of submergence which began with the Keewatin lava flows and ended with the deposition of the limestone.

Certain schists of indefinite character lie between the magnesian limestone and the Keewatin. They are considered to represent a co-mingling of sediments and volcanic rocks, the former having been deposited on the uneven, ropy and vesicular surface of the latter. Intense dynamic metamorphism has produced schists difficult to describe but which are now represented by calcareous quartz-mica schists or slates, and probably were originally, in part, quartzites or greywackés. These schists may be seen in Contact bay at the southwest end of Belmont lake, and at Roddy bay, near the mouth of the North river. We have not been able to find any evidence which would tend to show that the Keewatin greenstones are in intrusive contact with the Grenville sediments; hence, it is inferred that the greenstones formed the basement on which were deposited the Grenville sediments.

Relation of Hastings series to Keewatin and Grenville.—The Hastings conglomerate, quartzite and slate were deposited unconformably upon the surface of the Keewatin and Grenville series. The evidence for this statement is twofold: (1) The Hastings series is less altered or metamorphosed than the Keewatin and Grenville, (2) The conglomerate holds pebbles of some, but not all, of the older rocks exposed in this area. The

Fig. 16—Pebble of crystalline limestone of Grenville series in Hastings conglomerate. Belmont lake.

water-worn pebbles of crystalline limestone, Figs. 11 and 16, which occur in the conglomerate, are similar to the underlying limestone, proving the unconformity between the two series. But perhaps the most convincing evidence consists in the occurrence of pebbles and boulders of what we have called "eozoon," Figs 4 and 5, which cannot be mistaken for anything else. These "eozoon" forms, which have been described in this report, occur in the Grenville limestone, and their presence as pebbles and boulders in the conglomerate is proof of the erosion interval between the conglomerate and crystalline limestone. The pebbles of red chert and jasper are similar to the iron formation which occurs at the northwest corner of Belmont lake, and it is probable that they have been derived by erosion from that formation.

The conglomerates at Belmont lake now rest, in so far as can be seen, wholly on crystalline limestone, but in the Actinolite-Cloyne area, described in later parts of this report, they have been found in actual contact with most of the pre-Hastings rocks. At Belmont lake the basal member of the Hastings is sometimes conglomerate and at other times slate. Thus on the west part of Big island, at the most western point near the shore, the conglomerate may be seen resting directly on the Grenville crystalline limestone. The two series pass into each other in a few feet, the conglomerate holding occasional limestone pebbles derived from the underlying limestone. About 300 yards southeast of here, and to the south of a knoll of crystalline limestone, slate several feet thick is succeeded by conglomerate, but it is not known whether or not this slate rests directly on the limestone without basal conglomerate, since the contact is not exposed. It is probable, however, that on this island conglomerate was first deposited and was followed by slate and then by a second bed of conglomerate.

The east side of Birch island is composed of quartzose, crystalline limestone, on the western flank of which rests Hastings conglomerate, the contact between the two being drift-covered.

Slate of the Hastings series may be seen resting directly on the Grenville limestone at several points, including the following, (1) West Twin island, No. 27, is made up largely of crystalline limestone, with the exception of a narrow strip of slate on the west side, Fig. 8. The latter is in vertical position and rests against the limestone, holding a few pebbles of this rock. (2) On the east shore of Belmont lake, opposite the south

Fig. 17 —Scoriaceous or ropy facies of post Hastings basalt. Belmont lake.

end of Green island, the limestone and slate may be seen in sharp contact at the water's edge, there being no conglomerate present. (3) South of this place a few hundred yards fine-grained, bedded greywacké and slate rest on each flank of a long rib of magnesian limestone. At one point there is present a doubtful conglomerate, holding fragments of limestone. (4) The second patch of limestone on the shore, north of Conglomerate point, is shown on the map. Against this limestone rests fine-grained slate or schist of the Hastings series.

In the Belmont lake area the presence of water-worn fragments of igneous rocks, like quartz-porphyry, shows that somewhere part of the basement on which the Hastings rests must have been composed of these types, but if such basement does exist it is covered by later formations, or completely eroded.* This facies of the basement has, however, been found farther to the northeast in the Actinolite-Cloyne area.

* A similar phenomenon has been observed in connection with the pre-Cambrian rocks of Scotland, certain pebbles in the Torridonian sandstone having been derived from rocks not now known to occur in the region. See "The Geological Structure of the North-West Highlands of Scotland," p. 5. Memoir of the Geological Survey of Great Britain.

It may be added that it is necessary to exercise care in distinguishing squeezed or drawn-out pebbles of crystalline limestone in the conglomerate from secondary calcite or dolomite.

Relation of post-Hastings intrusives to Keewatin, Grenville and Hastings series.—These intrusives, which are composed of gabbro-diabase, basalt, and basic and acid dikes, are younger than the Keewatin, Grenville and Hastings series. Intrusive contacts of the gabbro-diabase with the crystalline limestone may be seen north of the school house of Cordova village, at the northeast corner of the map and elsewhere. North of Round lake several oval or round masses of gabbro intrude the quartz-feldspar gneiss.

Dikes of altered diabase intersect the Hastings series. Three of these dikes, cutting the conglomerate, have been mapped on Big island. Similar dikes intrude the crystalline limestones; (1) on the west side of Belmont lake, north of the North river; (2) on Sammy and Silver islands; (3) on lot 19, in the second concession of Belmont township, and at other places. These dikes also cut the Keewatin green schists. One of them is shown on the map in Clark bay at the southwest part of Belmont lake.

The basalt has been found in intrusive contact with the older rocks at the following places among others: (1) On the east part of lot 17 in the second concession of Belmont township; here the basalt has altered the crystalline limestone to a rock which is composed largely of garnet, and subordinate amounts of epidote. (2) North of Wilson bay on the east side of Belmont lake; the basalt, which is here sometimes scoriaceous and ropy, is in intrusive contact with steeply dipping beds of the Hastings conglomerate.

The acid dikes, which as already explained, are the end phase of the cooling gabbro-diabase-basalt mass, intersect the crystalline limestone and the Hastings conglomerate. They may be seen to cut the latter rock about 300 yards northwest of the Belmont iron mine. On the north part of lot 20 in the first concession of Belmont township the dikes are coarse granite-pegmatite in places.

Relation of Paleozoic to Pre-Cambrian.—The Paleozoic rocks, represented by horizontal beds of Ordovician, Black River, limestone, rest with great unconformity on the pre-Cambrian.

Fig. 18.—Keewatin greenstone hills with Laurentian in the distance. Actinolite, township of Elzevir.

(Illustration taken from the Report of the Geological Survey of Canada, 1872-73. The title has been changed to conform with present views as to the ages of the rocks.)

THE ACTINOLITE-CLOYNE AREA*

INTRODUCTION

The Actinolite-Cloyne area occupies a belt of country thirty miles long and about eight miles wide, the map being the largest of the seven that accompany the report. It stretches in a northeasterly direction across three counties, namely, Hastings, Addington and Frontenac, and lies immediately to the east of the Madoc area. The outline of the map was determined solely by the remarkable form of the belts of Hastings conglomerate which occupy the central parts of the area. One of these belts is about twenty-two miles long and a mile wide at the widest part. The conglomerate has been referred to by the early workers, including Logan, Murray and Vennor, but no attempt has hitherto been made to connect up the isolated outcrops, a few of which were briefly alluded to by these writers. The stratigraphic significance of the conglomerate was not appreciated. References to the literature are given on preceding pages.

The Keewatin series consists of green schists which, at the northeast part of the map, pass into typical pillow lavas, Fig. 20, thus proving the igneous origin of these schists. The order of deposition of the Grenville sediments, which rest on and are younger than the Keewatin lavas, has been determined in this area as well as at Belmont

Fig. 19.—Channel of Skootamatta river through crystalline limestone at Actinolite.

lake. The basal members of these sediments consist of quartzite and greywacké, together with at times rusty schists and jaspilyte; these rocks are succeeded by limestones. The Keewatin and Grenville series were intruded by Laurentian granite and syenite, and, after a prolonged period of erosion, the Hastings conglomerate was laid down on the three older series of rocks, namely, Keewatin, Grenville and Laurentian.

It will be noted that our map shows that much of the area consists of Laurentian granites and gneisses, but it is possible that some of the rocks mapped as Laurentian may be intrusive into the Hastings conglomerate. When a granite has not been found in contact with the Hastings conglomerate it is difficult to determine its stratigraphic position.

Intruding the Keewatin, Grenville, Laurentian and Hastings are granite, pegmatite, basalt, diabase, and other rocks.

The description of the area brings out several facts that, heretofore, have not been recognized, viz.: the presence of Keewatin rocks, the order of deposition of the Grenville sediments and their relation to the Keewatin, the presence of an older granite-gneiss (Laurentian) and a younger acidic group (Moira granite), and finally the age relations of the conglomerates and other sedimentary rocks of the Hastings series.

The Paleozoic is represented in the area by Black River limestone with basal sandstone.

* The village of Actinolite was formerly known as Bridgewater.

ROCKS OF THE AREA

The rocks of the Actinolite-Cloyne area are classified by the authors as follows:

Pleistocene	
GLACIAL AND RECENT	Boulder clay, sand and gravel.
Paleozoic	
ORDOVICIAN	Black River limestone, with basal sandstone and conglomerate.
(Great unconformity.)	
Pre-Cambrian	
POST-HASTINGS INTRUSIVES	Diabase, grey felsite, Moira granite, coarse granite-pegmatite.
(Intrusive contact.)	
HASTINGS (TEMISKAMING ?) SERIES	Conglomerate and quartzite, in part altered to mica-schist and gneiss.
(Unconformity.)	
LAURENTIAN	Felsite, partly altered to sericite-schist or gneiss, gneissoid granite and syenite, quartz-porphyry, feldspar-porphyry.
(Intrusive contact.)	
GRENVILLE SERIES	Non-magnesian and magnesian crystalline limestones. Iron formation (banded chert, jasper, or granular quartz). Rusty schist. Grey gneiss, quartz-mica schist, greywacké, quartzite.
KEEWATIN COMPLEX	Hornblende-schist, ellipsoidal basalt, and other rocks.

The rocks will be described, beginning with the oldest series.

THE KEEWATIN COMPLEX

The Keewatin series in the Actinolite-Cloyne area, like that at Belmont lake, consists of hornblende and chlorite schists having a green color; but other rocks occur, including ellipsoidal and amygdaloidal basalt, greyish-green, hornblende gneiss of intermediate composition, and serpentine rock. The greenstones have for the most part recrystallized, although to the northwest of Actinolite they are occasionally massive and retain what appear to be original feldspar crystals. The hornblende and chlorite schists pass by insensible gradation into pillow lavas, thus proving their igneous origin; while these lavas still retain their pillow structure, they, on the other hand, appear to have entirely recrystallized. The rocks are generally impregnated with calcite or dolomite, and along certain zones are garnetiferous.

North of the village of Cloyne, along the Addington road, and on the shores of Loon lake, which is about three miles northwest of the village and beyond the confines of the map, fine and coarse-grained hornblende schist and gneiss are exposed. On the northeast shore of Loon lake these rocks are intersected by numerous narrow dikes of felsite. Between Cloyne and the south end of Mazinaw lake, which lies two and one-half miles north of Cloyne, the greenstones gradually become grey in color and pass into grey gneisses, having a well-banded structure in places. The banding seems to be due to original bedding; thus these rocks are more properly classed with the Grenville series, and probably represent sediments which were deposited on the surface of the pillow lavas.

At Harlowe, which lies southeast of Cloyne six miles, the greenstone series is represented by a diorite-like gneiss, or hornblende gneiss, in which are sometimes developed zones of garnets. Northwest, north and northeast of Harlowe, the rocks vary from basic to intermediate in composition, and from grey to green in color. There is also a subordinate amount of intrusive, medium-grained granite or felsite. It may be that some of these grey gneisses are altered Grenville sediments; or, on the other hand, very highly metamorphosed greenstones or acid lavas. The metamorphism could be due to the great intrusion of granite gneiss at Gull lake.

About a mile and a half south of Cloyne, near what is locally known as Bishop Corners, there is a small schoolhouse, immediately southeast and north of which are low hills, well exposed, of ellipsoidal basalt, or pillow lava, often containing considerable quantities of calcium or magnesium carbonates. Amygdules occur around the border of the ellipsoids, as is commonly the case in similar rocks elsewhere. The pillow structure, Fig. 20, is similar to that in the Keewatin basalts at Cobalt or Porcupine, and may be seen, with more or less distinctness, over an area of some two square miles; but, as the more metamorphosed parts are approached, the structure gradually disappears. Some three hundred yards south of Bishop Corners the basalts are amygdaloidal, though the ellipsoidal structure is not seen. The amygdules are filled with quartz, calcite and chlorite.

At Flinton areas of green schists occur, resting in and invaded by Laurentian granite and syenite. Twelve miles southwest of Flinton, in the vicinity of Actinolite (Bridgewater), the greenstone is a calcareous, fine-to-coarse-grained hornblende schist, rarely showing ellipsoidal structure. Traces of the ellipsoids were, however, observed about two and a half miles west of the village, at a point seventy-five yards northwest of the bridge crossing Black creek. Thin sections of the hornblende schist, that occurs one mile northeast of Actinolite, show the rock to consist dominantly of green hornblende, together with clear grains of quartz and feldspar. A little magnetite and calcite occur. The hornblende sometimes has a poikilitic texture due to the presence of quartz or feldspar inclusions.

Northeast of Actinolite two or three miles, the greenstones are sometimes altered to actinolite and serpentine, which have in past years been ground and used for roofing material.

It may be that parts of the areas mapped as Keewatin include intrusions of basic igneous rocks which are later in age than the Grenville series next to be described.

THE GRENVILLE SERIES

The Grenville series in this area is divided into four groups, which are presumably of sedimentary origin, viz.: (1) Magnesian and non-magnesian crystalline limestones, (2) "Iron formation" (banded chert, jasper or granular quartz), (3) Rusty schist, (4) Grey gneiss, quartz-mica schist, greywacké, and quartzite. On the Actinolite-Cloyne map, groups (1), (2) and (4) are shown by distinctive colors, while on the large scale map showing the iron pyrites deposits near Queensboro, the rusty schist, group (3), is also separated from the other rocks by a color.* These rocks, which sometimes retain bedding planes, constitute a thick sedimentary series which rests on the Keewatin green schists.

(1) *Crystalline limestones.*—Five important areas or belts of limestone are shown on the map. The first lies in the southwestern corner of the sheet; in it are found the Henderson and Connolly talc mines. The second belt lies in the vicinity of Actinolite and has a width at its widest part, measured across the strike, of a mile and a

*Map No. 22e.

Fig. 20. Pillow lava of Keewatin age. Two miles south of the village of Cloyne, and 200 yards east of the Addington road, township of Barrie, Frontenac county.

Fig. 20. Pillow lava of Keewatin age. Two miles south of the village of Cloyne, and 200 yards east of the Addington road, township of Barrie, Frontenac county.

quarter. The third is shown near the northeast part of the map, to the south of the village of Cloyne. The fourth occurs south of Harlowe post office, and the fifth southwest of Queensboro. The limestones, many of which are magnesian, vary from coarse to fine in grain and weather to various tints of brown, grey and blue. Those having brown colors are highly magnesian, and those having blue or grey colors are generally low in magnesia. At times as much as 50 per cent. of silica is present, occurring in bands and irregular vein-like areas, sometimes showing "eozoon" structure similar to that already described at Belmont lake, Fig. 4, and Madoc. The rocks on the south part of lot 1, in the third concession of Elzevir, resemble the magnesian limestone at Belmont lake. On the east part of the same lot there are present bands of actinolite or tremolite in the limestone. Sometimes the limestones have a banded structure, as may be seen immediately behind the hotel at the village of Actinolite. For the most part the banding is not marked, though it may be present in vague outlines. It is difficult to determine whether the banding is due to original bedding or to pressure.

The following results of analyses, made from different portions of the limestones, show that many of the samples are dolomitic:—

	CaO	MgO	Loss on Ignition	Insoluble	Fe_2O_3	SO_3
1	51.96	0.64	41.48	4.49	......	......
2	47.49	6.82	43.91	1.14	.56	.18
3	27.90	17.25	41.96	9.16	......	......
4	45.53	1.08	37.94	12.50	......	......
5	40.44	1.99	34.59	21.10	......	......
6	51.96	2.79	43.06	1.75	......	......
7	51.96	2.90	42.78	1.79	......	......
8	53.64	.99	42.92	2.54	.34	.34
9	29.90	19.13	45.50	3.20	......	......
10	30.15	17.72	45.16	2.70	......	......
11	29.84	19.64	44.10	3.17	......	......
12	30.95	18.28	43.12	4.04	......	......
13	50.47	2.01	42.28	4.90	......	......
14	30.89	20.53	43.48	1.18	......	......

1. Fairly coarse-grained limestone, weathering grey, but having on fresh fractured surfaces a greyish white color with a faint suggestion of very pale blue. Immediately behind the hotel at Actinolite.
2. Harrison's quarry, Actinolite.
3. Grey to brown-weathering limestone, south part of lot 1 in the third concession of Elzevir.
4. Medium-grained, grey to slate-colored limestone, one mile northeast of Actinolite.
5. Medium-grained, brown-weathering limestone, east side lot 1, in the second concession of Elzevir, beside Queensboro road.
6. Medium-grained, white limestone, Hastings quarry (formerly Ellis quarry), beside railway track one and a quarter miles south of Actinolite.
7. Same locality as number 6.
8. Same locality as number 6.
9. Brown-weathering limestone 100 yards east of Hawkins bay on the Moira river, from a prospect pit.
10. Brown-weathering limestone one-quarter mile east of Bishop Corners.
11. Grey to brown-weathering limestone, 650 yards south of Bishop Corners, on Addington road.
12. Grey limestone, one and a half miles east of Bishop Corners.
13. Bluish band of limestone, twenty feet wide, in dolomite; same locality as number 12.
14. Grey limestone, same locality as number 12.

(2) *Iron Formation.*—Between Harlowe and Bishop Corners the map shows six bands of so-called "iron formation," colored carmine; the largest has a length of a

mile and a half and a maximum width of 250 feet. It is difficult to give this rock a specific name. Thus, it might be described by different writers as coarse chert, granular quartz, or quartzite. Although much of it is too coarse in grain to be called a chert, nevertheless that term will be found convenient in describing the rock. It is usually grey in color, though sometimes having a light pink or reddish-brown tint, due to the presence of iron oxides. The rock generally has a banded or bedded structure, similar to the Keewatin iron formation, and is of the same nature as the iron formation at Belmont lake, but is lighter in color, coarser in grain, and contains only small amounts of iron oxide. Thin sections show the rock to be made up of interlocking grains of quartz, together with subordinate sericite, iron oxides and a little iron pyrites. Its appearance under the microscope resembles somewhat the quartz-mica schists or quartzite schists described under group (4) below. A chemical analysis of the rock from the larger band west of Harlowe gave the following result:—

SiO_2	87.05
Fe_2O_3	2.05
FeO	1.23
Al_2O_3	5.52
CaO	0.10
MgO	0.34
Na_2O	0.83
K_2O	1.50
CO_2	nil.
S	0.10
H_2O	1.55
Total	100.27

(3) *Rusty Schists.*—South of the village of Harlowe a few hundred feet, and east of Bishop Corners the same distance and also southwest of Queensboro, are bands of fine-grained, rusty schists a hundred yards, more or less, in width. They are similar to the rusty schists at Gilmour, chemical analyses of which show them to be of sedimentary origin, page 85. The rusty color is due to the decomposition of iron pyrites or pyrrhotite. At Harlowe these schists lie in the greenstone, the strike of the rocks coinciding. At Bishop Corners they are associated not only with the greenstones, but with the crystalline limestones, and there is evidence here to show that the rusty schists are a facies of the iron formation (banded chert), since the one passes into the other.

These rocks are of economic importance at the pyrite deposits southwest of Queensboro, where a narrow band has been mapped in detail by P. E. Hopkins. The map accompanies this report. A deposit of pyrite on the Canadian Sulphur Ore Company's property occurs near the contact of this rusty schist and an intrusive body of felsite. The rusty schist here is interbedded with quartzite and greywacké.

(4) *Greywacké, Quartzite, Grey Gneiss, Quartz-Mica Schist.*—Under this heading have been grouped, for convenience of description, several varieties of schistose and gneissoid rocks of sedimentary origin which include grey to brownish or greenish colored gneiss, quartz-mica schist, garnet schists, quartzite, schists. quartzite, greywacké, and more rarely, dark green amphibolite. The gneiss and schist are believed to have been derived by metamorphism from greywacké, quartzite and other sedimentary rocks. These rocks are all more or less calcareous or dolomitic, and they pass into each other generally by easy gradations. It is possible that parts of the lighter colored coarser-grained, grey gneisses may be a facies of the Laurentian granite gneisses, as, for example, on lots 2 and 3 in the sixth and seventh concessions of the township of Elzevir, and again on lots 7, 8 and 9 in the twelfth and thirteenth concessions of the township of Hungerford. It is likewise possible that parts of the calcareous amphibolite are more closely related to the Keewatin greenstones than to the Grenville series

Some of the quartzites and quartz-mica schists may be metamorphosed Hastings sediments. But, on the whole, this group has a distinctive enough appearance in the field to permit of its separation on the geological map. Moreover, pebbles of quartzite, quartz-mica schist, and grey gneiss occur in the Hastings conglomerate.

The quartzite and greywacké at the Canadian Sulphur Ore Company's property, southwest of Queensboro are well bedded, and are interbanded with the crystalline limestone. A thin section of a greywacké near this mine shows the rock to have a fragmental texture, and to consist of angular grains of quartz and feldspar set in a matrix of the same minerals. This fragmental texture is not, however, often observed under the microscope. Parts of the quartzite resemble the so-called "iron formation," described under group No. 2 above.

Thin sections, Nos. 356, 357, 358, of the quartz-mica schist, about a mile northeast of Actinolite and immediately southeast of the road, show the rock to consist largely of interlocking grains of clear quartz, often showing little or no wavy extinction.

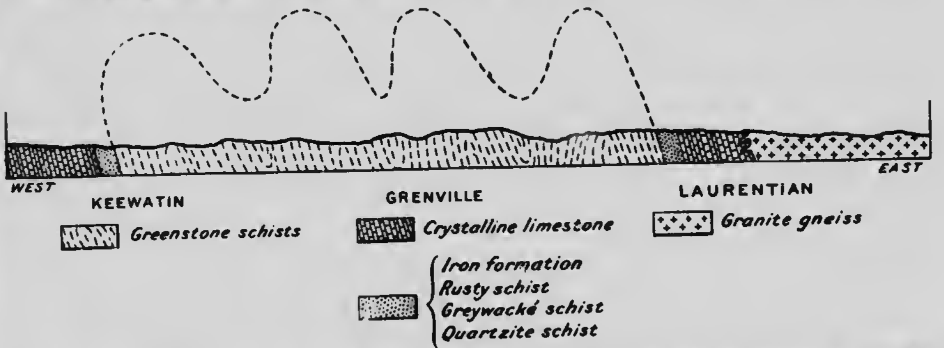

Fig. 21.—Cross-section in Elzevir township, Hastings county, showing relation between the Keewatin and Grenville series. Beginning on the west, the section passes through the property of the Canadian Sulphur Ore Company near Queensboro, and thence continues easterly to a point one mile northeast of the village of Actinolite. The Keewatin pillow lavas, now largely altered to green schists, form the nucleus or core on each side of which rest Grenville sediments, namely: quartzite, greywacké, iron formation, and, finally, at the top of the series, crystalline limestone. The Grenville sediments are closely and intricately infolded in the Keewatin lavas; erosion has left only the lower parts of one of the major folds of sediments resting on each side of the greenstone.

The felsite, intrusive into the sediments on the western part of the section, is not shown. As in the Belmont Lake area, the lower part of the crystalline limestone is high in magnesia, while the higher part is low in this constituent. The section, which is not drawn to scale, should be compared with Section A B F on the Actinolite-Cloyne map.

Brown biotite or sericite, or both of these micas, are present in varying amounts, and give the schistose texture to the rock. Magnetite and calcite also occur. A thin section, No. 355, of a quartzite schist, occurring about two hundred yards east of the abandoned railway bridge over the Skootamatta river at Actinolite, shows the rock to consist of interlocking grains of clear quartz, with subordinate sericite.

Mica schist occurs at the south edge of the Hastings conglomerate in Kaladar township, on lots 13, 14 and 15 in the second and third concessions. This schist may be a Grenville sediment, because the granite appears to be intrusive into it on lot 13 in the second concession, on the east side of Stony creek.

THE LAURENTIAN

Gneissic Granite.—The Laurentian of southeastern Ontario has been defined by the International Committee as the great masses of gneissic granite, also known as the Fundamental gneiss, which invade the Grenville series.* However, the age relations of these granite masses were not definitely determined by the Committee, and the authors believe that certain of them are younger than the Laurentian and are of Moira or post-Hastings age. The petrographic characters of the granites, which occur in the form of batholiths in Haliburton, Peterborough and Hastings counties, have been fully described by Adams and Barlow.† In mapping the Actinolite-Cloyne area a grey granite gneiss of uniform character was found in the southeast part of the area. It is classed as

* Journal of Geology, Vol. 15, 1907, pp. 191-217.
† Memoir No. 6, Geol. Survey of Canada.

Laurentian, because pebbles similar to it have been found in the overlying Hastings conglomerate and because it does not invade the latter sediment. The gneiss is exposed for many miles, commencing at the northeast end of the map and continuing southwesterly, just to the south of the village of Actinolite, thence southerly towards the town of Tweed, where it is covered by horizontally lying limestones of Paleozoic, Ordovician, age. In the area southeast of Actinolite the gneiss has a pink or pinkish-grey color, becoming dark and basic in certain areas, especially near its contact with the Grenville series.

The northwest part of the map is also extensively occupied by the gneissoid granite.

Gneissic Syenite.—About a mile and a half southwest and south of the village of Flinton there occurs an area of gneissoid syenite occupying several square miles. The syenite is clearly penetrated by dikes from the Fundamental gneissic granite on lot 20, concession 1, Kaladar township, immediately east of the cheese factory, Fig. 22. It is thus evident that the Laurentian series consists of rocks of at least two ages: (1) a younger gneissic granite, and (2) an older gneissic syenite. A similar syenite outcrops about three miles west of Bishop Corners on the prominent hill westerly from the bridge (locally known as O'Donnell's bridge) over the Skootamatta river. The relationship of this syenite to the granite is not so clear as that at Flinton, five miles to the southwest.

The gneissic granite south of Harlowe sends dikes of felsite and fine- or medium-grained granite and quartz-porphyry into the Keewatin green schists. It is therefore certain that these felsite dikes are of the same age as the gneiss, because they may be directly traced into it. In other parts of the Keewatin, however, there occur felsite and quartz-porphyry dikes, which, although they cannot be directly connected with the Laurentian gneiss, may be of the same age, since they are more or less schistose. Examples of these dikes are found, (1) about a mile northeast of Actinolite, (2) on the Addington road near the northeast corner of Kaladar township, and at other places.

Pink Felsite and Sericite Schist or Gneiss.—A fine- to medium-grained, pink felsite schist, or felsite, is found southwest of Actinolite. It is evident that this rock is Laurentian in age, because pebbles of it occur in the Hastings conglomerate. West of Hawkins bay it is about one and a quarter miles in width, measured across the strike. As the rock is traced to the northeast towards Actinolite the band becomes gradually narrower, until at the Queensboro road it is about 250 feet wide; it rapidly pinches out seven hundred yards farther east. At times the rock is more or less massive, but often it is altered to a sericite schist, showing glistening flakes of sericite. Under the microscope several thin sections, Nos. 371 to 375 inclusive, show the rock to consist of quartz, feldspar, sericite and small amounts of calcite.

An old stone mill, originally a grist-mill, stands near the bridge crossing the Moira river at the point where it leaves Moira lake. Several hundred yards northeast of the mill the felsite schist has been crushed, forming an autoclastic conglomerate.

A composite sample of the felsite schist, consisting of thirteen chips taken at various points for two miles along the strike, gave the following results on analysis:—

	Per cent.
SiO_2	71.24
FeO, Fe_2O_3	4.80
Al_2O_3	15.38
CaO	0.49
MgO	0.44
Na_2O	2.68
K_2O	4.10
H_2O	1.06
Total	100.19

The silica content of three other samples of the schist was found to be 72.4, 68.34 and 72.37 per cent., respectively.

Fig. 22. Syenite intruded by granite dikes from Laurentian granite-gneiss. Lot 20, concession 1, Kaladar township, Addington county.

Granite.—West of O'Donnell's bridge, referred to above, is exposed for three-quarters of a mile a medium-grained, pink granite. The rock holds large masses many feet in diameter of the syenite, and these inclusions are intersected in an intricate manner by dikes from the granite. This medium-grained granite has not been found in contact with the Hastings conglomerate, hence its relative age, whether pre-Hastings or post-Hastings, is not known. A few hundred yards west of the village of Flinton medium-grained granite dikes invade the Laurentian gneiss, and they also penetrate the syenite to the southwest of Flinton. Similar dikes are also seen at the schoolhouse at Actinolite invading the Fundamental gneiss. The age of these dike rocks is not definitely known.

It is probable that the areas mapped as Laurentian may contain masses of granite, or granite gneiss, which are younger than the Hastings conglomerate.

THE HASTINGS SERIES

The map of the Actinolite-Cloyne area shows the distribution of the Hastings sediments, which consist of conglomerate, Fig. 23, quartzite, mica-schist, slate and gneiss, but in which limestones are not known to occur. About a dozen belts or exposures, extending in a northeasterly and southwesterly direction, have been mapped. The largest of these is about twenty-two miles long, with a maximum width, measured across the strike, of about a mile; other lenses are smaller, being patches a few hundred feet in length. It is probable that all of these outcrops, since they are alike in lithological character and in the extent of their metamorphism, form part of what was once a continuous series, the thickness of which there is no means of approximating. The sediments, like almost all the pre-Cambrian rocks in southeastern Ontario, have been subjected to pressure exerted in a northwesterly-southeasterly direction, causing the matrix to become schistose, and the pebbles to be drawn out so that at times the longer diameters are several times the shorter. The contact of the conglomerates and other Hastings sediments with adjacent rocks is more or less vertical, coinciding with the dip of the schists.

The conglomerate has a grey or pink color, due to the fact that the major part of the rock is made up of pebbles of coarse chert and quartzite, derived from the "iron formation" and quartzite of the Grenville series. While these constitute the main mass of the rock, the following pebbles also occur: granite, granite gneiss, quartz and feldspar-porphyry, green schist, felsite, white quartz, black chert (jeweller's touchstone), red jasper and crystalline limestone. Although the number of pebbles of granite and other igneous rocks is subordinate compared with the quartzite and chert, they are, nevertheless, of profound significance, denoting, as they do, the existence of a great unconformity between the granites, greenstones, and other rocks, and the conglomerates. The character of this unconformity is dealt with on following pages, under the heading "Relationships."

Much of the conglomerate and other sediments are now represented by sericite or biotite schist, and gneiss, in which few pebbles can be detected. Quartzite is a common rock in the Hastings series. The members of the series pass gradually one into another. Original bedding in the sediments is seldom seen. Thus, it is not possible to estimate the thickness of this fragmental series. Many exposures occur at various places which will be mentioned in the discussion of the relationships of the series to other rocks.

POST-HASTINGS INTRUSIVES

These intrusives consist of diabase, grey felsite, Moira granite and coarse granite-pegmatite.

A diabase dike is shown on the map two and a quarter miles west of Actinolite, and about 300 yards south of the main road. It is from 50 to 200 feet wide, of medium grain, dark in color, and sometimes weathers rusty. Under the microscope it is seen to consist of hornblende, plagioclase and iron oxides. The feldspar, which is fresh, occurs in irregular rods set in the hornblende, producing the ophitic texture.

Fig. 23. Hastings conglomerate. Golden Fleece mine, Kaladar township, Addington county.

Dikes of altered diabase also occur at the pyrite mines southwest of the village of Queensboro, on the property of the Canadian Sulphur Ore Company.

An intrusion of a massive, fine-grained, grey felsite occurs at the property mentioned in the preceding paragraph. Thin sections examined under the microscope show the rock to consist of tiny phenocrysts of feldspar set in a fine-grained matrix of quartz or feldspar. In places the rock is brecciated, and in others schistose.

The Moira granite, named after Moira lake, is well exposed on the south and east end of the lake. The rock also occurs in the Madoc area. It is a massive, pink rock, and where it has been subjected to pressure shows slickensides. It is sometimes schistose or gneissoid, and contains in places iron oxides. Under the microscope it is seen to consist of quartz and feldspar, much of the latter showing albite twinning lamellæ. Some scattered grains of calcite or dolomite are present.

Dikes, or other intrusions, of coarse granite-pegmatite are of common occurrence.

Relationships

Relation of Keewatin to Grenville.—The Grenville series of this area has already been shown to consist of four members: (1) Crystalline limestone; (2) "iron formation"; (3) rusty schist; (4) grey gneiss, schist, quartzite and greywacké. This very ancient series of sediments is so disturbed and metamorphosed that original sedimentary textures have been largely obliterated. The grey gneisses or schists, as mapped, may include igneous rocks in the form of dikes, sills, or interbedded lava flows, but owing to the general metamorphism none have been recognized; nor has the presence of tuffs been proved.

The question regarding the basement upon which the Grenville sediments were laid down may now be dealt with.

The structural relationship between the Grenville and Keewatin is shown by cross section A B F, lying about a mile and a quarter west of Actinolite. The greenstone schists form a nucleus, or core, on each flank of which occur quartzite, greywacké gneiss, schists and crystalline limestone of the Grenville series. At the northwest end of the section, near Queensboro, the succession in descending order is as follows: (1) crystalline limestone with minor beds of greywacké; (2) greywacké, rusty schist and quartzite; (3) Keewatin greenstone schist. At the southeast end of the section the succession is about the same, but the quartzite and greywacké are altered to schist and gneiss, and in addition there are present lenses of younger, infolded, Hastings conglomerate. Thus it is seen that there rest directly on the greenstone nucleus quartzite and greywacké, and that this type of sediment is followed by crystalline limestone. Contacts of the greenstone schists and sediments may be seen at both ends of the cross-section, and east and west of the village of Actinolite for two or three miles. About a mile northeast of the village, at the side of the Flinton road, the Keewatin green schist passes into a quartz-mica schist of the Grenville series in a few feet. In fact it may be said that this transitional type of contact is characteristic of all the known exposures between the two series, Fig. 21, page 45.

Let us now consider the age relationship between the greenstone nucleus and the sediments on each side of it. In the first place it is clear that the greenstone is not a deep-seated intrusive, or batholith, invading the Grenville sediments. It is a volcanic or surface rock, retaining in places an ellipsoidal or pillow structure, and a fine or medium-grained texture. The ellipsoidal structure shows that the green schists probably, were originally submarine lava flows. In the second place, the greenstone does not send dikes into the sediments, nor give other evidence of being intrusive into these rocks. It is thus inferred that the quartzite, greywacké, and limestone are younger than the pillow lavas.

There is no evidence, such, for example, as the presence of greenstone fragments in the quartzite, to show that the greenstones in this particular area were eroded befor the deposition of the quartzite and other Grenville sediments. It is probable that the sediments were deposited directly on the surface of the submarine, Keewatin lava flows.

At Bishop Corners, 21 miles northeast of Actinolite, basic lavas of the Keewatin series, showing ellipsoidal structure and amygdaloidal texture, have already been described. The ellipsoids are remarkably well preserved, Fig. 20, although the rock seems to be altered to secondary minerals, including hornblende and other varieties. Magnesian limestone, rusty schist, iron formation and greywacké or its schistose representative are all exposed between Bishop Corners and Cloyne, two and a half miles to the north. These sediments lie east of the Addington road and rest on the ellipsoidal lava. The greywacké, rusty schist and "iron formation," which are, however, not shown by a separate color on this part of the map, occur between the lava and the limestone, suggesting that they were first deposited and were followed by the limestone. This succession is similar to that on section line A B F described above.

Relation of Laurentian series to Keewatin and Grenville.—The Laurentian granite and syenite are intrusive into the Keewatin and Grenville series. The intrusive character of the Laurentian may be seen at various localities in the Actinolite-Cloyne area. South of Harlowe post office, for instance, on lot 30 in the second concession of Kennebec township, the contact of the gneissoid granite and Keewatin greenstone is exposed a few hundred yards south of the road. Here the granite sends long tongues or dikes into the greenstone, parallel to the schistosity of the latter, producing a banded structure in the rocks not unlike that commonly found in the Laurentian gneiss in various other parts of Ontario. A few of these parallel tongues, or dikes, of granite are first met with in the greenstone; as the granite mass is approached the dikes become more numerous, and, when finally the granite is entered, long lenses or bands of the greenstone are found enclosed in the granite.

A little west of here, at the northeast corner of Kaladar township and at the roadside, the granite magma, in place of sending parallel dikes into the green schist, has, on the other hand, partly dissolved the latter; half digested fragments still remain in the granite. The banded structure has not been produced.

One of the best localities in which to observe the banding caused by the intrusion of granite into the Keewatin-Grenville complex is at Mazinaw lake, which lies two and a half miles north of Cloyne and beyond the confines of the map. The lake, which is narrow and about nine miles long, is one of the most beautiful in southeastern Ontario. Near the middle of the lake, on the east shore, there is a perpendicular cliff rising some 200 feet or more above the water. On the face of the cliff the Laurentian gneissoid-granite holds many long lenses of dark-colored gneiss which vary from a foot to 100 feet in width. The latter may be either metamorphosed Grenville sediments or Keewatin greenstones. The rocks dip steeply to the southeast, but, as the north end of the lake is approached, the dip becomes more gentle. It would appear that the granite was forced, in the form of sills or dikes, between the schistose layers of the dark-colored gneiss.

Contacts of the gneissoid granite and greenstone may also be seen two or three miles west of Cloyne, along the east side of the Skootamatta river, where the granite penetrates the greenstone and holds fragments of it.

The intrusive contact is particularly well exposed about three miles northeast of Actinolite. Here the gneiss contains immense blocks of the Keewatin greenstone.

At the marble schoolhouse of Actinolite, the granite sends dark-colored dikes into the crystalline limestone of the Grenville series. It may also be observed here that the Fundamental gneiss is cut by medium-grained granite dikes, and that these are intersected again by coarse granite-pegmatite dikes. Thus, at Actinolite four distinct groups of igneous rocks, differing in age, are recognized. These are in descending order: (1) coarse granite-pegmatite dikes; (2) medium-grained granite dikes; (3) gneissoid granite or Fundamental gneiss of the Laurentian series; (4) Keewatin greenstone.

West of Actinolite, about a mile and a quarter, and immediately east of the Queensboro road, on lot 1 in the third concession of Elzevir, a dike from the pink felsite schist, described under the Laurentian series, penetrates the grey gneiss of the Grenville series.

The syenite of Flinton invades the greenstones. This may be seen about one and a half miles south of the village, near the Skootamatta river.

Relation of Hastings conglomerate to Keewatin, Grenville and Laurentian series.—In the Actinolite-Cloyne area, the Hastings fragmental series, consisting of conglomerate, quartzite and other rocks, has been found to rest unconformably on each of the following, viz.: (1) greenstones and green schists of the Keewatin series; (2) crystalline limestone, grey gneiss and iron formation of the Grenville series; (3) gneissoid granite of the Laurentian series. The conglomerate, which holds pebbles of all of these rocks, rests on the older series in the form of long, closely infolded belts or lenses, the contacts being about vertical. It will be convenient to describe these conglomerate lenses and their contacts with adjacent rocks by beginning first at the southwest corner of the map and then following the rocks for 30 miles to the northeast.

The first belt is met with on lots 2 and 3 in the eighth, ninth, tenth and eleventh concessions of Madoc township, through which the main road between Madoc and Actinolite runs.* The belt is two and a quarter miles long and about one-quarter of a mile wide at its widest point. At the west end it disappears under a covering of heavy drift, while at the east end it thins out to a point. On the south part of lot 3 in the ninth concession, along the banks of a creek which has exposed the rocks to view, the schistose conglomerate may be seen in contact with a small area of dolomitic limestone of the Grenville series. The conglomerate holds, besides other fragments, elongated pebbles of the limestone, proving the unconformity between the two rocks. One of the limestone pebbles has two veinlets of quartz cutting it, but the quartz does not cut the conglomerate; the veinlets were, therefore, probably formed in the limestone before the latter was eroded. There may be a fault at the contact of the two rocks. About half a mile east of here, at the cross-road between the ninth and tenth concessions, lots 2 and 3, a good exposure of the conglomerate is to be seen, Fig. 24. Besides pebbles of limestone several other varieties may be recognized, including quartz-porphyry, fine-grained pink felsite, granite, red chert or jasper, coarse granular quartz, and mica schist or gneiss. A few hundred yards to the northeast of this cross-road, near the southwest corner of lot 3 in the tenth concession, the schistose greenstone and conglomerate may be seen in contact for a few feet, but the metamorphosed character of the junction does not throw light on the relationships.

Southeast of the cross-road about three-quarters of a mile, on the road to the village of Tweed, two lenses of conglomerate occur, one on each side of the road. That on the east side is made up largely of chert fragments, some of them jasper-like in appearance. About one mile farther south the road crosses the Moira river, parallel to which and at a distance of 100 yards, there is a narrow lens of much disturbed conglomerate about one mile long. The pebbles are mainly a pink or grey quartzite and chert and the lens rests in a schist or gneiss of the Grenville series. Much of this conglomerate, however, has altered to a mica-schist in which the occurrence of pebbles is rare, making the line of contact between the two rocks, i.e., Grenville schist and Hastings conglomerate, more or less indistinct. The map shows two small conglomerate lenses, about two hundr

* Many years ago H. G. Vennor described this conglomerate and pointed out the presence of limestone pebbles. (Geological Survey of Canada. Report of Progress, 1866-69, page 15 Vennor says: "At the village of Bridgewater [now Actinolite] conglomerate layers abou in a band of mica-schist 120 feet thick, having a streaked surface from the alternation grayish and reddish layers. The enclosed pebbles are of red and white quartz, occurring parallel beds, from two inches to five feet in thickness, which are separated by mica-sch layers holding only a few scattered pebbles Westward from this a similar band of co glomerate is seen on the north side of the road leading from Bridgewater to Madoc, ... which appears to me to be a continuation of that of Bridgewater. Here, howev it is associated with one of the coarser conglomerate bands rising in large rounded rid from the field. The matrix appears to be chiefly a black silicious slate, and it is more less charged with well-rounded fragments of quartz and syenite. Adjoining this, but bel it, there occurs a conglomerate with a schistose dolomitic matrix, the pebbles themsel sometimes being of dolomite, interstratified with similar black silicious slates."

Fig. 24. Hastings conglomerate holding pebbles of crystalline limestone. Northeast corner of lot 2, concession 9, Madoc township, Hastings county. This conglomerate was described by Vennor in the Report of the Geological Survey of Canada for 1866-69.

yards long, lying adjacent to the last mentioned lens; the one which is farthest from the road contains a few grey, granite-gneiss pebbles, one of them about a foot long. A thin section, No. 369, of the latter shows the pebble to be a biotite granite consisting of quartz, feldspar, some of which shows albite twinning lamellæ, and biotite; it has been crushed, resulting in rims of crushed feldspar surrounding parent grains. This lens of conglomerate is easily reached by an old road which runs along the northwest bank of the Moira river.

A few hundred yards west of the village of Actinolite, the second lens of conglomerate and quartzite is exposed. It has a maximum width of a quarter of a mile and may be follow[illegible] for two and a quarter miles to the west. At the southern edge, about 200 yards ea[illegible] Black creek, the conglomerate holds several pebbles of granite. A thin section of o[illegible] of these showed the pebble to be made up of quartz, feldspar and brown mica. The conglomerate is enclosed in a schist or gneiss of the Grenville series. The contact of the two rocks may be seen on the north and south sides of the belt at several points. There is a gradual transition between the two rocks, the transitional part being several feet or more wide; because of this transition the unconformity between the two series cannot be directly proved, and the line of contact shown on the map is arbitrary. There is indirect evidence, however, that an unconformity exists. This consists in the fact that the pink felsite, shown on the map to occur in the form of a long tongue lying south of the conglomerate a few hundred feet, sends a dike into the Grenville schist, proving that the schist is older than the felsite. A few pebbles of the felsite occur in the conglomerate, showing further that both the felsite and the schist are older than the Hastings conglomerate. The felsite dike referred to occurs on lot 1 in the third concession of Elzevir, about 100 feet east of the Queensboro road; this dike has already been mentioned on page 52. The majority of the pebbles in the conglomerate, near this road, consist of pink and grey colored chert or quartzite, often showing fine banding similar to that in the Grenville iron formation. The percentage of silica, determined in fourteen samples of these pink and grey cherts, is as follows:

No.	Per cent.
1	94.23
2	93.98
3	90.06
4	95.22
5	94.26
6	93.86
7	[illegible]
8	86.24
9	92.26
10	85.12
11	80.74
12	87.96
13	87.40
14	89.60

The [illegible] most important belt of conglomerate is first exposed about three miles eas[illegible]. It is about 22 miles long and a mile wide at its wide[illegible] point. West of the [illegible] Northbrook, in the north part of Kaladar township, Addington county, it divid[illegible]o arms which continue northeasterly until they finally pinch out south of Gull lake in the extreme northeast, beyond the confines of the map. The conglomerate rests successively upon rocks of Keewatin, Grenville and Laurentian age, and may be seen in actual contact with them at several places. Contacts of Keewatin green schists and Hastings conglomerate occur at the following points: (1) South of Harlowe postoffice, on lot 31 in the second concession of Kennebec, the conglomerate lies sharply against calcareous greenstone schist. Pebbles of the green schist were not observed in the conglomerate. (2) About a mile and a half north of the postoffice of Northbrook, the Addington road takes a sharp bend to the northeast. Here, on the west side of the road, the conglomerate passes gradually into the greenstone in a few yards.

(3) At the Golden Fleece mine, about a mile and a half northeast of Flinton the Hastings sediments are in contact with the green schists.* The contact zone has, however, been disturbed and impregnated with quartz and other minerals. Hence not much light is here thrown on the relative ages of the two series. Fine examples of conglomerate occur on the property, Fig. 23.

The long conglomerate lens or belt, referred to in the preceding paragraph, lies almost wholly in Laurentian gneissoid granite and syenite between the village of Actinolite and Flinton. Contacts between the conglomerate and other rocks occupy, for the most part, drift-covered valleys or other depressions, and are therefore difficult to find, but on lot 9 in the first concession of Kaladar township, near Stony creek, the two series are exposed in such a manner that their relations seem clear. The gneissoid granite at the contact becomes more distinctly gneissoid or schistose, and gradually, in a distance of a few yards, pebbles of coarse grey quartzite or chert appear. There appears to be no evidence that the granite gneiss is in igneous contact with the conglomerate.

Pebbles of gneissoid granite, similar to the Laurentian gneiss, are not of common occurrence in the Hastings conglomerate, but many of them may be seen about four miles easterly from Actinolite on lots 2 and 3 in the ninth concession of Elzevir township. These pebbles have been drawn out by pressure.

The granite gneiss is also in contact with the conglomerate northeast of Northbrook postoffice, on lot 31 in the ninth concession of Kaladar township. The nature of the contact is similar to that near Stony creek, just described, i.e., there is a gradual transition between the conglomerate and gneiss. The latter gradually gives place to a rock containing pebbles of coarse quartzite or chert. The prominent hill of conglomerate on this lot contains a few pebbles of quartz-porphyry and granite, but it may be noted, that, as usual, chert and quartzite pebbles constitute the dominant part of the sediment. There is no evidence that the granite is intrusive into the conglomerate, but, on the other hand, this same granite invades the Keewatin greenstone about a mile to the east of the lot last mentioned. The intrusive contact has been described on page 51.

The characteristics of the banded, grey chert of the "iron formation" have been discussed on page 44. Contacts of this formation and the long lens of Hastings conglomerate, described in preceding paragraphs, occur at the following points: (1) At the Ore Chimney mine, three miles southeast of Cloyne, good exposures of both rocks are found. The conglomerate is made up almost wholly of pebbles which are exactly similar to the chert. The actual contact may be seen at the mine, where the conglomerate lies against the bevelled and eroded edges of the banded chert. This is probably one of the clearest cases of an unconformity in the pre-Cambrian yet discovered in southeastern Ontario. (2) Easterly from here, and about a mile west of Harlowe postoffice, the banded chert is also well exposed. The conglomerate lens, which is 600 yards wide,

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* Mr. H. G. Vennor examined the conglomerates in the vicinity of Flinton in the year 1872 (Report Geol. Survey of Canada, 1872-73, pp. 150-1). Vennor says: "The diorites, green slates, schists and conglomerates are particularly well developed around the village of Flinton, situated on the twenty-first and twenty-second lots of the third and fourth concessions of Kaladar. Here, much of the rock is a light green slate, graduating into a finely speckled hornblendic schist impregnated with reddish brown garnets. A short distance beyond this village, on the road leading to the Addington road, the first conglomerate is met with. In it the pebbles, which are of quartzite, are enclosed in a matrix of sand and mica, or micaceous quartzite, and are clearly seen to be flattened out, and elongated along the plane of bedding. They are mostly small, or would appear to be so from an inspection of the mere worn surface of the rock; but, on fracture, the pebbles, which on the surface shew only perhaps a cross measurement of say from a-half to one inch, are found to have a length of from five to ten inches, the length being generally proportional to the thickness. They are easily removed from the matrix, and a number were found lying loose in the soil, near the outcrop of the band. In some localities the character of this conglomerate changes in a most marked manner. Instead of interstratified layers of pebbles, we have alternate layers of vitreous quartz or quartzite and glistening mica schist, with here and there something like an enclosed pebble; and again—on the course of the same outcrop—we find these layers of quartz or quartzite pinched out into lenticular or eye-shaped forms and entirely surrounded by mica schist. Still higher in the series, and about 60 chains farther along the Flinton road, a second conglomerate is met with of a coarser description. In it, the pebbles, which are much larger, and of different shades of color, are enclosed in a greyish and greenish hornblende schist. This is separated from the first by green slates and greyish hornblende schists with garnets, and similar rocks again overlie it. . . . . Northeastward from Flinton village, similar green schists, with an interstratified conglomerate, cross the Addington road a short distance above the Kaladar postoffice [now Northbrook postoffice], namely on lots thirty and thirty-one in the seventh, and thirty-one and thirty-two in the eighth concessions. They here follow the general course of the road, and form a high ridge along its western side up to the boundary line of Anglesea and Barrie."

rests upon and against the chert. Pebbles of the latter form the dominant part of the conglomerate. The contact of the chert and conglomerate may be followed for several hundred yards. The evidence here appears to the writers to be sufficient to warrant the statement that an unconformity exists between the banded quartzite or chert and the Hastings conglomerate. Interbedded with the conglomerate is quartzite similar in character to that from which the pebbles in the conglomerate were derived, thus producing in certain outcrops a somewhat puzzling structure.

Another lens of conglomerate, resting in Keewatin greenstone, is exposed at Bishop Corners. A good contact with the greenstone schist occurs half a mile southwest of the corners immediately to the north of what is locally known as the "river road," which crosses the Addington road at right angles. The base of the conglomerate is exposed for several feet, and holds pebbles of greenstone schist which are similar to the adjacent Keewatin schist, proving the unconformity between the two series. Three-quarters of a mile north of here, along the same contact, the conglomerate is again exposed where it crosses the Addington road. The base for several feet consists of a conglomerate schist containing pebbles of white quartz about an inch in diameter; this passes into a very fine-grained, grey schist or slate. About 300 yards farther north, on the east side of Addington road, the conglomerate lies against a fine exposure of ellipsoidal basalt; the contact between the two is vertical and sharp.*

Conglomerate Southeast of the Actinolite-Cloyne Area

During the course of our work many areas, beyond the boundaries of the maps accompanying the report, have been examined. One of these areas consists of prominent ridges locally known as the "Bald Mountains," because of the scant vegetation which they support. T[illegible]lls stretch in a northeast-southwest direction for some fifteen or twenty miles [illegible]etween the southeast boundary of the Actinolite-Cloyne area and the Canadi[illegible]c railway, partly in the southern portion of Kaladar township, Addington county. [illegible] Addington road, which crosses the railway at Kaladar station, 148 miles east of Toronto, runs in a northerly direction over the ridges and thence north to the village of Cloyne and many miles beyond. The distance from Kaladar station to Cloyne by the sinuous road is about eighteen miles.

Our reconnaissance work on the Bald mountains resulted in the discovery of an important lens of Hastings conglomerate which crosses the Addington road about two and a half miles north of Kaladar station just to the north of a great beaver meadow.

The conglomerate is similar to other lenses already described in the Actinolite-Cloyne area, but is probably more metamorphosed. Owing to its being in contact with granite-gneiss it is worthy of description. It strikes in a northeast direction and dips steeply to the southeast. The rock, which is schistose and has its pebbles generally drawn out into long lenses, may best be examined about a mile to the northeast of the road. The base of the series is well exposed here, and is seen to consist almost wholly of granite-gneiss boulders and pebbles similar to the granite-gneiss mass with which it is in contact on its northwest edge. Some of the boulders are four feet long. The contact between the granite and conglomerate, which shows unconformable relations between the two rocks, is not indicated by a well-defined line, one rock passing gradually into the other within a distance of a few feet. The materials comprising the basal member of the conglomerate have been derived directly from the underlying granite basement.

In the Bald mountains the conglomerate, containing numerous fragments, passes upward into a conglomerate which contains few granite pebbles, and slowly acquires fragments of amphibolite and chert or quartzite, finally passing into a variety in which chert or quartzite pebbles compose almost the whole rock. The latter is sometimes

* R. W. Ells, about 18 years ago, made brief mention of the conglomerates to the south of Mazinaw lake and Cloyne. He says: "To the south of Mazinaw lake, the rocks are mostly hornblendic, often with a well-marked green shade, passing in places into well-defined chloritic schists. These often become micaceous, and are associated with slaty bands which sometimes contain an abundance of quartz pebbles, thus constituting true conglomerates, in which the pebbles are usually elongated along the lines of schistosity. They are well seen in the township of Kaladar, near the gold mine, not far from Flinton." Report Geol. Survey of Canada, Vol. IX, p. 58 A.

interbedded with schistose quartzite. The fragmental series along this cross-section is 1,500 feet or more in thickness. Beyond this, to the southeast, the sediments are followed by pink gneisses, various schistose rocks and crystalline limestone.

All of these rocks, namely: granite gneiss, conglomerate, pink gneiss, schists and crystalline limestone, are intruded by dikes and bosses of massive granite sometimes several hundred feet in diameter.

Other Conglomerate Areas

A small patch of conglomerate, less than 400 feet long, occurs about one and a half miles south of Bishop Corners, at the extreme southeast corner of the township of Anglesea. This small patch is shown on the map. Dikes of quartz-porphyry cut across the strike of the Keewatin schists. The dikes are sheared and altered to sericite schist which, nevertheless, still retains "eyes" of quartz representing original phenocrysts. A lens of grey chert of the Grenville series rests in the schist. The conglomerate is in contact with and holds pebbles of the chert. The conglomerate also contains several long flat pebbles of soft sericite schist which probably represent altered pebbles of the quartz-porphyry.

Three-quarters of a mile east of Flinton the contact of another lens of conglomerate and green schist is exposed immediately north of the main road. The junction between the two rocks is abrupt. This lens, which continues six miles to the northeast, is parallel to the main conglomerate belt already described. At a point about a mile and a half west of Northbrook postoffice it contains, at its western edge, several pebbles of massive granite three or four inches in diameter. The lens continues as far as the Addington road at the southeast corner of the township of Anglesea, where, at an abrupt turn in this road, the base of the conglomerate is exposed for several feet resting on the green schists. This is seen immediately west of the road on a low knoll. The basal member of the conglomerate is composed largely of fragments of the underlying green schists. On the east side of the road, at a distance of about 300 yards, in the field, a fine outcrop of conglomerate occurs, containing, besides other fragments, numerous pebbles of quartz-porphyry.

Immediately south of Harlowe postoffice, the rusty schists and coarse-grained greenstone schists are intruded by quartz-porphyry dikes. Numerous pebbles of quartz-porphyry occur in the conglomerate southeast of this postoffice, on lots 19 and 20 in the first concession of Barrie, which is evidence to show that not only the porphyry but also the rusty schist and greenstone schist are older than the conglomerate.

Relation of post-Hastings intrusives to Keewatin, Grenville, Laurentian and Hastings series.—The intrusives have already been shown to consist of (1) diabase, (2) grey felsite, (3) Moira granite, (4) coarse granite-pegmatite. These rocks have not often been found in contact with the Hastings conglomerate, but, judging solely from their massive and fresh characters as compared with the schistose conglomerate, it is certain that they are younger than the Hastings sediments.

At the property of the Canadian Sulphur Ore Company, southwest of Queensboro, altered diabase dikes intersect not only the Keewatin greenstone and Grenville limestone, but also the grey felsite. A diabase dike intrudes the Grenville limestone and schist about two miles east of Madoc.

A body of grey felsite, at the property mentioned in the preceding paragraph, invades the Keewatin greenstone and the Grenville sediments.

Dikes of Moira granite intrude the Grenville schist or gneiss at the east end of Moira lake, about 75 yards west of the point where the Madoc-Tweed road crosses the Moira river. Near the northwest corner of Hungerford township, at the contact of the granite and Grenville schist, the rocks have been crushed to an autoclastic conglomerate.

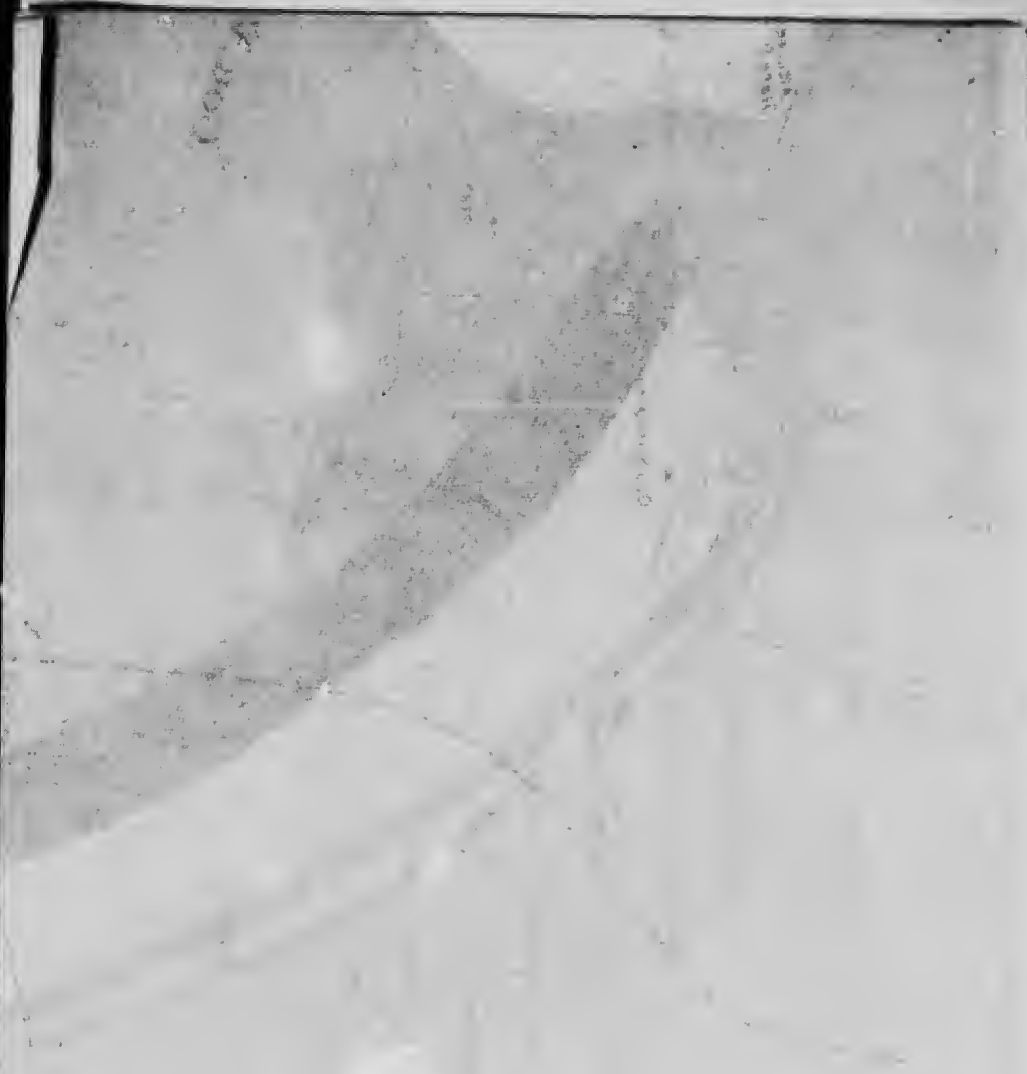
Coarse-grained pegmatites occur between Actinolite and Flinton. They intersect in every direction, not only the Laurentian gneissoid granite, but also the Hastings conglomerate.

Generally speaking, it may be stated that the basic post-Hastings intrusives are younger than the acid post-Hastings intrusives.

Relation of Paleozoic to the pre-Cambrian.—Horizontal beds of Black River limestone with basal sandstone and conglomerate rest with strong unconformity upon the pre-Cambrian rocks. Areas of these Paleozoic rocks are shown on the map.

Fig. 25. Part of Mazinaw lake, township of Barrie, beyond the northeastern limits of the Actinolite-Cloyne map. On the left of the illustration are the "pictured" cliffs of granite-gneiss, and across the expanse of the lake in the foreground is Bon Echo Inn, stretching beyond which is the peneplain.

No. 4



BUREAU OF

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MADOC

TOWNSHIPS of MADOC and HUNT

PROVINCE o

To accompany Part II, Volume 22,

Hon. W. H. Hearst, *Minister.*

Scale : 1/12000 or 1,0

1000 500 0 100

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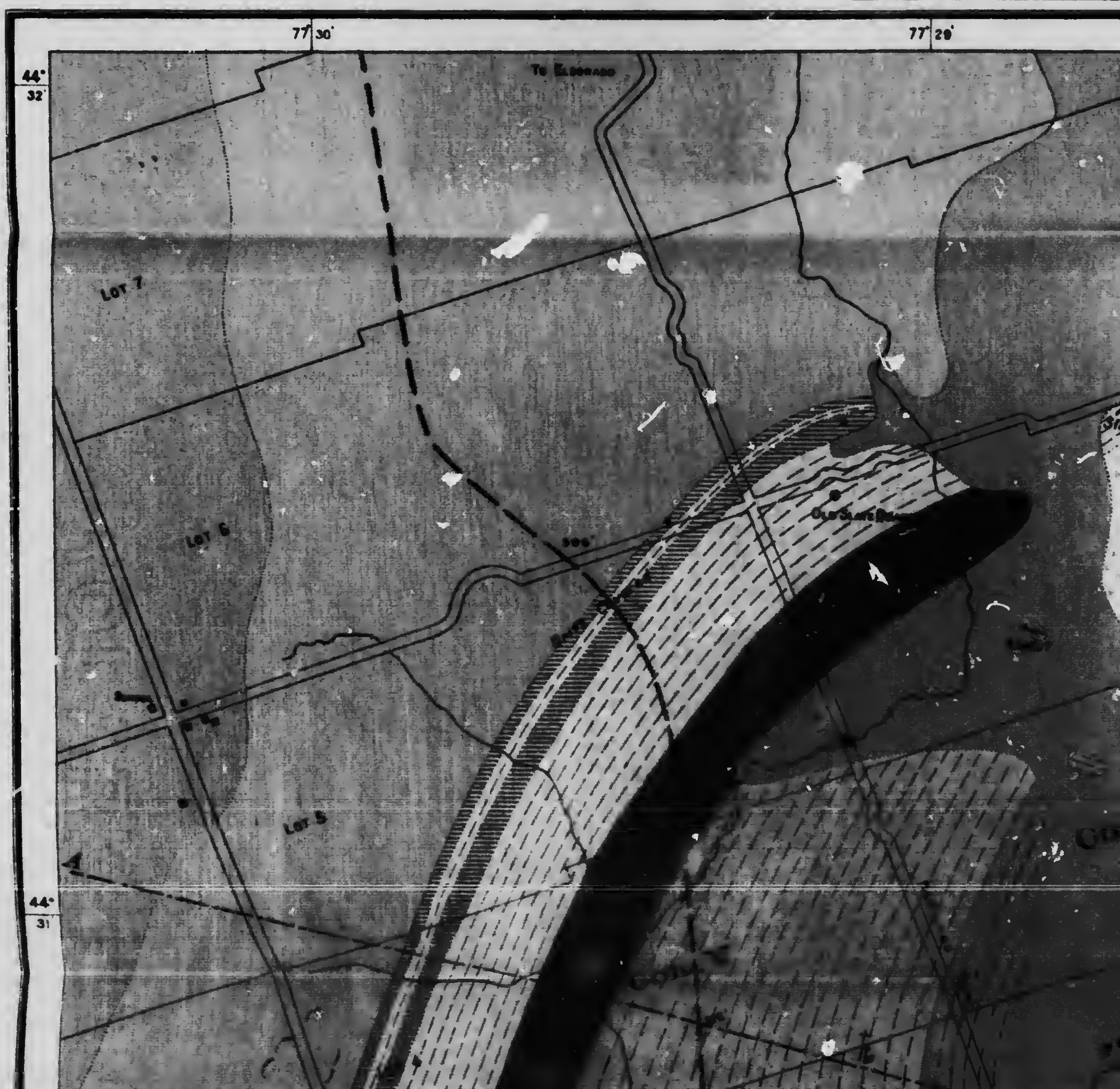


ONTARIO

...MENT OF LANDS, FORESTS AND MINING

...UREAU OF MINES

MAP

OF THE

...OC AREA

...HUNTINGDON, HASTINGS COUNTY

...NCE OF ONTARIO

...lume 22, Report of Bureau of Mines, 1913.

Willet G. Miller, *Provincial Geologist.*

... or 1,000 Feet = 1 Inch.

1000' 2000' 3000 Feet

Kilometre

77° 28'

44° 32'

LEGEND

PALEOZOIC

Black River limestone (Ordovician), including also drift-covered areas.

GREAT UNCONFORMITY

PRE-CAMBRIAN

Basic dikes.

Moira granite and felsite.

Slate.

Greywacké and quartzite.

Conglomerate and limestone.

Agglomerate and tuff; crush-breccia; felsite intrusions containing inclusions of schist, crystalline limestones and other rocks.

Madoc andesite and rhyolite with some agglomerate and tuff.

Blue and white crystalline limestone, essentially non-magnesian.

Brown and grey magnesian crystalline limestone.

NOTE:—The relative ages of certain groups of rocks in this area have not been definitely determined. Hence in this legend the age relations of the pre-Cambrian rocks, one to another, are not indicated.

SIGNS

House.

Hill.

Road or Street.

Swamp.

Shaft.

Prospect Pit.

Quarry.

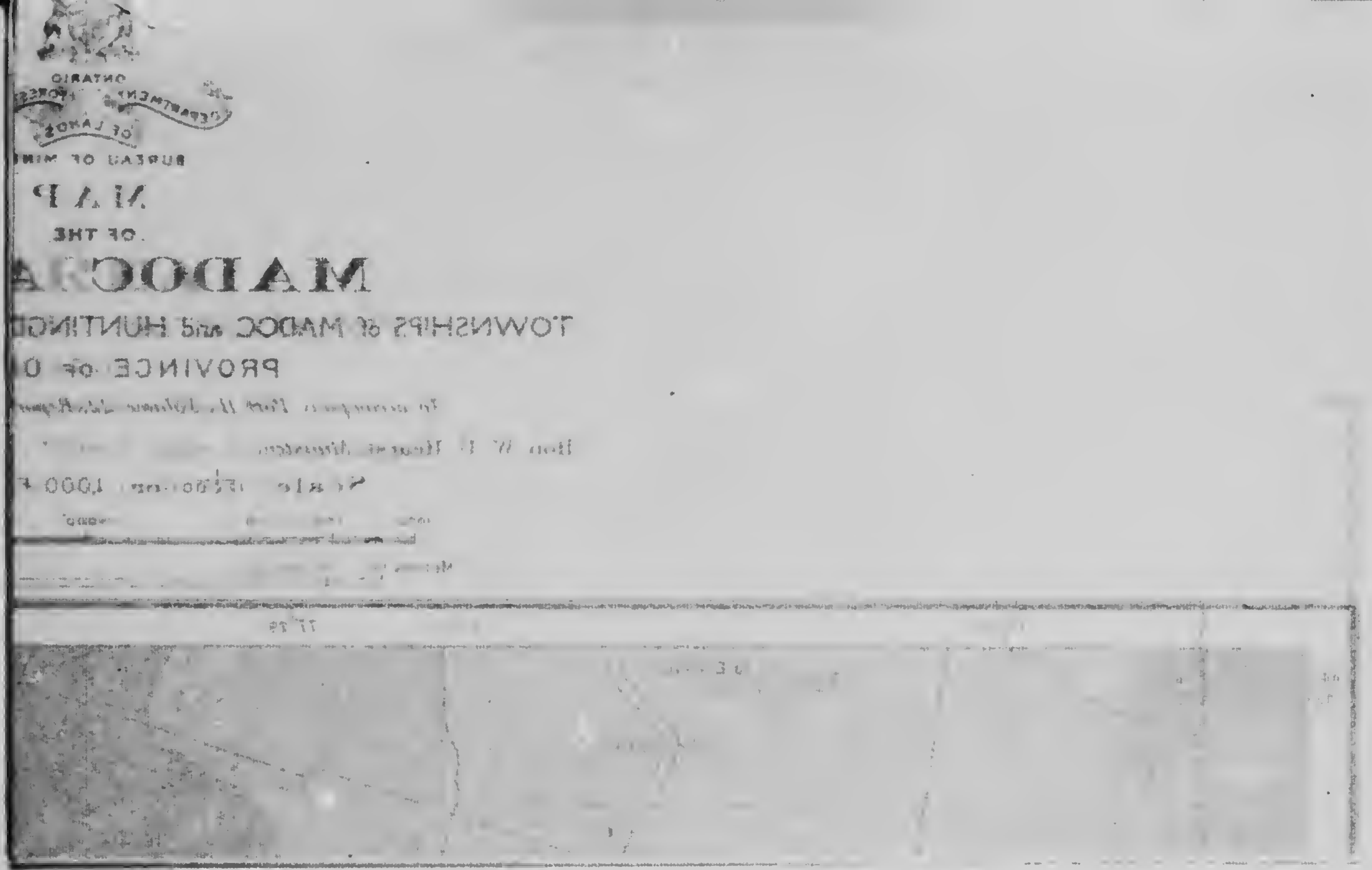
Strike and Dip.

575' *Elevation in feet above sea level.*

44° 31'


44°
31
44°
30'
LOT 2
LOT 10
GRAND TRUNK
77° 30'
77° 29'
B
600'
500'
400'
A
Road
Creek
600'
500'
400'


Swamp.
Shaft.
Prospect Pit.
Quarry.
Strike and Dip.
575' Elevation in feet above sea level.
SOURCES OF INFORMATION
Map of the "Madoc and Marmora Mining District" by E. Coste and J. White, 1890; with topographic additions by W. R. Rogers, 1918.
Geologically re-surveyed by Willet G. Miller and Cyril W. Knight, 1918.
44° 31'
44° 30'
MOIRA LAKE
507
77° 28'
Map Nº 22 d
D
600'
500'
400'
SECTION B.D.
C
DRIFT
600'
500'
400'
SECTION A.B.C.


MAP
MADOC
TOWNSHIPS of MADOC and HUNTINGD
PROVINCE of O

THE MADOC AREA

INTRODUCTION

The Madoc area shown on the accompanying map, No. 22d, contains about seven square miles, occupying parts of the townships of Madoc and Huntingdon, Hastings county.

The town of Madoc, in the township of the same name, the centre of a prosperous farming community, was the site of a pioneer iron industry, a small furnace, built in 1837, being operated for eight or nine years, using wood and charcoal as fuel. The iron ore was obtained from the Seymour mine, distant about three miles north of the town. In the year 1866 the town witnessed great mining excitement, caused by the discovery of a pocket of rich gold ore at a point, afterwards known as Eldorado, about eight miles distant. There was scarcely a lot or homestead in the immediately surrounding country on which pits or shafts were not sunk. Since then iron ore, copper pyrites, gold and other minerals have been spasmodically mined in the vicinity. At the present time,

Fig. 26. International Geological Congress party at contact of limestone "conglomerate" and Madoc andesite, August, 1913.

however, the Henderson talc mine, on the outskirts of the town, and the Canadian Sulphur Ore Company's pyrite mine, which lies several miles to the northeast of Madoc, are being successfully operated.

In the reports of the Geological Survey of Canada are to be found notes and papers on the area, by Logan, Murray, Macfarlane, Coste and other writers.

THE PRE-CAMBRIAN GEOLOGY

The age relations of certain groups of pre-Cambrian rocks in the Madoc area, as explained in the legend of the geological map, have not been satisfactorily determined. From their own examination of the field, the writers could not come to a decision as to the relations. During the meeting of the Geological Congress, and at other times, while on visits to the area, they had the advantage of conferences with workers familiar with the oldest groups of rocks in various parts of the world. But certain problems still remain unsolved. Good outcrops present features that lead to different interpretations, and the difficulties are increased by the fact that fully one-half of the area is overlain by Paleozoic and later deposits which hide important contacts.

Certain groups of rocks in the area are different from those found in any of the other six areas described in this report. This statement applies to the interbedded limestone "conglomerate" and slate, and to the conglomerate or agglomerate on the north edge of the town, to the north of the Catholic church, Fig. 30. Section A B C on the map, passes over, near both its eastern and western ends, exposures of interbedded "conglomerate" and slate. Near the middle of section B C is the outcrop, with rounded outline, of the agglomerate and other rocks.

By most observers who have visited the area the limestone "conglomerate" is considered to be a true conglomerate. It consists almost entirely of rounded fragments of limestone, some of which are a foot or more in diameter, Figs. 27, 28, 31, 32. A small percentage of dark slaty substance is present as cement material. Interbedded with the "conglomerate" are beds of a dark rock which on analysis proves to be slate, the beds of which are little fractured. If the rock containing limestone fragments is a true conglomerate, it is one of the most remarkable rocks of the class ever observed. On the other hand, if it is a pseudo-conglomerate, or autoclastic rock, the question arises as to

Fig. 27. Contact between Madoc andesite and limestone "conglomerate." Lot 4, concession 5, Madoc township, Hastings county. Contact is at hammer.

why, when the beds of limestone were fractured and the fragments rounded by pressure the interbedded slate practically escaped fracturing At one point, near section line A B, lot 4, in the fifth concession of Madoc township, a bed of sandstone or quartzite about two feet thick, is interbedded with the limestone "conglomerate." By those who consider the limestone rock to be a true conglomerate, this bed of sandstone is believed to lend support to the opinion held by them.

If we consider the rock containing the limestone fragments to be a true conglomerate and to be succeeded in conformable sequence upward by the thin bed of sandstone, interbedded slate and conglomerate, together with the great thickness of limestone described on page 67 we have a section different from any found in other parts of southeastern Ontario. Elsewhere no such succession of strata is known as is indicated by the limestone "conglomerate" and slate with the overlying great thickness of limestones. If the rock is a true conglomerate it represents the erosion product of crystalline limestone older than the great thickness of these rocks now exposed in the Madoc area.

Unconformable Groups

On the other hand, in spite of the fact that the dip and strike of all the rocks are he same, as shown in the section at the bottom of the map, it may be that what apppears o be a conformable succession of sediments, from the limestone "conglomerate" at the ase upward through the two feet of sandstone to slate and crystalline limestone, is eparable into two unconformable groups. The limestone "conglomerate," sandstone nd slate may be a younger unconformable series resting on the magnesian and non-agnesian limestones. Here the younger group would thus bear a relationship to the lder rocks similar to that which the Hastings series of fragmental rocks bears to the renville crystalline limestones e' ewhere in the district.

Fig. 28. Limestone "conglomerate." Lot 4, Concession 5, Madoc township, Hastings county.

Autoclastic Origin of "Conglomerate"

As already suggested the other hypothesis as to the origin of the "conglomerate" that it is a pseudo-conglomerate, having been formed by the fracturing of limestone nds, the interbanded slate having escaped fracturing. The whole series of sediments, z: limestone "conglomerate," narrow bed of sandstone, slate and great thickness of mestone would thus be classed as Grenville, the "conglomerate," sandstone and slate presenting the base of the series. But it may be repeated that elsewhere in the Gren-lle no such interbanding of crystalline limestone and slate is known.

Relation of Andesite to Limestone "Conglomerate"

Not only is the origin of the limestone "conglomerate" in dispute, but the relation the Madoc andesite to this rock is not understood. To certain observers it has appeared t the "conglomerate" rests on the eroded surface of the andesite and contains fragments of it. Other observers are of the opinion that the andesite is intrusive into the "conglomerate" and that the fragments of andesite are due to the breaking up of small dikes which penetrated the "conglomerate." Two or three competent observers, who visited the area, would not express an opinion as to whether the andesite is intrusive or not.

Comparison with Other Areas

Considering what is known of the relations of similar rocks in other areas described in this report, the andesite should be intrusive into the "conglomerate," whether the latter is a true or a pseudo-conglomerate. In other areas, the series of rocks that physically resembles most closely the Madoc andesite and felsite is the Belmont basalt. Both series of volcanic rocks occupy considerable of the surface of their respective areas and show various phases—amygdaloidal, porphyritic and tufaceous. They also show approximately the same degree of metamorphism or alteration. The Belmont rock is younger than both the Grenville limestones and the Hastings conglomerate. On this basis, the Madoc andesite should be considered to be younger than the "conglomerate" with which it is in contact, whether the latter is a true conglomerate or an autoclastic limestone—unless, however, it is a conglomerate younger than the Hastings conglomerate.

Having stated some of the difficulties in determining the relationships of the rocks in the Madoc area, it may be added that the failure to make a satisfactory determination does not affect the solution of the larger problems considered in this report. Doubtful evidence in the Madoc area may be discarded, there being sufficient data in the other areas described to show the age relationships of the Keewatin, Grenville, Hastings and other groups of rocks in the district.

ROCKS OF THE AREA

Without reference to the age relations of the members of the pre-Cambrian, one to another, the rocks of the area may be grouped as follows:

Paleozoic

ORDOVICIAN. Black River limestone and basal sandstone.

(Great unconformity)

Pre-Cambrian

(1) Basic dikes.
(2) Moira granite and felsite.
(3) Greywacké and quartzite.
(4) Slate.
(5) "Conglomerate" and limestone.
(6) Agglomerate and tuff; crush-breccia; felsite intrusions containing inclusions of schists, crystalline limestones and other rocks.
(7) Madoc andesite and rhyolite with some agglomerate and tuff.
(8) Blue and white crystalline limestones, essentially non-magnesian.
(9) Brown and grey magnesian limestones.

In following paragraphs are given descriptions of the various groups.

(9) *Brown and grey magnesian limestones.*—Rocks of this class are shown on the map at the Henderson talc mine, about a mile southeast of the town, and on lots 2, 3, 4 and 5 in the fifth, and lot 5 in the sixth concession of Madoc township, about a mile northwest of the town. Other small areas are also indicated. These crystalline limestones, which are fine to medium in grain, weather to a brown or grey color, and, at times, contain bands of granular quartz, resembling what has been called "eozoon" at Belmont Lake, Fig. 4. The limestone immediately to the north and south of the Hen-

derson talc mine contains many of these peculiar bands. The chemical composition of the rocks is shown in the following table:

No.	CaO.	MgO.	CO_2	$Fe_2O_3+Al_2O_3$	Insoluble.
1.	28.15	19.00	42.54	1.66	8.36
2.	29.29	15.58	43.67	...	4.62

1. Centre of lot 4, in the fifth concession, Madoc township, Hastings county.

2. Henderson talc mine, lot 14, in the fourteenth concession, Huntingdon township, Hastings county.

Notes on both the pre-Cambrian and Paleozoic limestones of Madoc and vicinity will be found in earlier Reports of the Bureau of Mines.*

(8) *Blue and white crystalline limestones, essentially non-magnesian.* These limestones are the most common sedimentary rocks of the pre-Cambrian at Madoc. They have, generally, a peculiar bluish or drab color which is suggestive of certain beds in the Ordovician; indeed, it has been thought by some investigators, that there is a possibility of finding fossil remains in them. They are, however, highly crystalline, and sometimes white in color, and are often interbedded with schistose greywacké and quartzite. It will be seen from the table, given below, that they differ chemically from the brown and grey limestones in containing little magnesia. There is probably some of the magnesian limestone included in the areas mapped as the blue variety. The wonderful purity of certain of these ancient limestones is noteworthy.

No.	CaO.	MgO.	$Fe_2O_3+Al_2O_3$	Insoluble.	Loss on ignition.
1.	37.38	1.50	2.94	26.74	31.60
2.	50.28	1.63	1.00	5.64	40.95
3.	54.00	.50	.54	1.10	43.75
4.	45.12	67	.36	16.76	36.62
5.	53.45	[illegible]	1.32	1.08	43.40
6.	50.10	3.88	.82	1.37	43.32

1. Along the railway track, south part lot 4, in the fifth concession of Madoc township, Hastings county.

2. About 100 yards northwest of old black marble quarry, lot 1, in the sixth concession of Madoc township.

3. Three feet west of felsite intrusion on north part of lot 13, in the fourteenth concession of Huntingdon township, Hastings county.

4. Same locality as No. 3, but on east side of felsite.

5. Same locality as No. 2; both Nos. 2 and 5 were collected a few feet from a basic dike several feet wide. The intrusion of this dike evidently has not had much effect on the magnesia content of the blue limestone.

6. Old marble quarry, Madoc.

(7) *Madoc andesite and rhyolite, with some agglomerate and tuff.* This volcanic series is shown on the northwest part of the map, but it extends for a few miles to the north of here. Chemical analyses show that the rocks vary in composition from a rhyolite to an andesite, the former occurring, for example, on lot 6, in the sixth concession of Madoc, the latter on lots 4, 5 and 6, in the fifth concession. There is a gradual transition between the two types, and both facies are in places amygdaloidal, Fig. 29, and contain agglomerate and tuff, showing the volcanic character of the rocks. The andesite variety, which, at times, contains much hornblende, is a massive, greenish, brown to grey colored rock, fine or medium in grain, and at times strikingly porphyritic. Thin sections show it to be made up of plagioclase, microcline, hornblende, biotite, and quartz. The amygdules, which are filled with calcite or quartz, are not seen in all parts of the mass, but good examples may be observed on the north part of lot 5 in the

* Vol. 13, part 2, pp. 59 et seq.

fifth concession of Madoc, to the south of the bend in the road. The following results of analyses will show the composition of the andesite facies.

	(1)	(2)
SiO_2	60.34	54.44
Al_2O_3	15.01	17.63
Fe_2O_3	3.71	7.18
FeO	10.57	6.12
CaO	1.05	2.83
MgO	.05	3.19
Na_2O	2.72	4.03
K_2O	3.23	1.49
H_2O	1.22	2.04
CO_2	2.57	1.64
	100.47	100.59

Fig. 29. Amygdaloidal facies of Madoc andesite. Lot 4, concession 5, Madoc Township, Hastings County.

The rhyolitic variety, which is fine in grain, has a peculiar light grey or pinkish color, and consists essentially of quartz, feldspar and sericite. Its composition is as follows:

SiO_2	72.20
Al_2O_3	13.62
Fe_2O_3	2.61
FeO	2.59
CaO	0.60
MgO	0.29
Na_2O	2.54
K_2O	4.98
Loss on ignition	0.82
	1[illegible]25

it may be noted here that the andesite and rhyolite both show evidence of alteration and metamorphism in various parts of their masses. The rhyolite is slightly schistose at times, and the andesite appears to have in part recrystallized.

A good contact of the andesite with the peculiar limestone "conglomerate" is to be seen on the northwest part of lot 4 in the fifth concession of Madoc township, near the western end of section A B. At the contact the andesite rises with steep face against the "conglomerate." The intrusive relation of the andesite is disputed, certain observers claiming that the "conglomerate" rests on the eroded surface of the andesite. The contact of the two rocks is exceptionally well exposed for fifty yards or more, Figs. 27 and 32. At the contact the andesite does not possess its typical character, considerable biotite in coarse flakes occurring in it, at times. Thin sections, taken a few inches from the contact, show the rock to consist of biotite, hornblende, sericite, quartz or feldspar grains, and magnetite. The biotite and hornblende occur in phenocryst-like forms set in the other minerals. Several feet from the contact the andesite is distinctly amygdaloidal, and is impregnated with calcite or dolomite.

At the Sexsmith mine and elsewhere the rhyolite clearly intrudes the crystalline limestone.

(6) *Agglomerate and tuff; crush breccia; felsite intrusions containing inclusions of schist, crystalline limestone and other rocks.* This group of fragmental rocks, together with felsite, is shown on the map immediately north of the town, and on lots 4 and 5 in the sixth concession of Madoc. The hill north of the town exposes these rocks in an excellent manner, Fig. 30. Such a prominent outcrop naturally attracted the early workers, and it was described by Sir Wm. Logan in 1863, as a conglomerate. Logan remarks that: "In a field a little way north from the village of Madoc, still in ascending continuation of the section, a ridge of a somewhat micaceous schist occurs; it is slightly calcareous, of a bluish color, weathering greenish, and holds numerous fragments of rock different in character from the matrix, all being without calcareous matter, and some of them resembling syenite or greenstone. North from this ridge another succeeds, consisting of micaceous schists, beyond which, for 300 yards, ridges of a decided conglomerate, with distinctly rounded pebbles enveloped in a matrix of micaceous schist, alternate with ridges of schist containing few or no pebbles. The exact dip of the strata has not been satisfactorily ascertained."*

A more detailed examination of these rocks has shown that they are not all water worn conglomerates, but are complex in origin, part being an agglomerate or tuff, part autoclastic, and part consisting of felsite dikes containing inclusions of the adjacent rocks. They have obviously been considerably disturbed, for, in several places zones of red garnets have been developed. The fragments vary from microscopic in size to those which are eighteen inches or more in diameter. The outlines are angular, subangular or round, Fig. 30. They consist of felsite or rhyolite, devitrified glass showing flow textures, amygdaloid, fine-grained acid porphyries, quartz, feldspar, crystalline limestone, slate, fine-grained greywacké or quartzite, and chert; sericite, calcite, garnet and biotite have been developed as secondary minerals.

While some of the fragmental material is agglomerate in character, other parts are more like normal conglomerate or agglomerate that has been worked over by water. The chemical composition of some of the crystalline limestone fragments, obtained from the hill north of the village of Madoc, is shown in the following table:

No.	CaO.	MgO.	Loss on ignition.	Insoluble.
1.	49.37	1.41	40.30	3.44
2.	48.86	2.08	40.93	3.44
3.	46.06	.76	[illegible]	6.50
4.	45.19	.95	[illegible]	11.64

* Geology of Canada, 1863, pp. 32-3[illegible].

Fig. 30. Agglomerate. Madoc village, Hastings coun.y.

The varieties of these rocks, here grouped together, although differing widely in origin, have not been separated on the geological map. Examples of the agglomerate and tuff are exposed two or three hundred yards northeast of the Catholic church. The autoclastic rock, or crush-breccia, may be seen at the edge of the creek southwest of the Catholic cemetery, while felsite intrusions, holding fragments of the country rock, occur a few hundred yards east of the Grand Trunk railway station, and just to the south of the hematite pit on lot 5, in the sixth concession of Madoc. The felsite dikes near the Grand Trunk tation contain fragments of crystalline limestone. The fragmental rocks exposed on the hill north of the town also contain many limestone fragments.

Outside of the places mentioned in the preceding paragraph, felsite occurs, as will be seen from the map, on lots 1, 4 and 5 in the sixth concession of Madoc, and on the north half of lot 13, concession fourteen, of Huntingdon.

(5) "*Conglomerate*" *and limestone*. The largest, and almost continuous, exposures of the rocks, included under this heading on the map, form a belt which extends, in a northeast direction, from lots 3 and 4 in the fourth concession of Madoc township through lots 4, 5 and 6 in the fifth into lot 6 in the sixth. The "conglomerate," as explained on a preceding page, is composed essentially of more or less rounded fragments of crystalline limestone, Fig. 28. Fragments of quartz, resembling that which is frequently found in veinlets or in irregular forms in Grenville limestone, are common. There are also fragments of a greenish material which may represent fractured dikes of the andesite, with which the "conglomerate" is in contact, or erosion products from this rock. As previously said, different opinions are held as to the relations of the andesite to the "conglomerate," Figs. 27, 32.

The chemical composition of two of the limestone fragments, or pebbles, in the "conglomerate" is giv n in the following table:—

CaO.	MgO.	Loss on ignition.	Insoluble.
22.18	15.22	35.24	23.10
29.76	20.27	45.02	2.80

The massive crystalline limestone in the vicinity of the "conglomerate" has the following composition, showing that the limestone, like the "conglomerate" fragments, contains considerable magnesia.

CaO.	MgO.	Loss on ignition.	Insoluble.
29.84	21.07	46.02	1.28
29.39	20.06	44.80	3.18

On the lots referred to, as shown by the map, and section A B, two beds of "conglomerate" are separated by a bed of slate, which has a thickness of about 65 feet. One of the beds of the "conglomerate" is in contact with andesite and the other is succeeded to the eastward by slate and the latter by magnesian limestone.

Near the northeastern corner of the town of Madoc, viz., on the north edge of lot 2 in the sixth concession of Madoc township and on the south part of lot 3 in the same concession, an interbanding of limestone "conglomerate" and slate, similar to that described in preceding paragraphs, is to be seen, Fig. 31.*

In a general way the longer belt of interbanded "conglomerate" and slate, extending from lot 3 in the fourth concession to lot 6 in the sixth, might appear to be the base of a sedimentary series forming one side of a syncline and the beds of similar rocks on lots 2 and 3 in the sixth concession part of the other side.

(4) *Slate*. Shown on the map are four main bands of slate interbedded with limestone "conglomerate." The largest occurs to the northwest of the town and runs through lots 3 and 4 in the fourth concession of Madoc township to lot 6 in the sixth

* The color on the map for the limestone "conglomerate" here is not correctly shown. It should have horizontal white lines through the blue, as on lots 4 and 5 in the fifth concession and adjacent lots.

Fig. 31. Bedding in pre-Cambrian sediments. 1 and 3 are slate, 2 and 4 limestone "conglomerate." Madoc, Hastings county.

Fig. 32. Contact between Madoc andesite and limestone "conglomerate." Lot 4, concession 5. Madoc township, Hastings county.

concession. The rock is a very fine-grained, drab-colored type that breaks with a marked slaty cleavage, so marked, indeed, that an outcrop was at one time worked as a slate quarry at the northwest corner of lot 5 in the sixth concession. It was found, however, that the cleavage was too coarse and irregular to render the slate of economic value. Under the microscope the fine-grained facies is seen to consist of sericite, biotite, quartz, calcite and iron oxides.

The slate on the north edge of lot 2 and on the south part of lot 3 in the sixth concession, interbedded with limestone "conglomerate," is shown in Fig. 31.

Three analyses were made of the slate, and the results are given in the following table:

	1	2	3
SiO_2	56.40	52.92	53.90
Al_2O_3	17.80	16.69	20.71
Fe_2O_3	7.52	9.75	8.31
FeO	1.53		
CaO	3.67	4.36	3.15
MgO	3.45	2.38	0.34
Na_2O	.75	0.80	0.76
K_2O	4.38	5.36	5.83
H_2O	4.42	7.32	6.88
CO_2	Trace		
Total	99.92	99.58	99.88

1. Old slate quarry, northwest corner, lot 5, in the sixth concession of Madoc.
2. North part of lot 2 in the sixth concession of Madoc, near boundary of lot.
3. North part of lot 2 in the sixth concession of Madoc, near boundary of lot.

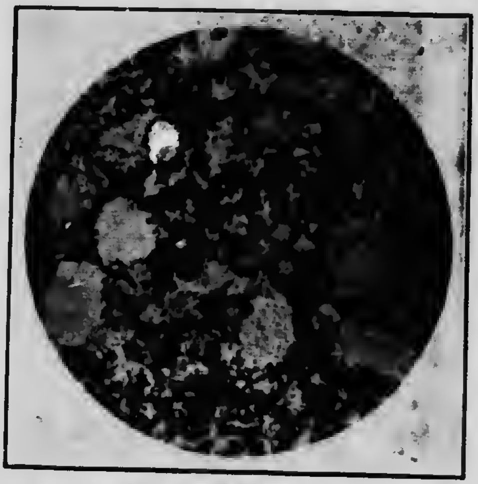


Fig. 33. Photomicrograph of greywacké of Grenville series, crossed nicols, Madoc.

(3) *Greywacké and quartzite.* These rocks, as will be seen from the map, are of common occurrence in this area. They are dark colored, generally fine-grained types which are for the most part schistose. The original sedimentary texture was found to be present at one point, namely, about 400 feet northwest of the talc mill, which is located opposite the Grand Trunk Railway station. The rock here is a medium-grained greywacké, Fig. 33, in which small fragments of quartz may be distinguished with the naked eye. Under the microscope the rock is seen to consist of quartz and feldspar fragments, set in a matrix, which consists of biotite, sericite, quartz, feldspar and calcite.

The quartzites are hard, dark, fine-grained rocks, in which the original sedimentary textures have been destroyed, and the dark color of which is due to the presence of secondary ferro-magnesian minerals. Quartzite, apparently conformable with blue, crystalline limestone, is exposed along the Hastings road, on the east part of lot 3 in the fifth concession of Madoc.

About the middle of lot 13 in the fourteenth concession of Huntingdon, the rocks of this group are impregnated with iron sulphides and resemble the "rusty schists" of the Grenville iron formation.

While the quartzite and greywacké outcrops have all been given one color on the map, it has not been definitely proved that all of these rocks in the area occupy the same stratigraphical position.

The following table gives the results of an analysis of the altered greywacké which occurs two or three hundred yards to the southwest of the Presbyterian church:

SiO_2	70.52
Al_2O_3	16.73
Fe_2O_3	.74
FeO	1.47
CaO	1.47
MgO	.05
Na_2O	.93
K_2O	4.27
H_2O	1.62
CO_2	1.90
	99.70

(2) *Moira Granite and Felsite.* A few small areas of the Moira granite and felsite are shown on the Madoc sheet. The rock, which is massive and usually free of gneissoid facies, has a pink color and varies from coarse to fine in grain; the finer-grained variety is commonly known as felsite. The rock is developed on the south and northeast parts of Moira lake, but occurs in greatest volume to the northwest of Madoc, where it is represented by a batholith, exposed in the Huckleberry hills beyond the confines of our map.*

On lots 12 and 13 in the fourth concession of Madoc township, the coarse-grained, fresh Moira granite appears to pass gradually into a fine-grained, volcanic facies of the Madoc andesite and rhyolite. Erosion has removed the fine-grained, surface-formed phase of the intrusive, exposing the deeper-seated, coarse-grained core.

The dikes of felsite, at times, contain numerous fragments of limestone, producing a rock of a striking and puzzling character, especially when the dikes are fractured and take on the appearance of a true sedimentary rock. Dikes with such inclusions occur a few hundred yards east of the Grand Trunk Railway station, and immediately south of the hematite pit on lot 5 in the sixth concession of Madoc township.

The relation of these intrusives to the mineral deposits of the area is referred to on a following page.

(1) *Basic Dikes.* These dikes occur at several places, including three points in the rock cuts of the abandoned Grand Trunk Railway, on lot 1 in the fifth and sixth concessions of Madoc. They are dark, generally fine-grained rocks often referred to as "trap." One of these basic dikes appears to intersect a felsite dike, indicating that the latter is older than the former. This occurrence is to be seen in the village of Madoc, on the north side of Livingstone avenue, on the west bank of Deer creek.

* *See* "Geological and Topographical Map of the Madoc and Marmora Mining District," by Eugene Coste and James White, Geol. Sur., Can., 1886.

Thickness and Structure of Sediments

The thickness and general structure of the "conglomerate," slate, limestone, quartzite and greywacké, that have been described in preceding paragraphs, will be seen from the cross-sections on the map. Along cross-section A B the sediments dip at an angle of about 37 degrees to the southeast. Beginning with the most western sediments on the cross-section, on lot 4 in the fifth concession, the thickness of the different rocks, to the point B on the Hastings road, is as shown in the following table. Judging from the dip, the group of sediments might form a conformable series, with the greywacké and quartzite as the uppermost member, but, as stated on preceding pages, the relationship of the sediments, one to another, has not been definitely determined.

	Thickness in feet.
1. Limestone "conglomerate," including a two-foot bed of brown impure quartzite a thin section of which consists dominantly of quartz grains and subordinately of calcite or dolomite. An analysis of a fresh sample of the quartzite showed it to contain 79.44 per cent. of silica, while an analysis of a sample, in which the carbonate seemed to be weathered out, showed 89.82 per cent. of silica	42
2. Fine-grained, grey slate	65
3. Limestone "conglomerate," similar to No. 1	80
4 Fine-grained, grey slate, similar to No. 2	435
5. Grey magnesian limestone	330
6. Blue limestone, low in magnesia, and containing many small beds, an inch or so in thickness, of hard cherty material	1,305
7. Dark, impure, fine-grained quartzite	300
Total thickness	2,557 feet

Another, but much smaller, section of the sediments is exposed a few hundred yards to the northeast of Madoc, on the north part of lot 2, in the sixth concession. Fig. 31 shows the appearance of four of the beds. The east part of section BC includes these beds, but does not show all of the details. From west to east the beds may be described as follows:

	Thickness in feet.
1. Fine-grained, grey slate	4+
2. Brownish grey limestone "conglomerate." The rock also contains fragments of quartz. The contact of the slate and limestone "conglomerate" is not sharp, part of the slate encroaching on the "conglomerate" in an irregular branching manner. A little slaty matter is found in the matrix of the "conglomerate"............	6
3. Fine-grained, grey slate, similar to bed No. 1. It includes a bed of limestone about two inches thick. The "conglomerate" of bed No. 2 thins out in a distance of 35 feet to the north, and gives place to the slate beds Nos. 1 and 3, which then join each other..	3
4. Limestone "conglomerate," similar to bed No. 2. The last mentioned bed is succeeded to the eastward by slate	22

The chemical composition of limestone fragments from beds Nos. 2 and 4 is shown in the following table:

No.	CaO	MgO	Fe_2O_3+ Al_2O_3	Loss on ignition.	Insoluble.
1.	30.03	19.57	1.28	44.32	4.32
2.	30.25	20.18	1.16	45.36	2.58
3.	42.18	1.38	1.39	34.89	19.84
4.	52.58	1.00	1.24	41.96	2.92

5. Soft, calcareous, grey slate, including a thin bed of crystalline limestone	5
6. Grey quartzite, becoming conglomeratic, owing to the presence of small pebbles of granular quartz	1½
7. Grey slate, similar to beds 1 and 3. It includes several calcareous beds one inch thick	250
8. Hard, dark-colored, fine-grained quartzite or greywacké	75+
	366½+

Fig. 34. International Geological Congress party near Bishop Corners, Anglesea township, Addington county August, 1913.

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BUREAU

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OF

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TOWNSHIP OF MADO

ONT

To accompany Part II, Vol. 21,

Hon. W. H. Hearst, *Minister of Lands, Forests and*

SCALE: $\frac{1}{15,840}$

Metres 500 0

E. H. HARCOURT CO LTD LITHO TORONTO

SECTION AB

SCALE: { Horizontal: 1320' Feet = 1 Inch. Vertical: 400' Feet = 1 Inch.

ONTARIO
DEPARTMENT OF LANDS FORESTS & MINES

BUREAU OF MINES

MAP

OF THE

D'S CORNERS AREA

MADOC, HASTINGS COUNTY
ONTARIO

t II, Vol. 21, Report of Bureau of Mines, 1912.

, Forests and Mines. Willet G. Miller, *Provincial Geologist*

$\frac{1}{15,840}$ or $\frac{1}{4}$ Mile = 1 Inch.

1 Mile

1 Kilometre

LEGEND

PALEOZOIC

Ordovician

Black River limestone and basal conglomerate.

UNCONFORMITY

PRE-CAMBRIAN

Hastings

Conglomerate and quartzite.

UNCONFORMITY

Grenville

Blue and white non-magnesian crystalline limestone, including also subordinate areas of magnesian limestone.

Brown and grey crystalline limestone, magnesian. A few bands of rusty schist are included.

NOTE: The Pre-Cambrian rocks are cut by felsite and basic dikes.

SIGNS

House

Swamp

Hill

Road

Strike and Dip

SOURCES OF INFORMATION

Map of the "Madoc and Marmora Mining District" by E. Coste and J. White, 1886; with topographic additions by W. R. Rogers, 1912.

Geologically re-surveyed by Willet G. Miller *and* Cyril W. Knight, *1912.*

5.

6.

7.

8.

Fig. 34

THE HAZZARD'S CORNERS AREA

The Hazzard's Corners area lies four miles northeast of Madoc village, in the township of Madoc, Hastings County. The area mapped is small, comprising less than four square miles.* But it includes important beds of conglomerate and other rocks of the Hastings series, which are, perhaps, as little disturbed as are any of the rocks of this series described in this report. They rest with striking unconformity on crystalline limestone of the Grenville series, Figs. 35, 36.

The rocks of the area have been classified as follows:

Pleistocene

GLACIAL AND RECENT — Boulder clay, sand and gravel.

Paleozoic

ORDOVICIAN — Black River limestone and basal conglomerate.

(Great unconformity)

Pre-Cambrian

HASTINGS SERIES — Conglomerate, greywacké and quartzite.

(Unconformity)

GRENVILLE SERIES — (1) Blue and white non-magnesian, crystalline limestone.

(2) Brown and grey magnesian, crystalline limestone. A few beds of rusty schist are interbedded with this limestone.

Grenville series.—Crystalline limestones, magnesian and essentially non-magnesian, largely compose the Grenville series at Hazzard's Corners. The magnesian variety is fine-to-medium in grain and weathers to a light grey or brown color; at times the rock has a bluish color on fresh fractures. It contains, as usual, varying amounts of quartz and other impurities. The chemical composition is shown in the following table:

	CaO	MgO	CO_2	Fe_2O_3 Al_2O_3	Insoluble.	Total.
1.	30.36	20.20	44.34	3.70	1.00	99.60
2.	31.12	20.11	45.79	1.60	1.13	99.75
3.	30.42	20.25	44.62	1.70	2.60	99.59
4.	26.30	18.40	.....	1.28	13.30	

1. Fresh fractures have blue color; rock weathers to grey color. Northwest corner, lot 11, concession VIII, Madoc township.

2. Fresh fractures have blue color; rock weathers greyish brown. Northwest corner, lot 11, concession VIII, Madoc township.

3. Northwest corner, lot 11, concession VIII, Madoc township.

4. Southwest corner, lot 12, concession VIII, Madoc township.

* Map No. 22c.

The crystalline limestone which contains low amounts of magnesia weathers to a blue or drab color. The following table shows the chemical composition of the rock.

	CaO	MgO	CO_2	Fe_2O_3 Al_2O_3	Insoluble.	Total.
1.	45.61	3.40	39.36	1.44	9.70	99.52
2.	50.40	.01	42.20	....	3.20	

1. Blue limestone, south part lot 12, concession VIII, Madoc township.
2. Blue limestone, south part lot 12, concession VIII, Madoc township.

Fig. 35. Crystalline limestone of Grenville series in foreground, Hastings conglomerate and quartzite in background. Hazzard's Corners, Madoc township, Hastings county.

Hastings series.—The rocks comprising the Hastings series consist of conglomerate, greywacké and quartzite. They may be best seen on the south face of the prominent hill on lot 12, concession VIII, in Madoc township, where the beds, resting in highly inclined position, are well exposed. The pebbles have not been elongated by pressure, and the rocks are thus less metamorphosed than similar rocks in most parts of southeastern Ontario. The conglomerate contains pebbles of felsite, medium-grained granite (rare), quartz, dark ferruginous chert, and crystalline limestone. The quartzite has a peculiar brownish-grey color; under the microscope it is seen to be made up of grains of quartz and feldspar irregular in outline, together with some calcite or dolomite. The composition of one sample was found to be: CaO, 3.56; MgO, 1.91; CO_2, 3.93; insoluble, 84.61. Part of the dense, fine-grained brown rock, mapped as quartzite, may be silicified crystalline limestone.

The conglomerate of the area has a somewhat peculiar appearance, due apparently to incomplete sorting.

Ordovician.—Horizontal beds of Black River limestone occupy the eastern and western portions of the area.

Unconformity between Hastings conglomerate and crystalline limestone.—The conglomerate, as shown in the cross-section at the bottom of the map, is closely infolded with the crystalline limestone, so that a discordance in dip between the two series is not noticeable. But the unconformity is clearly shown by the presence of pebbles and boulders of limestone in the conglomerate, Fig. 36. These may be seen on lots 14 and 15 in the seventh concession of Madoc, along the west side of the road south of the cheese factory.

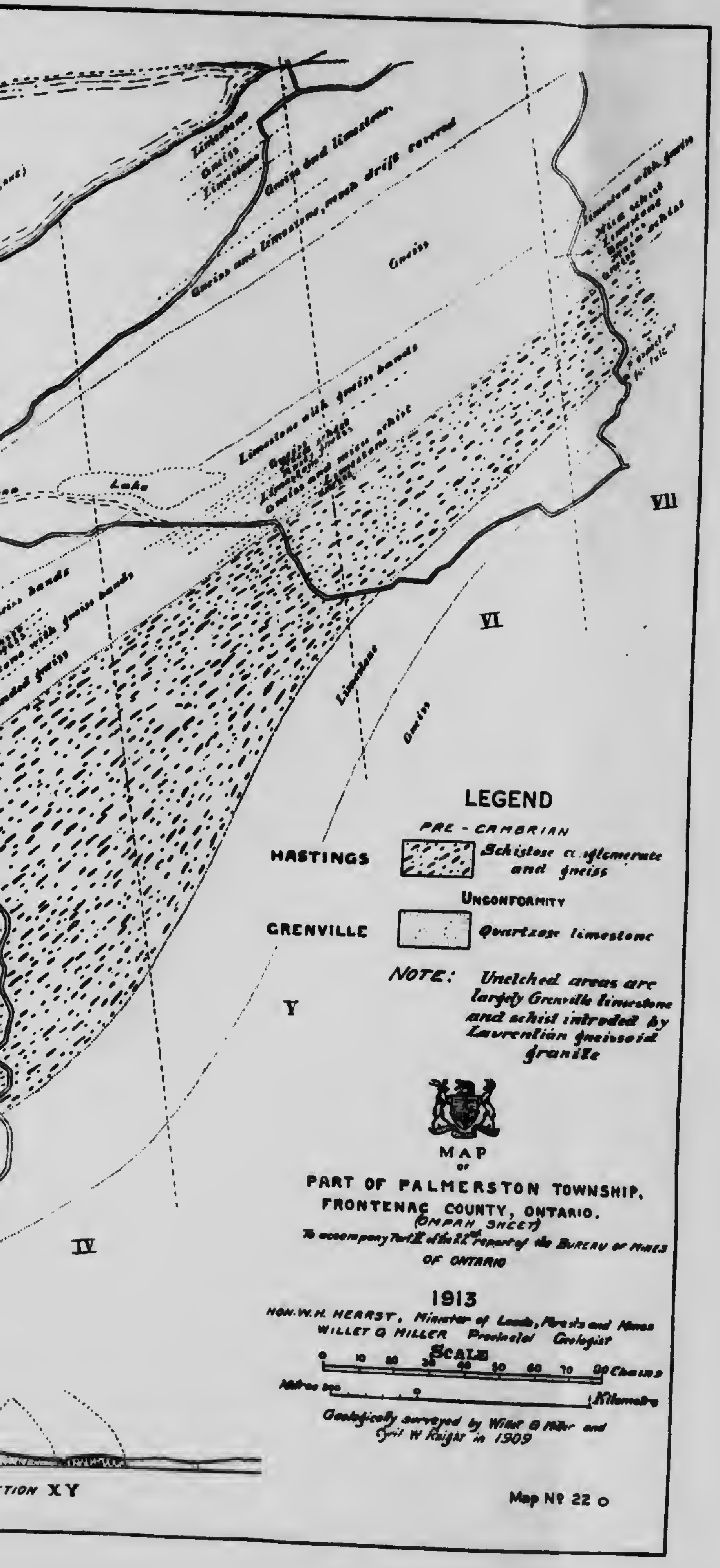
Dikes.—Both the Grenville and Hastings are intruded by felsite and basic dikes.

Fig. 36. Hastings conglomerate, holding boulder of crystalline limestone of Grenville series. Hazzard's Corners.

Fig. 37. Hastings conglomerate, showing bedding planes. Hazzard's Corners, Madoc township, Hastings county.

Fig. 37. Hastings conglomerate, showing bedding planes. Hazzard's Corners, Madoc township, Hastings county.

Madawaska Lake
Limestone with gneiss bands
Gneiss
Limestone with gneiss bands
Gneiss with limestone bands
Banded gneiss
Limestone
Gneiss
28
27
26
25
24
23
22
21
20
I
II
III
X
Y
R
SECTION XY


Limestone
Gneiss
Limestone
Gneiss and limestone
Gneiss and limestone, much drift covered
Gneiss
Limestone with gneiss
Mica schist
Limestone
Lake
Limestone with gneiss bands
Limestone
Gneiss
VII
VI
V
IV
LEGEND
PRE-CAMBRIAN
HASTINGS
Schistose conglomerate and gneiss
UNCONFORMITY
GRENVILLE
Quartzose limestone
NOTE: Unetched areas are largely Grenville limestone and schist intruded by Laurentian gneissoid granite
MAP
OF
PART OF PALMERSTON TOWNSHIP,
FRONTENAC COUNTY, ONTARIO.
(OMPAH SHEET)
To accompany Part II of the 22nd report of the BUREAU OF MINES
OF ONTARIO
1913
HON. W. H. HEARST, Minister of Lands, Forests and Mines
WILLET G. MILLER Provincial Geologist
SCALE
0 10 20 30 40 50 60 70 80 Chains
Kilometre
Geologically surveyed by Willet G. Miller and Cyril W. Knight in 1909
SECTION XY
Map No 22 c

THE PALMERSTON OR OMPAH AREA

The Palmerston area, in the township of the same name, Frontenac county, lies about nine miles west of Lavant station on the Kingston and Pembroke branch of the Canadian Pacific railway. The area is sixty-five miles northeast of Belmont lake. Its relation to the other areas, described in this report, will be seen from the index map, Fig. 1. The accompanying sketch map, No. 22o, covers about twenty square miles and is traversed by four wagon roads, which cut more or less diagonally across the strike of the rocks, affording sections for study.

The rocks are probably more metamorphosed than are those of the other areas described in this report, and are now gneissoid or schistose in texture; the limestones are whiter in color and coarser in grain. The gneisses, schists and limestones occur interbanded with one another in long, narrow lenses. The general strike of the lenses, which may be from a few inches to a mile in width, is N. 50° E. The limestone lens immediately south of Ompah post office is about eight hundred feet wide, and contains some fifteen bands of gneiss, while in other cases the gneissic belts may contain several limestone lenses. Because of this complexity it was found possible to differentiate only two groups: (1) a schistose conglomerate, and (2) a quartzose, magnesian limestone. The latter is placed in the Grenville series, the former in the Hastings.

It is probable that the remaining rocks, not included in the above two subdivisions, are largely Grenville and Laurentian in age.

THE GRENVILLE SERIES

The limestone classed with the Grenville series is shown at the southwest corner of the map. It is a medium-to-coarse-grained, brownish-weathering marble, which in parts is very impure and carries about fifty per cent. of granular quartz or quartzite with smaller quantities of light-colored amphibole. The quartz occurs in irregular bands and has a white to light pinkish-grey color. A few grey to dark-colored bands of gneiss are found running parallel with the general strike of the limestone. They vary in width from a few inches to about a dozen feet. For the most part the limestone is massive, but parts of it have a banded structure due to the segregation of silicates in lines, or to alternate bands of limestone having a slightly different color.

The table given below shows the average composition of this limestone lens. The specimens were taken from various points.

No.	CaO	MgO	$Al_2O_3 + Fe_2O_3$	Insoluble	Loss on Ignition	Total
1	30.45	16.27	......	3.06	44.54	94.32
2	28.24	14.74	......	6.70	42.92	92.60
3	45.65	1.13	2.42	13.44	37.48	100.12
4	31.43	18.85	1.70	2.60	45.33	99.91
5	46.00	1.83	3.18	10.08	38.84	99.93
6	31.44	16.20	3.50	4.70	44.32	100.16
7	29.89	16.60	1.60	10.30	41.50	99.89
8	31.43	2.05	4.60	35.00	27.21	100.29
9	49.48	1.30	1.40	6.70	40.83	99.71
10	30.42	2.08	2.80	39.90	24.98	100.18
11	44.10	4.00	1.66	12.10	38.40	100.26

THE HASTINO SERIES

The rocks classed with the Hastings series are shown on the map to occur in a lenticular belt running northeasterly across it. They consist of schistose or gneissic conglomerate which passes into gneiss and schist.* The pebbles are made up dominantly of medium-grained, granular quartz, or quartzite, of a pinkish-grey color; others are pure white, coarser in grain, and resemble vein quartz. In parts of the belt these quartzite pebbles make up almost the whole conglomerate, the matrix being sandy, micaceous or calcareous; but most of the belt consists essentially of a grey to dark-colored gneiss with mica and hornblende and at times garnet. In this gneiss it is difficult to recognize with certainty any pebbles except quartz. Although the quartzite and granular quartz pebbles make up most of the conglomerate, a few granite, limestone, and dark-colored gneiss pebbles have been found.

In all cases the pebbles have been flattened so that their longer diameters are generally several times their shorter ones, Fig. 38.

Regarding the thickness of the conglomerate it can merely be said that the hills composing this rock rise to a height of about one hundred feet. This has not much significance because little evidence of original bedding remains.

Fig. 38. Pebble elongated by pressure, Hastings conglomerate, Palmerston township, Frontenac county.

A thin section of the gneissic or schistose matrix of the conglomerate shows it to be made up of green hornblende, quartz, biotite and a little plagioclase feldspar, all of the constituents being fresh. Much of what has been classed with the conglomerate consists of similar gneissic material containing few recognizable pebbles.

Under the microscope, a pebble of granular quartz, or quartzite, similar material to that which makes up most of the conglomerate, is seen to consist of interlocking grains of quartz together with a little sericite and iron ores.

A thin section of a medium-grained, pink granite pebble shows it to be made up of twinned and untwinned feldspar, and quartz. The feldspar is partly altered to sericite and calcite. The occurrence of granite pebbles in the conglomerate is rare.

Relation of Hastings conglomerate to Grenville limestone and Laurentian.—The evidence for believing that an unconformity occurs between the conglomerate and limestone is found on the southwest part of the area near the Mississippi river, at the point marked "R" on the map. Here a cliff about 35 feet high cuts across the strike of the rocks so that the contact of the conglomerate and the Grenville limestone is well exposed. The latter contains at this point about fifty per cent. of a medium-grained, granular quartz or quartzite. The pebbles in the conglomerate are similar to this quartzose facies, and it is, therefore, believed that they have resulted from its disintegration. The

* This conglomerate was briefly described by Dr. R. W. Ells, Report Geol. Sur., Canada. Vol. XIV, 1901, p. 47 J.

presence of a few limestone pebbles in the conglomerate is additional evidence of an unconformity between the two series.

If the conglomerate be followed from this point to the southwest for about half a mile, the pebbles will be found to gradually decrease in number until the rock becomes a mica-schist. Similarly, at the northeast end of the belt, the conglomerate facies passes into various schistose and gneissoid rocks.

Fig. 39. Hastings conglomerate, Palmerston township, near the village of Ompah, Frontenac county. The part of the cliff shown in the photograph is about 15 feet high.

In some places a mica-schist or gneiss occurs at the contact of the Grenville limestone and the conglomerate. Here the structure has the appearance of a conformable relationship, if the unconformity above described were not taken into consideration.

The conglomerate contains pebbles of dark-colored gneiss, and, more rarely, of granite. The presence of these pebbles is evidence of an unconformity between the conglomerate, on the one hand, and granite and dark-colored gneiss on the other.

THE LAURENTIAN AND GRENVILLE SERIES

Much of the area shown on the accompanying sketch map is unetched, indicating that the rocks have not been subdivided, but, as already pointed out, it is believed that they are largely of Laurentian and Grenville age, since pebbles of granite, limestone and dark-colored gneiss occur in the Hastings conglomerate. This part of the map is somewhat complex, consisting, as it does, of hundreds of limestone and gneiss lenses, resting in more or less vertical attitude, and interbanded with one another.

The problem of the quartz-feldspar gneisses associated with the limestones is not a simple one. For example, the road for about a quarter of a mile north and south of the village of Ompah passes over some twenty parallel bands of gneiss, which vary from a few feet to 800 feet in width, and average about 30 feet. The gneisses are interbanded with crystalline limestone, and the question arises: Does this alternation of gneiss and limestone represent a sedimentary succession?

In order to determine its origin, whether igneous or sedimentary, one of the typical gneissoid lenses, several feet wide, north of the hotel was sampled. The rock has a grey color, is of medium grain, and is made up of an acid plagioclase, microcline and quartz, together with biotite, muscovite and a few grains of calcite. An analysis gave the following results:

Typical grey gneiss, northeast of hotel at Ompah, Palmerston township, Frontenac county.

	Per cent.
SiO_2	67.42
Al_2O_3	15.74
Fe_2O_3	.35
FeO	3.46
MgO	1.86
CaO	3.36
Na_2O	2.94
K_2O	1.73
H_2O	3.55
CO_2	.31
Total	100.72

The analysis shows that the gneiss is of igneous origin. It would seem probable, therefore, that many of these gneissoid bands are parallel dikes or sheets which have been intruded between the schistose or bedding planes of the Grenville limestone in much the same manner that the Laurentian has invaded the Grenville sediments at Mazinaw lake or at Harlowe. The two latter places are described in connection with the Actinolite-Cloyne area.

Another analysis was made of a band of gneiss, 6 inches wide, which occurs in the limestone near the north end of the bridge over the Mississippi river. The gneiss has a pinkish grey color, and consists essentially of twinned and untwinned feldspar, together with subordinate amounts of biotite. The analysis of the rock gave the following results:

	Per cent.
SiO_2	47.56
Al_2O_3	24.65
Fe_2O_3	.36
FeO	4.54
MgO	5.15
CaO	6.58
Na_2O	1.00
K_2O	5.62
H_2O	4.32
CO_2	Trace.

The analysis shows that this six-inch band of gneiss has the composition of an igneous rock, and was probably a dike which intruded the crystalline limestone.

The composition of many of the crystalline limestone bands, associated with the gneisses, is shown in the following table:—

No.	CaO	MgO	Al_2O_3 + Fe_2O_3	Insoluble	Loss on Ignition	Total
1	43.30	6.94	3.34	13.30	32.61	99.59
2	32.43	18.86	1.34	2.70	44.40	99.73
3	49.80	1.36	0.90	6.48	41.12	99.66
4	52.52	0.58	0.60	4.44	41.60	99.74
5	40.79	3.92	......	4.55	42.60	......
6	27.20	15.72	......	3.78	44.05	......

1. Thirty chains southeast of bridge over Mississippi river at edge of small pond.
2. Lot 24, concession II, Palmerston township, on old road.
3. East part lot 25, concession II, Palmerston township, at road side.
4. Lot 23, concession II, Palmerston township, north part of lot on old road.
5. Twenty chains east of Ompah post office at road side.
6. Two and a half miles east of Ompah, near talc prospect.

GRANITE AND PEGMATITE INTRUSIVES

These acid intrusives are the youngest rocks in the area, and have been found at several places, including the following: (1) At the northeast end of Madawaska (Upper Trout) lake a coarse-grained, massive granite, showing at times a well-developed graphic texture, cuts the crystalline limestone, (2) A few hundred yards northeast of Ompah post office a coarse-grained, granite-pegmatite cuts diagonally across the strike of the gneiss and limestone. These granites and pegmatites may be of the same age as the Moira granite at Madoc.

Fig. 40. Hastings conglomerate, showing squeezed pebbles Palmerston township, Frontenac county.

Fig. 41. Crystalline limestone containing beds of quartzite or chert. Palmerston township, Frontenac county.

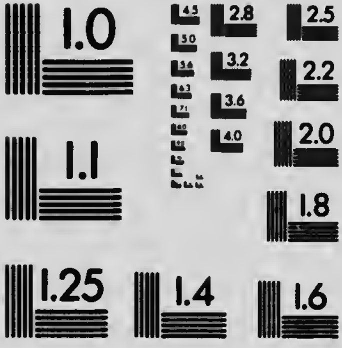
Fig. 42. Specimens of staurolite from lot 26, concession 10, Clarendon township, Frontenac county.

Limestone occurs to the south of the staurolite schist, quartz-feldspar gneiss to the north. The series of altered, pre-Cambrian sediments strikes E. 10° N. and dips about 60 degrees to the north. The staurolites, which are sometimes as long as three inches, are embedded in a groundmass of white and green mica. Garnets are commonly found in the schist, and also a light grey mineral with good prismatic cleavage which is probably cyanite, but is not definitely determined.

§ See map No. 22 f.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



ONTARIO
DEPARTMENT OF LANDS FORE
BUREAU OF MIN

MAP
OF THE
GILMOUR

TOWNSHIPS of LIMERICK and TU
PROVINCE OF ON

To accompany Part II, Volume 22, Report

Hon. W. H. Hearst *Minister*

Scale : 1/15840 or ¼

BUREAU OF MINES

MAP
OF THE
…UR AREA

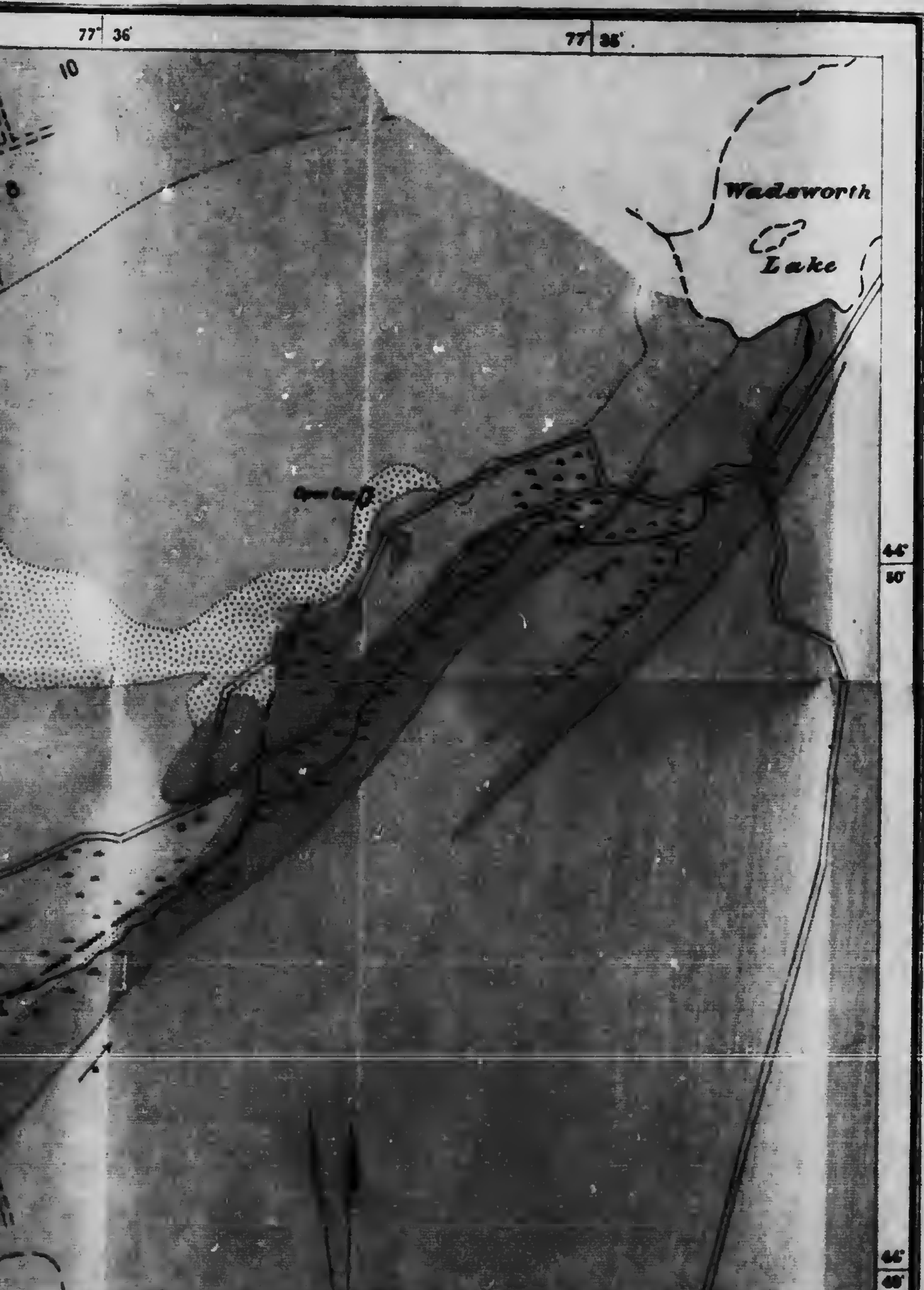
… and TUDOR, HASTINGS COUNTY

…E OF ONTARIO

…22, *Report of Bureau of Mines, 1913.*

Willet G. Miller, *Provincial Geologist.*

… or ¼ Mile = 1 Inch



LEGEND

PRE-CAMBRIAN

Post-Hastings intrusives

Granite

Gabbro

INTRUSIVE CONTACT

Hastings

Conglomerate and gneiss, the former in part auto-clastic.

UNCONFORMITY

Grenville

Blue and white crystalline limestone, essentially non-magnesian, and subordinate areas of magnesian limestone.

Magnesian limestone.

Garnet-epidote rock (altered limestone?)

Rusty schist.

Grey gneiss.

Keewatin.

Greenstone schists.

SIGNS

House.

Hill.

Road.

Swamp.

Strike and dip.

Rapids
Con.
77° 38'
77° 37'

MAP Nº 22 f.

Grey gneiss.

Keewatin.

Greenstone schists.

SIGNS

- House.
- Hill.
- Road.
- Swamp.
- Strike and dip.
- 1018' Elevation in feet above sea level.

SOURCES OF INFORMATION

TOPOGRAPHY

Central Ontario Railway plan.

Township plans; Department of Lands, Forests and Mines.

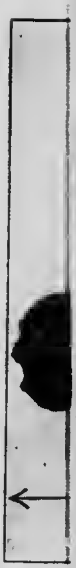
Pacing and compass survey by C. W. Knight.

Bancroft map by Drs. Adams *and* Barlow.

Compilation by W. R. Rogers.

GEOLOGY

Geologically surveyed by Willet G. Miller *and* Cyril W. Knight.



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THE GILMOUR AREA

INTRODUCTION

The Gilmour area, which covers about ten square miles, is included in the Bancroft map* of Adams and Barlow, and occupies a small portion of the township of Tudor, Hastings county. We have mapped the rocks in somewhat greater detail than that shown on the Bancroft sheet, in an endeavor to throw further light on a peculiar conglomerate which was discovered by Dr. Barlow several years ago.† The nature of some of this conglomerate is still uncertain. The members of the International Committee, who examined the occurrence in 1906, were not agreed as to its origin.‡ Barlow considered it to be autoclastic in origin, and believed that the rock has been produced by crushing and brecciation. Other members of the committee regarded the conglomerate "to be in part of autoclastic origin, and, in all probability, in part of volcanic origin, representing tufaceous material derived from volcanic centres now represented by the masses of granite associated with it." Messrs. Cushing and Adams, members of the committee, found that the conglomerate was interstratified with limestone, and consequently of the same age as these rocks. The committee concluded that the conglomerate is of interformational origin, and has no special structural significance.

In this report we have classified certain rocks as of Keewatin age, believing them to have been originally basic lavas, and have separated them from the Grenville sediments. The supposed thickness of these sediments is thus reduced.

The area is not an ideal one in which to work out the age relations of the sediments, because the latter have been intruded by masses of gabbro and granite which have helped to metamorphose them and render their relationships obscure. It is considered, however, reasonably certain by the senior author of this report that the conglomerate is largely a true water-worn sediment, and that it rests unconformably on the Keewatin greenstones and the Grenville sediments.

ROCKS OF THE AREA§

We classify the pre-Cambrian rocks of the Gilmour area as follows:—

Pre-Cambrian

POST-HASTINGS INTRUSIVES	Granite, acid dikes, gabbro.
(Intrusive contact)	
HASTINGS SERIES	Conglomerate and gneiss, the former in part autoclastic.
(Unconformity)	
GRENVILLE SERIES	(1) Blue and white crystalline limestone, essentially non-magnesian, and subordinate areas of magnesian limestone. (2) Magnesian limestone. (3) Garnet-epidote rock (altered limestone). (4) Rusty schist. (5) Grey gneiss.
KEEWATIN	Greenstone schist.

The rocks, beginning with the oldest series, are described in following paragraphs.

* Geological map of portions of Hastings, Haliburton, and Peterborough counties, Province of Ontario, by Frank D. Adams and Alfred E. Barlow. The map, No. 770, accompanies Memoir No. 6 of the reports of the Canadian Geological Survey. While the map shows in detail lithological distinctions, age relations of the rocks are not indicated.

† On the Origin of some Archean Conglomerates.—The Ottawa Naturalist, Feb., 1899, Vol. XII, pp. 205-217.

‡ Special Committee on the Correlation of the pre-Cambrian Rocks of the Adirondack Mountains, the "original Laurentian area" of Canada, and Eastern Ontario.—Journal of Geology, Vol. XV, pp. 191-217.

§ *See* map No. 22 f.

THE KEEWATIN

The Keewatin series consists of fine or medium grained green schists, resting in almost vertical position, and composed largely of hornblende and chlorite, together with occasional remnants of plagioclase phenocrysts. The general name amphibolite has been applied to these green schists and many other dark-colored rocks, and they have been considered by Adams and Barlow to be mostly altered sediments.* In the Gilmour area, however, the chemical composition of the green schists, and the presence of amygdules and volcanic fragmental material, show that the rocks were originally basalts, and therefore of igneous origin. The fragmental facies may be seen about half a mile south of the railway station at Gilmour, on the west side of the track, and also on the east side of what is locally known as the "Snow" road, one mile south of Macdonald's siding. The two analyses given below show that these green schists have the composition of basalts, and should not be grouped with the Grenville sediments.

	1.	2.
SiO_2	48.10	46.34
Al_2O_3	17.14	19.31
Fe_2O_3	6.69	5.80
FeO	11.83	10.14
MgO	4.33	1.13
CaO	7.09	10.22
Na_2O	2.68	2.07
K_2O	0.48	1.00
H_2O	2.00	2.08

Nos. 1 and 2, green schists south of Gilmour station, Tudor township, Hastings county.

An analysis was also made of some of the volcanic material associated with the schists. The fragments which are basic and schistose are not more than a few inches in diameter and have been flattened out parallel to the prevailing schistosity of the rocks. The outcrop is several feet in diameter and cannot be separated from the green schists with which it is in contact.

Volcanic fragmental material, associated with the greenstone schists, one mile south of Gilmour, on the west side of the railway track.

	Per cent.
SiO_2	49.14
Al_2O_3	20.47
Fe_2O_3	2.09
FeO	9.56
MgO	3.34
CaO	4.74
Na_2O	1.94
K_2O	0.39
H_2O	5.80
Co_2	2.95
	100.42

It may be noted that the greenstone schists which are here classed as Keewatin have a strong resemblance to rocks of similar age in other parts of Ontario. Moreover, we have found a few narrow bands, several inches wide, of jaspylite, resting in these schists, and it is considered that the presence of this characteristic iron-formation further strengthens the reason for classing the rocks with the Keewatin.

* Geology of the Haliburton and Bancroft areas, by F. D. Adams and A. E. Barlow. Memoir No. 6. Department of Mines, Geol. Survey Branch.

THE GRENVILLE SERIES

The Grenville series consists of sediments which include limestone, rusty schists and grey gneiss, the latter probably being an altered greywacké or closely allied rock. These sediments, which are all schistose, lie in more or less vertical position closely infolded not only with the Keewatin greenstone schist, but also with the younger Hastings conglomerate, later to be described. They are considered to constitute a conformable series which was deposited on the surface of the submarine Keewatin lavas.

Grey gneiss.—The grey gneiss was probably originally greywacké or other sedimentary material, but it is now altered to a gneissic or schistose rock consisting of quartz, feldspar, mica and other minerals which do not show the original fragmentary texture.

Rusty schist.—Rusty schists are well exposed south of Gilmour station and elsewhere in the area. They are fine-grained rocks, the rusty color of which is due to the decomposition of pyrite or pyrrhotite. Similar rocks have been described by Adams and Barlow, and are believed by them to be of sedimentary origin; one of these areas occurs about six or seven miles north of Gilmour, between Ormsby Junction and Ormsby, which is said by the last-mentioned writers to be the thickest body of typical rusty weathering schist in the Bancroft area, it having a thickness of a mile. Thin sections of the rusty schist at Gilmour examined under the microscope show the rock to consist essentially of biotite, quartz, feldspar, calcite, pyrite and limonite. In certain other parts of southeastern Ontario these schists contain graphite, as at the Canadian Sulphur Ore Company's mine, southwest of Queensboro. Two analyses of samples from the rusty schist at Gilmour were made. They indicate a sedimentary origin.

	1.	2.
SiO_2	63.12	73.78
Al_2O_3	3.94	9.44
FeO	4.04	4.93
Fe_2O_3	....	1.03
MgO	2.65	2.37
CaO	4.99	1.09
Na_2O	.73	2.72
K_2O	1.30	1.51
H_2O	1.33	2.57
CO_2	4.67	.63
FeS_2	13.32	...
	100.09	100.07

No. 1. Rusty schist, one mile east of Gilmour, Tudor township, Hastings county.
No. 2. Rusty schist, second railway cut, south of Gilmour station, Hastings county.

Garnet-epidote rock (altered limestone?).—The map shows on the southern edge of the granite, to the east of Gilmour, a rock which is made up largely of the minerals garnet, epidote and hornblende. This garnet-epidote rock appears to have been originally a limestone which has been altered by the intrusion of granite. There is generally a contact zone of only a few inches between the unaltered limestone and the garnet-epidote rock. It may also be noted that the granite sometimes comes in contact with the blue limestone, producing little or no alteration. The contact action of the granite on the limestone is described by Messrs. Cushing and Adams in the following words: " . . . . . at the granite mass immediately about its contact with these rocks, exerted a very pronounced exomorphic contact action, changing the limestones for a distance of at least 100 yards into a mass of reddish-green rock, consisting of an admixture of epidote, garnet, pyroxene and other minerals."*

* Journal of Geology, Vol. 15, pp. 202-203.

Magnesian crystalline limestone.—The crystalline limestone at Gilmour is largely the blue, essentially non-magnesian variety, but our map of the Gilmour area shows a very small exposure of magnesian limestone about a quarter of a mile southwest of the railway station. It is less than 100 feet long and occurs at the edge of a swamp in contact with the Hastings conglomerate. This dolomitic limestone weathers to a yellowish-brown color, is fine-grained and resembles he magnesian limestones already described in other parts of this report, especially at Belmont lake. An analysis of the rock showed it to have the following percentage composition:

CaO	29.13
MgO	18.70
CO_2	43.90

Blue and white crystalline limestones, essentially non-magnesian.—These limestones, which are fine-to-medium in grain, predominate in Gilmour. Their composition is shown in the following table:

	1.	2.	3.	4.	5.	6.
CaO	51.84	40.00	48.26	51.42	52.71	52.08
MgO	1.07	.03	.74	.89	.01	.03
CO_2	42.76	31.56	39.86	40.65	42.30	40.46
Insoluble	2.91	26.06	8.84	5.02	1.34	2.25

Specimens Nos. 1, 2 and 3 were taken a few hundred feet north of Gilmour post office, at distances of 10, 15 and 100 feet respectively, south of the contact of the limestone and conglomerate. No 4 is from the first railway cut south of the station. No. 5 is a blue limestone about one and a half miles northwest of Gilmour; it has been partly brecciated into fragments, Fig. 43, from a few inches to four feet long, and these have been cemented together by a brown calcite, the analysis of which is given under No. 6. Analyses Nos. 5 and 6 tend to show that the chemical composition of the crystalline limestones of the region, viz., whether they contain high or low percentages of magnesia, does not depend on the degree of dynamic metamorphism to which they have been subjected.

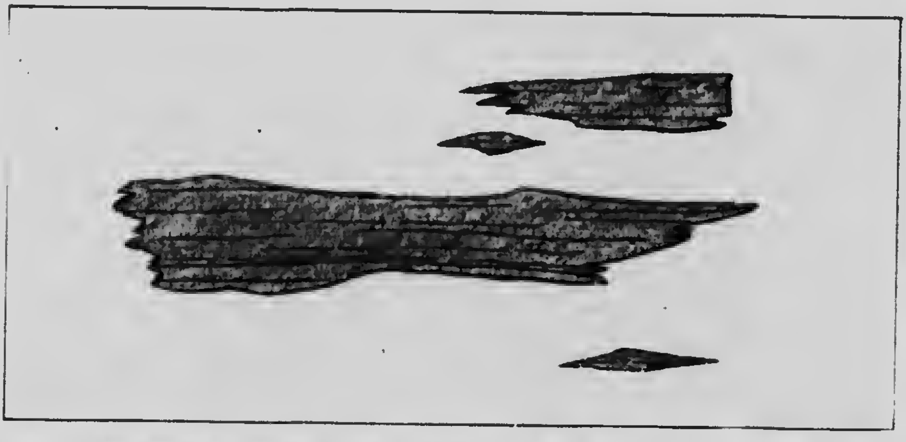


Fig. 43. Brecciated "blue" limestone. The fragments are set in a matrix of brown limestone which has a similar chemical composition to the fragments. Township of Tudor, near Gilmour.

THE HASTINGS SERIES

The Hastings series at Gilmour consists of conglomerate, much of which is, however, a fine-to-medium-grained, grey, calcareous and micaceous gneiss, in which it is difficult to distinguish the fragments from the matrix. This is especially true on fresh-fractured surfaces. The best places to observe the fragments of the conglomerate are on weathered joint planes which lie at right angles to the strike of the rocks. The fragments, which are in form angular or round, consist of feldspar-porphyry, quartz-porphyry, felsite, grey schist, and crystalline limestone. Thin sections of the fine-grained matrix of the conglomerate show it to consist of quartz, feldspar, biotite, calcite and other minerals, this facies having the appearance of a greywacké. Bedding planes have not been recognized.

It is certain that some of the "conglomerate" is not a true water-worn sediment. For example, immediately west of the railway track, at mile post 92, there are granite dikes in the crystalline limestone; both rocks have become crushed and brecciated, the harder granite being squeezed into, and thus intermixed with, the softer limestone. This process has produced a rock which resembles a conglomerate, and which has had various names applied to it, e.g., autoclastic conglomerate, pseudo-conglomerate, and crush-breccia.

The analysis given below shows the composition of the schistose matrix of the conglomerate, the sample being composed of fifteen chips from various parts of the rock in order to obtain an average example:—

SiO_2	
Al_2O_3	61.59
Fe_2O_3	19.47
FeO	1.96
MgO	3.07
CaO	1.09
Na_2O	2.60
K_2O	3.32
H_2O	2.58
CO_2	1.48
	.06

POST-HASTINGS INTRUSIVES

The igneous rocks included under this head are gabbro, granite and acid dikes.

The gabbro occurs in dikes and in irregular masses, some of which are shown on the map.

Medium-grained granite occurs in several places, and it is probably the youngest rock in the area.

A few hundred yards northeast of the railway station there are present peculiar acid dikes, having a light grey or cream-like color. They are fine in grain, and under the microscope consist largely of muscovite, together with feldspar and quartz. The quartz, which has a clear, purple color, is not common, and occurs in the form of round phenocrysts. The following is an analysis of one of these peculiar-looking dikes:—

SiO_2	
Al_2O_3	60.18
Fe_2O_3	27.29
FeO	1.31
MgO	0.66
CaO	.03
Na_2O	.84
K_2O	4.82
H_2O	1.37
CO_2	1.12
MnO	.69
	Trace
	98.31

Relationships

Relation of Grenville sediments to Keewatin.—In the Actinolite-Cloyne area the normal succession of the Grenville sediments is : (1) Quartzite, greywacké, rusty schist, and iron formation; followed by (2) magnesian and non-magnesian limestones. At Gilmour this succession does not appear to hold, and it is found that grey gneiss (altered greywacké), rusty schist and crystalline limestone rest successively on the Keewatin schists. Southwest of the post office, for instance, the grey gneiss rests upon the greenstone schist, there being a gradual transition between the two rocks. Southeast of Gilmour the rusty schist lies directly on the greenstone schist, but, where the contact between the two rocks could be observed, it was found that the juncture between them was sharp and well defined. Again, immediately south of Wadsworth lake, the crystalline limestone seems to lie directly on the greenstone schists, although in places there may be a small thickness of greywacké or quartzite, now altered to schistose material, lying between the two rocks. Along these contacts we have not found any evidence that the Keewatin greenstones are intrusive into these sediments, and it is, therefore, believed that the greenstones originally formed a basement on which the sediments were deposited, in the same manner as has already been described at Belmont lake and in the Actinolite-Cloyne area.

It is probable that among the greenstone schists, which have been correlated with the Keewatin series, there are later intrusions of basic rock which are younger than the Grenville sediments. Thus, a few miles south of Gilmour station at mile-post 87 there occurs on the east side of the track a small area of crystalline limestone having the following percentage composition: CaO 52.67, MgO 1.24, CO_2 43.38. The greenstone near at hand appears to be intrusive into this patch of limestone, and is probably of the same age as the gabbro to the southwest, which is a post-Hastings intrusive.

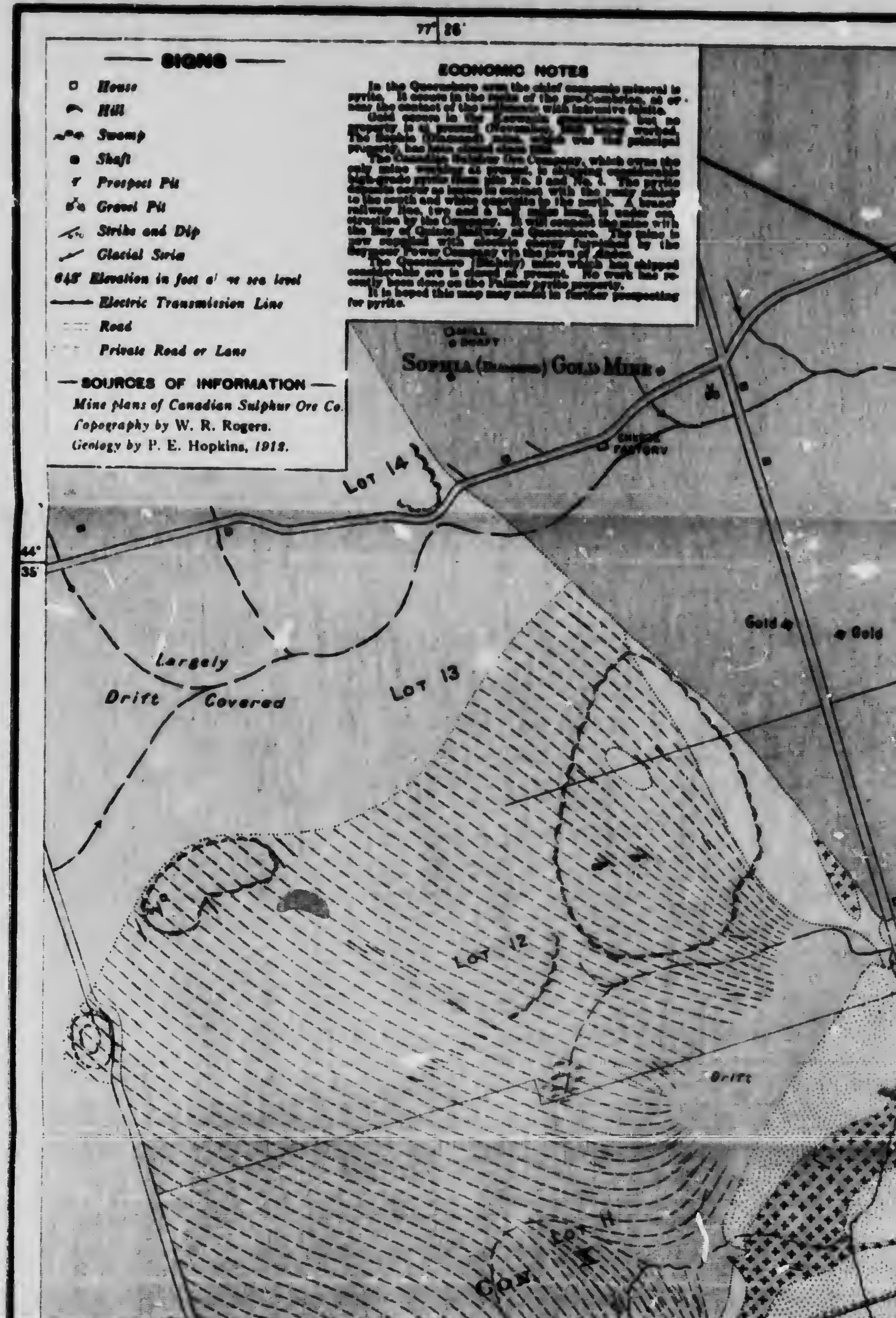
Relation of Hastings to Keewatin and Grenville.—Although bedding planes have not been recognized in the conglomerate, this rock is considered to be a true conglomerate on account of the presence of round pebbles, which look like water-worn fragments. A contact of the conglomerate and crystalline limestone occurs about a quarter of a mile southwest of Gilmour railway station where a small patch of brown crystalline limestone occurs. The conglomerate here holds pebbles of the limestone, and these pebbles may also be seen at several points to the northwest. Their presence in the conglomerate shows that an unconformity occurs between the crystalline limestone and the conglomerate. An analysis of one of these limestone pebbles gave the following results: CaO 22.71%, MgO 14.46%, CO_2 33.75%.

This is the only place in the Gilmour area where there is direct evidence of an unconformity between the Hastings conglomerate and the limestone member of the Grenville series. An unconformity is, however, inferred to exist between the rusty schist and grey gneiss of the Grenville and the greenstone schist of the Keewatin, on the one hand, and the Hastings conglomerate on the other, because this unconformity is known to occur between similar rocks in other parts of southeastern Ontario already described.

The rocks which yielded pebbles of quartz-porphyry and feldspar-porphyry have not been observed in the Gilmour area, but they are present in the Actinolite-Cloyne area.

Relation of post-Hastings Intrusives to Keewatin, Grenville and Hastings.—The granite and gabbro intrude the Hastings, Grenville and Keewatin rocks, and are therefore younger than these three series. The granite may be observed to intrude the conglomerate, the crystalline limestone, the garnet-epidote rock and the rusty schist. The gabbro intrudes the conglomerate, the crystalline limestone and the rusty schist. It also invades the greenstone schist; this intrusion may be seen at the southwest corner of the map, on the south side of the road.

The relation of the gabbro to the granite is not always clear. About a quarter of a mile east of mile-post 92, however, a few granite dikes intrude the gabbro, showing that the latter rock is older than the granite.


77° 26'
— SIGNS —
House
Hill
Swamp
Shaft
Prospect Pit
Gravel Pit
Strike and Dip
Glacial Striæ
645 Elevation in feet above sea level
Electric Transmission Line
Road
Private Road or Lane
— SOURCES OF INFORMATION —
Mine plans of Canadian Sulphur Ore Co.
Topography by W. R. Rogers.
Geology by P. E. Hopkins, 1912.
ECONOMIC NOTES
It is hoped this map may assist in further prospecting for pyrite.
SOPHIA (   ) GOLD MINE
CHEESE FACTORY
LOT 14
44°
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LOT 12
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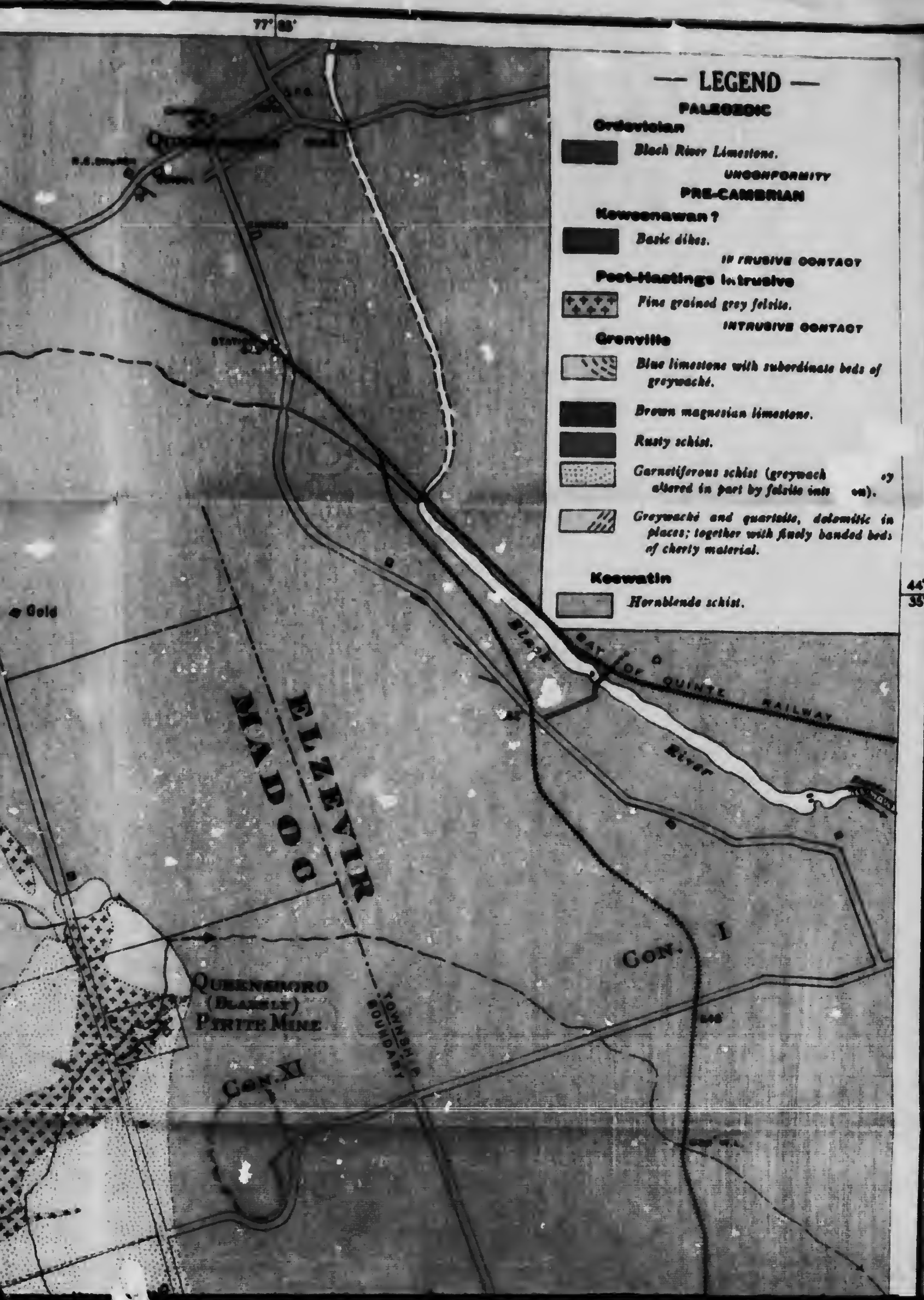
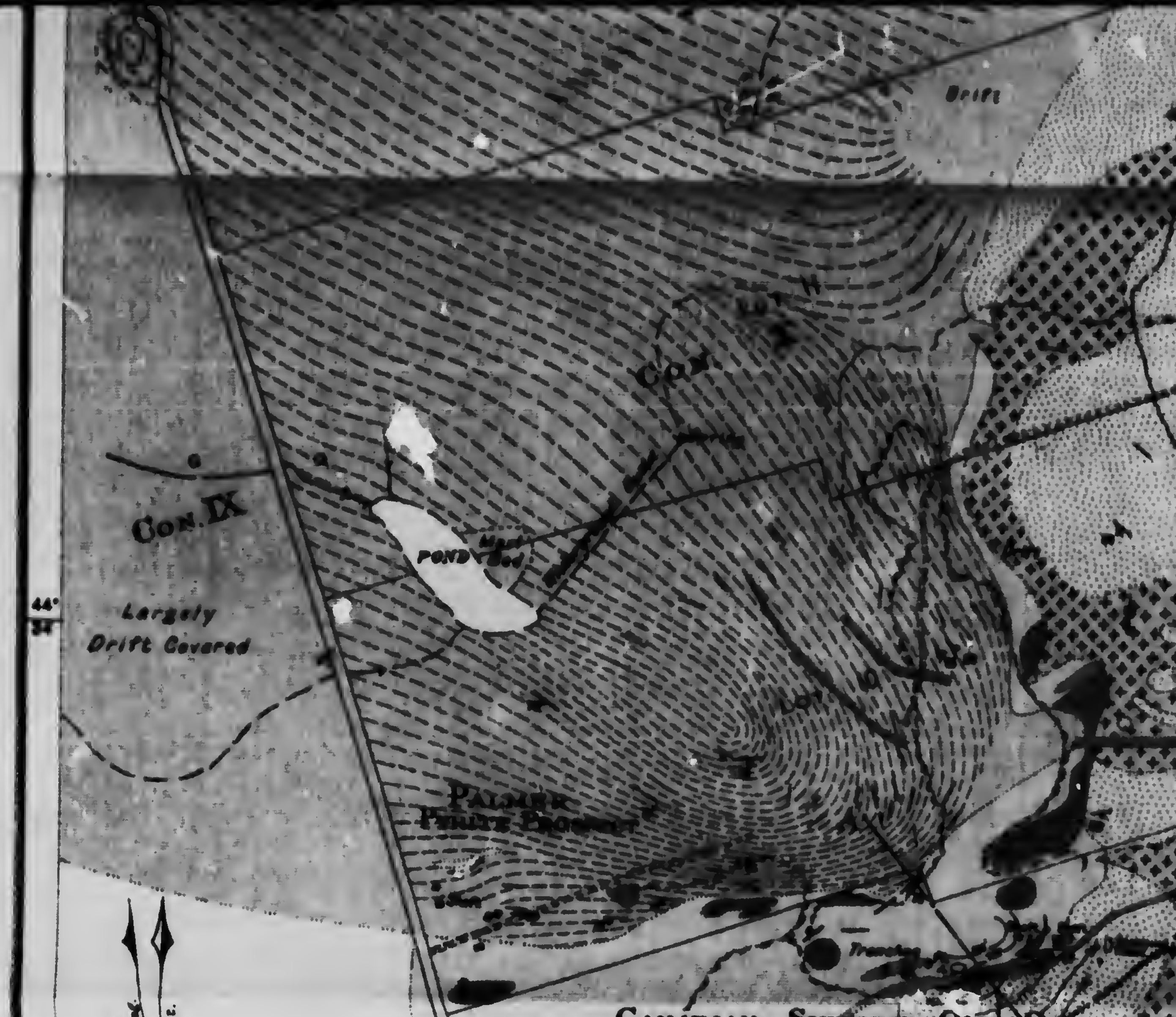
LOT 11


77° 35'
— LEGEND —
PALEOZOIC
Ordovician
Black River Limestone.
UNCONFORMITY
PRE-CAMBRIAN
Keweenawan?
Basic dikes.
INTRUSIVE CONTACT
Post-Hastings Intrusive
Fine grained grey felsite.
INTRUSIVE CONTACT
Grenville
Blue limestone with subordinate beds of greywacké.
Brown magnesian limestone.
Rusty schist.
Garnetiferous schist (greywack
altered in part by felsite int
Greywacké and quartzite, dolomitic in places; together with finely banded beds of cherty material.
Keewatin
Hornblende schist.
44° 35'
Gold
Black River
BAY OF QUINTE RAILWAY
ELZEVIR
MADOC
TOWNSHIP BOUNDARY
QUEENSBORO (BLAKELY) PYRITE MINE
CON. I
CON. XI



Drift
Con. IX
Pond
Largely
Drift Covered
Palmer
Pyrite Property
Canadian Sulphur Ore Co.
North Half
Lot 9
South Half
Private Road
Palmer Residence
Drift
Drift
North Mag.
North Ast.
Decl. 9° W.
Lot 8
B
SECTION A-B.
Horizontal and Vertical Scale —— 800 Feet = 1 Inch
A
B
44°
34'
77
26'


ONTARIO
DEPARTMENT OF LANDS FORESTS & MINES
BUREAU OF MINES
MAP
OF THE
QUEENSBORO PYRITE AREA
TOWNSHIPS of MADOC and ELZEVIR, HASTINGS COUNTY
PROVINCE of ONTARIO
To accompany Part II, Volume 22, Report of Bureau of Mines, 1913.
Hon. W. H. Hearst, Minister of Lands, Forests and Mines.
Willet G. Miller, Provincial Geologist.
Scale: 1/9600 or 800 Feet — 1 Inch.
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500 M.
1 Kilometre
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B

Map Nº 22 e.

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THE QUEENSBORO IRON PYRITES DEPOSITS

and

ECONOMIC MINERALS AND ROCKS OF OTHER AREAS

INTRODUCTION

It has frequently been pointed out that there occurs in southeastern Ontario a variety of minerals and rocks of economic value, probably as great as in any district of like size on the North American continent. Some of these deposits, including marble and trap, are inexhaustible. Others, including talc, Fig. 57, and iron pyrites, have proved to be of considerable economic importance. From time to time, during the last fifty years, the following minerals and rocks have been mined or quarried with varying success: gold, iron pyrites, zinc blende, copper pyrites, galena, mispickel, magnetite, hematite, talc, actinolite, mica, marble, ophicalcite, feldspar, fluorite, apatite, corundum, graphite and sodalite. Not all of these minerals occur in the comparatively small areas included in the map sheets accompanying this report and it will be necessary to confine the descriptions to those deposits which are found within the boundaries, or closely adjacent to, these mapped areas. All of the economic materials, with the exception of fluorite, appear to be of pre-Cambrian age. The fluorite veins penetrate the Ordovician, Black River, limestone.

The primary object of the work in the field being the determination of the age relations of the rocks, as a basis for future economic investigations, an attempt has not been made in this report to give a detailed description of the mineral resources. The iron pyrites occurrences near Queensboro have been investigated in some detail; the descriptions of these are by Mr. P. E. Hopkins. The notes on the Sophia gold mine near Queensboro are also from the pen of the same writer.

IRON PYRITES OF THE QUEENSBORO AREA

The iron pyrites deposits, described in following pages, lie close to the boundary of Madoc and Elzevir townships, Hastings county, near the village of Queensboro, on the Bay of Quinte Railway.

The chief economic mineral in the area is iron pyrites, which is used in the manufacture of sulphuric acid. The pyrites occurs in the Grenville sediments in close association with a felsite intrusion. The Canadian Sulphur Ore Company owns the principal property. Gold is also known to occur in the Keewatin greenstones, but no property is at present working. Gravel pits are numerous and afford material for road making.

The area was mapped in November, 1912, and accompanying this report is a colored geological map on a scale of 800 feet to the inch,* embracing about four square miles.

---

*Map No. 22 e.

The rocks of the area may be subdivided as follows:—

Pleistocene	
GLACIAL AND RECENT	Boulder clay, gravel and sand.
Paleozoic	
ORDOVICIAN	Black River limestone.
(Great unconformity)	
Pre-Cambrian	
POST-HASTINGS INTRUSIVES	Basic dikes.
(Intrusive contact)	
	Fine-grained, grey felsite.
(Intrusive contact)	
GRENVILLE SERIES	Blue limestone, with subordinate beds of greywacké; brown, magnesian limestone; rusty schist; garnetiferous schist (probably greywacké in part altered by felsite intrusion); greywacké and quartzite, dolomitic in places, together with finely banded beds of cherty material.
KEEWATIN	Hornblende-schist and pillow lavas.

The geological history of the area is similar to that for the district in general, given in the introductory pages of this report.

THE KEEWATIN

The Keewatin rocks are the oldest and among the most abundant rocks of the area. They consist dominantly of medium-grained, dark-green hornblende-schist with some chlorite-schist. At some points a less metamorphosed phase of the schist shows the ellipsoidal structure, as on lot 11, in the eleventh concession of Madoc township, which suggests that the original rock may have been a submarine basalt flow. At a rock-cut on the spur railway, about 2,400 feet from the main line, the rock is gneissoid. Dark layers of hornblende and chlorite are interbanded with light layers of secondary calcite, quartz and feldspar. The strike of the schist, which is shown in several places on the map, is usually parallel to the contact with the younger rocks.

The Keewatin greenstones were the basement upon which the rocks of the Grenville series were laid down.

THE GRENVILLE SERIES

Lying on the Keewatin greenstones are greywackés and gneisses, with occasional quartzite beds and thin bands of cherty material, garnetiferous schist, thin bands of rusty schist, and magnesian and non-magnesian crystalline limestones, classed as Grenville. On the map the quartzite and cherty bands are included with the greywacké, while the other formations are differentiated. These rocks are almost completely re-crystallized and dip nearly vertically.

Greywackés.—The greywackés, which are extensive, occupy a relatively high hill. Included with them are occasional white quartzite beds together with finely banded beds of cherty material which in places is dolomitic. The greywackés are almost entirely re-crystallized, and the original sedimentary texture destroyed by the later intrusions and by the folding of the rocks. However, the microscope occasionally shows original angular fragments of quartz and feldspar set in a fine-grained matrix of quartz, feldspar, sericite and chlorite. Iron pyrites is abundant in places. Coarse and fine bedding is also of frequent occurrence.

The field observations clearly show the greywackés to be sedimentary, for the coarse and fine bedding is prominent in places. Moreover, light bands of massive quartzite beds alternate with the more argillaceous and darker layers. Some of the grey gneiss may originally have been a greywacké.

Several fresh samples of the greywacké were collected, and an analysis of a composite sample, by Mr. W. K. McNeill, gave the following results:—

	Per cent.
Silica	61.02
Alumina	21.40
Ferric oxide	0.37
Ferrous oxide	3.43
Lime	4.40
Magnesia	0.41
Potash	2.52
Soda	1.82
Sulphur	0.35
Carbon dioxide	1.74
Water	2.23
	99.69

Fine-grained, white quartzite occurs in short bands, frequently up to 100 feet wide, with the greywacké and limestone. In places it has been rendered so vitreous by the intense metamorphism as to be scarcely distinguishable from the white felsite or quartz occurring in veins. Around the workings on the Canadian Sulphur Ore Company's property the quartzite is very pure. Certain bands contain 80 or 90 per cent. silica, the accessory minerals being calcite and iron pyrites.

Garnetiferous Schist.—The garnetiferous schist is a dark, medium-grained rock containing garnets sufficiently abundant to characterize the rock as such. It occurs at and near the margin of the felsite intrusion. The garnets have the usual red color, and range in size from very small grains to crystals half an inch across. They often show crystal faces, but frequently occur massive in thin continuous bands. The weathered surface is characteristic, for everywhere the garnets have resisted the forces of weathering more than the groundmass, and presents a very rough appearance.

Under the microscope the rock is seen to consist of garnet, often showing crystal outlines, and an occasional feldspar crystal, both minerals being set in a fine-grained groundmass of quartz, feldspar and biotite. Iron pyrites, magnetite, chlorite and sericite are abundant.

A chemical analysis of the garnet shows it to be almandite.

	No. 1.	No. 2.
Silica	46.06	39.12
Ferric oxide	8.18	} 33.28
Ferrous oxide	17.75	
Manganous oxide	0.24	0.80
Lime	3.84	5.76
Magnesia	1.05	....
Alumina	22.62	21.08
	99.74	100.04

No. 1 is a garnet near Queensboro. No. 2 is an analysis of a garnet from Dana's "System of Mineralogy," 6th Edition, p. 441.

From the greywacké analysis in a preceding paragraph, it will be seen that the sili and alumina are abundant while the iron is low to yield much garnet directly from t greywacké. It is possible that the iron necessary to form such extensive garnet zo may have come from the felsite magma, for in places the garnetiferous schist pass gradually into greywacké. Some of the garnetiferous schist may be altered hornblen schist.

Rusty Schist.—The rusty schists, Fig. 44, or pyritous slates, are perhaps the lea extensive of any of the sediments, but they are important economically on account the pyrite deposits being in close association with them. They occur in disconnected belt rarely exceeding 100 feet in width, and disappear beneath the drift to the southwe They are fine-grained, grey to black in color, and possess a slaty cleavage in place Their composition is variable, and they include quartzose and feldspathic facies wi iron pyrites, and in places pyrrhotite disseminated through them. In addition to iro pyrites, graphite occurs in fine flakes, and sometimes predominates over any othe mineral, giving the rock its dark color.

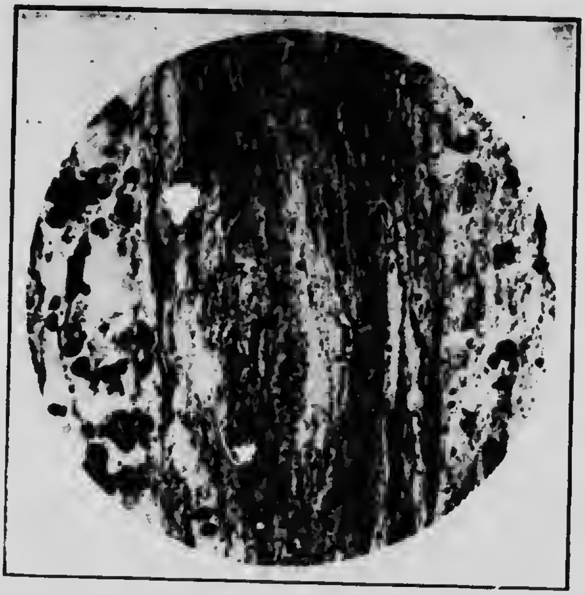

Fig. 44—Pyrite schist, or rusty schist, from iron pyrites mine of Canadian Sulphur Ore Company, Queensboro. Black spots are iron pyrites. One nicol in place.

The microscope shows over half the rock to be sericite with impregnations of quartz and veinlets of calcite. The presence of so much iron pyrites and calcite favors rapid weathering, which explains the brown, burnt-like capping the schist takes on, hence the name, rusty schist. The schists originally were probably shales and sandstones. They can be seen to grade into quartzite in a distance of six feet in pit No. 3 on the Canadian Sulphur Ore Company's property.

In other parts of this report rusty schists are described (1) near the village of Harlowe, (2) east of Bishop Corners, (3) near Gilmour and elsewhere. The chemical composition of the rusty schists points to a sedimentary origin.

Magnesian Limestone.—The magnesian limestone is light brown in color and granular. It occurs almost continuously along the base of the blue limestone and as remnants in the greywacké.

An analysis by Mr. W. K. McNeill shows it to be an impure dolomite.

	Per cent.
Insoluble	15.20
Ferric oxide and alumina	1.54
Lime	26.50
Magnesia	17.61
Loss on ignition	39.51
	100.36

This sample was taken from a point 200 feet northwest of No. 2 shaft on the Canadian Sulphur Ore Company's property. The insoluble material is chiefly silica.

Blue Limestone.—In this area the blue limestone has nearly as great a volume as the Keewatin. The rock is fine-grained and of a blue or drab color. Analyses show that the percentage of magnesia is very low. Interstratified with the limestone are thin layers of greywacké and fine-grained quartzite which give the appearance of original bedding.

Fig. 45.—Photomicrograph of felsite at Iron pyrites mine of Canadian Sulphur Ore Company, Queensboro. Crossed nicols.

The rock is greatly folded and contorted. The strikes and dips are recorded on the map. Around the workings on the Palmer, and in a few other places, the blue limestone is altered to white marble. Some of the iron pyrites on the Palmer property occurs in the limestone near the greywacké.

All of the Keewatin and Grenville rocks described are cut by acid and basic intrusives.

POST-HASTINGS INTRUSIVES

Felsite.—A very irregular, lens-shaped body of felsite occupies the central part of this area. It is very fine-grained, pink to grey in color, and resembles chert. Under the microscope, however, it has an igneous texture. An occasional small plagioclase phenocryst, Fig. 45, occurs in a very fine-grained groundmass of quartz and feldspar. Secondary grains of magnetite are scattered through the rock.

On the whole the felsite is very fresh-looking and unaltered; but felsite-schist and felsite-breccias occur immediately to the west of the Blakely workings and to the southwest of the Canadian Sulphur Ore Company's workings. The brecciation, which was probably caused by the intrusion of the trap dikes, may have assisted in the circulati of the iron and sulphur solutions.

On lot 10, in the tenth concession of Madoc township, are five small garnetifero schist areas surrounded by felsite, which suggest that the felsite may be a sill of whi the present surface represents the top or bottom of the sill. The true structure may determined by further development work.

Basic Dikes.—Narrow dikes of altered diabase, up to 40 feet in width, are the younge pre-Cambrian rocks in the Queensboro area. They consist essentially of hornblende wi small amounts of plagioclase and biotite. The secondary minerals are sericite ar chlorite. Much magnetite is present. The diabasic texture can frequently be seen bot megascopically and microscopically. The dikes have been somewhat fractured, the sma fissures being filled with chalcopyrite, quartz and calcite.

Fig. 46.—Gossan at pit No. 4, Canadian Sulphur Ore Company, Queensboro.

BLACK RIVER LIMESTONE

One small remnant of Black River limestone and sandstone, a few feet in thickness, lies unconformably on the crystalline limestone of Grenville age. The Black River limestone resembles the lithographic type, but is impure, due to numerous quartz grains being scattered through it.

GLACIAL AND RECENT

The direction from which the ice movement took place, as shown by the striæ which are well preserved on the hard felsite, is about 30 degrees east of north.

Deposits of gravel, sand, clay and some marl cover a large area, containing fine farming and grazing land.

Gossan

The gossan, Fig. 46, forms the upper part of the pyrites-bearing deposit, due to the pyrites readily oxidizing. It is dark brown in color, somewhat porous in texture, and comparatively light in weight. One sample on analysis gave 19.5 per cent. iron and 5.4 per cent. sulphur. The weathered material is conglomeratic in places with limonite as the cementing substance. Some of the rusty capping may be leached rusty schist. Its depth varies from two to thirty feet, the average on the Delyea farm being about twenty feet.

There is often a slight depression in the surface immediately above the iron pyrites deposits, due to the pyrites weathering more rapidly than the surrounding rocks. Such a depression is often a good indicator for the prospector, although at times the heavy gossan may represent the oxidized root of a lode with no ore beneath. At the bottom of the gossan there is often a water channel.

Fig. 47.—General view of Canadian Sulphur Ore Company's property, looking northwest, Queensboro.

Iron Pyrites Deposits

The iron pyrites deposits occur in the sedimentary rocks of the Grenville series and in close association with the post-Hastings felsite intrusion. The deposits are copper-free, for the most part, lenticular in outline and conform in a general way with the strike and dip of the surrounding rocks. Much of the pyrites is rich enough to ship directly without concentrating. It is also largely free from impurities which are objectionable in the manufacture of sulphuric acid. The mineral ranges from heavy dense material, containing about 50 per cent. of sulphur, to silicious pyrites containing about 5 per cent.

After describing the deposits in more detail, the genesis of the pyrites will be considered.

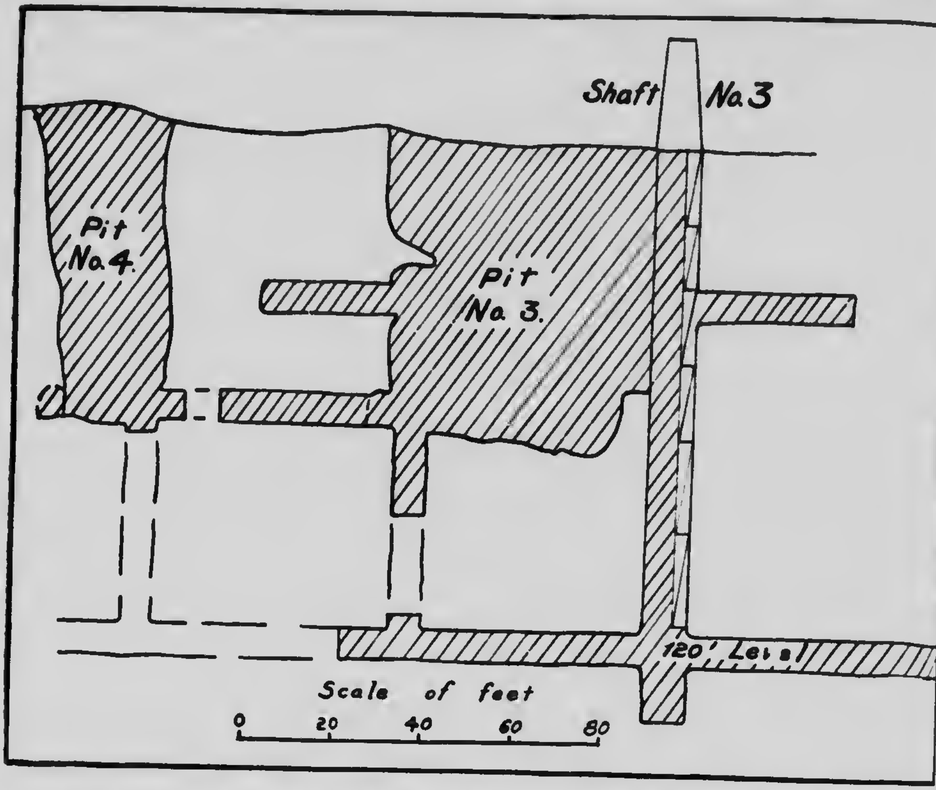

Fig. 48.—Part of underground workings, Canadian Sulphur Ore Company, April, 1913. Queensboro.

Fig. 49.—Canadian Sulphur Ore Company's property, looking east Queensboro.

DESCRIPTIONS OF PYRITES PROPERTIES

Canadian Sulphur Ore Company's Iron Pyrites Property

This is the only property in the area which was being worked in April, 1913. It includes the north half of lot 9 in the tenth concession of Madoc township, the east half being known as the Delyea farm, Figs. 47 and 50.

Mr. Stephen Wellington, noticing the very red soil on the freshly ploughed Delyea farm, decided to prospect for iron ore. On further examination, gossan was found on the hillside, and later merchantable iron pyrites was discovered.

In 1906, Mr. E. L. Fraleck described this property, then known as the Wellington prospect, as follows: "A series of pits and trenches have disclosed a belt of gossan over five hundred feet long, two hundred feet wide, and about twelve feet in depth. The gossan is mainly conglomerate with iron oxide as a cementing material. Certain portions, however, are a fairly fine limonite. Here and there throughout this material are found boulders of high-grade pyrite up to twelve inches in diameter. Although the outside of these is oxidized, the angular outline is still discernible. Prospecting has as yet failed to reveal the parent ledge."*

By sinking shafts Nos. 1 and 2, Mr. Wellington encountered a pyrites lens, from which a carload was shipped in 1908.

Later, the Canadian Pyrite Syndicate, under the management of Mr. G. H. Gillespie, bought the property, installed a small plant and shipped a few hundred tons of pyrite. In 1909, Mr. E. T. Corkill, Inspector of Mines, said:† "A shaft has been sunk 50 feet deep on the ore, and drifts started. Another shaft, 75 feet southeast, is 20 feet deep. About 500 tons of ore have already been shipped. Two small boilers are used to furnish steam for drills and hoist."

In the spring of 1910 the property was handed over to the present Company, which began shipments three months later and has continued shipping to the present. The workings have been described each year by Mr. Corkill.‡

Mine Workings.--The pyrites is mined by underground and open-cut methods. The development work consists of three shafts and two open cuts, with some diamond-drill borings. Nos. 1 and 2 shafts, which are 75 and 100 feet deep respectively, are both filled with water at present. All the work is now confined to shaft No. 3 and the two open pits which are shown in the accompanying section, Fig. 48. No. 3 is a vertical shaft, with a cage and ladder compartment. It is 120 feet deep, with levels at 50 and 120 feet. At the second level there are drifts 75 feet east and 75 feet west in pyrites which runs 46 to 49 per cent. sulphur. The largest quantity of the pyrites has come from the open cuts, which are sunk largely in pyrites, although pieces of slate, quartzite and calcite are partially or entirely enclosed in it. The surface of No. 3 pit is oval-shaped, 60 feet from east to west, 25 feet wide and 60 feet deep. Pit No. 4 is cylindrical in shape, having a diameter of 25 feet and a depth of 75 feet. Many trenches have been dug, but the overburden and gossan are so thick that the unaltered pyrites was seldom reached. A number of diamond drill holes have been put down to a depth of about a hundred feet.

*Ont. Bureau of Mines Report, Vol. XVI, 1907, p. 161.
† " " " Vol. XVIII, 1909, p. 136.
‡ " " " Vol. XX, 1911, p. 109, Vol. XXI, 1912, p. 160.

The pyrites deposits.—The accompan: .ng plan, Fig. 50, shows the geology and the workings on the south slope of perhaps the largest hill in the area. As already stated, the pyrites deposits are marked by gossan outcrops which extend from two to thirty feet in depth, and the bottom of the gossan is generally well defined and forms a water channel. The mineral beneath consists of pyrites in lenticular masses at the contact of the rusty schist and white quartzite. Occasionally horses of country rock are enclosed in the pyrites. The strike of the deposits is slightly north of east, while the dip is almost vertical, inclining a little to the south. Insufficient development work has been done to :efinitely outline the deposits, but lenses are known to occur from one to 25 feet in width, while the length is undetermined. In shaft No. 2 the pyrites is said to range from one inch to 15 feet in thickness. There are 18 inches of solid pyrites in pit No. 5. The great bulk of the mineral, however, has come from the open pits, Nos. 3 and 4, where the lense : are as wide as 25 feet, Fig. 48.

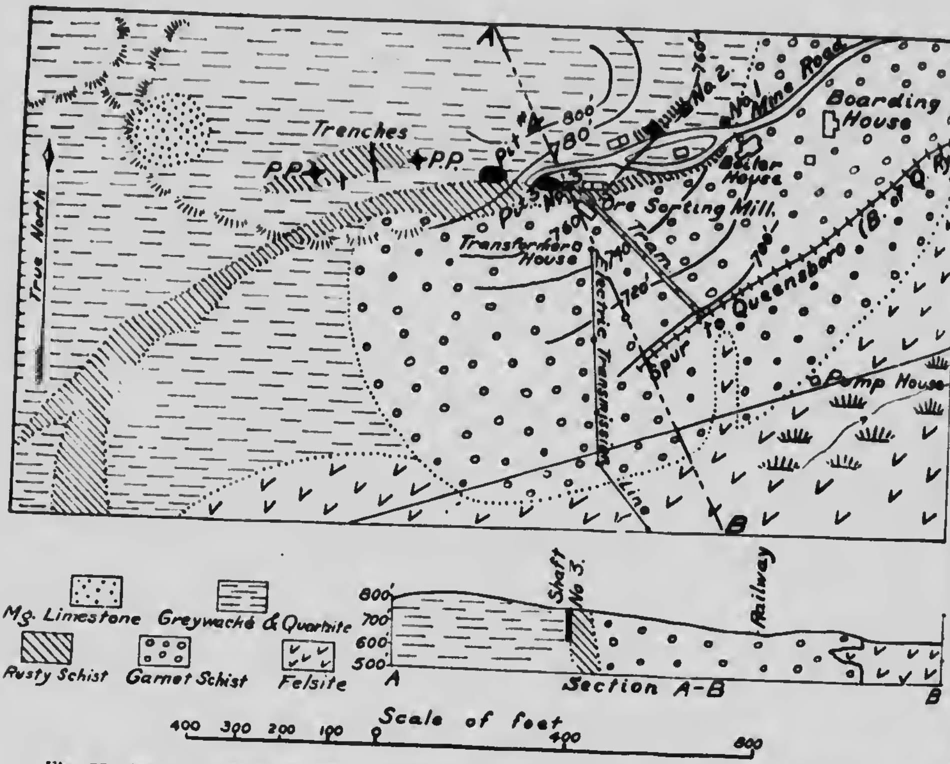

Fig. 50.—Plan of Canadian Sulphur Ore Company's property, north half of lot 9, concession 10, Madoc township. Queensboro.

The pyrites is of two grades. The low-grade is a siliclous, distinctly banded pyrites which contains about 35 per cent. of sulphur. At times it passes into pure quartzite in a short distance. The better quality of mineral, which is hard and dense, is faintly banded in places and contains from 46 to 49 per cent. of sulphur. The richness of the mineral may depend to some extent on the nature of the country rock. The pyrites, as well as the adjacent rock, is fractured in all directions, the cracks being filled with small veinlets of quartz, calcite, and more coarsely crystallized pyrites. Very small, angular, black particles of the rusty schist are also disseminated through the high-grade pyrites lenses. Under the microscope these particles are seen to consist largely of sericite, with some chlorite and quartz. They may be portions of unreplaced rock.

It is evident that metamorphic agencies have greatly altered the pyrites deposits, the pyrites having been brecciated. The deposits consist of large angular pieces of pyrites, slate and quartzite cemented by quartz, calcite and secondary pyrites. The brecciated mineral occurs to a depth of 30 feet in pit No. 4, and diamond drilling has also revealed it at greater depths. In pit No. 4, a very little pyrrhotite and chalcopyrite were deposited at the same time as the later generation of pyrites. The pyrrhotite from this pit gave a trace of nickel. There is also much pyrrhotite disseminated through the rusty schist at the bottom of No. 3 shaft on the south side. This rusty schist on analysis gave a trace of gold and 17.23 per cent. sulphur.

The deposit for the most part is copper-free and non-nickeliferous. Gold is also absent. The mineral contains no impurities, such as arsenic, zinc and lead, which are objectionable in the manufacture of sulphuric acid. The pyrites is rich enough to ship directly without concentration.

The contact of the pyrites and the rusty schist is sometimes well marked, a selvage of a clayey material lying between the two. This more or less impervious selvage may have played an important part in guiding or deflecting the mineral solutions and thus

Fig. 51.—Shaft No. 3 as seen from top of shaft No. 2, Canadian Sulphur Ore Company, Queensboro.

promoted a better concentration of the sulphide. On the other hand, on the quartzite side the pyrites is frozen to the wall, and some country rock has to be blasted to get out all of the mineral.

It is important to know the depth to which the black rusty schists extend. It is probable that in the widest parts they go down to a considerable depth, as the dip is about vertical.

In the old workings, on the 50-foot level, the walls are covered in places with minute flakes of epsomite, $MgSO_4+7H_2O$.

Equipment.—The mine is equipped to produce from 50 to 100 tons of iron pyrites per day, yielding 40 per cent. of sulphur. Since December 11th, 1912, it has been run by electricity supplied by the Seymour Power Company, via Madoc. The three-phase, 130-horsepower motor runs a compressor which supplies air for two hoists, two pumps and five drills. The surface and underground workings are lighted by electricity. About 50 men are employed.

As the pyrites comes from the mine it is dumped on a table, where it is raked over and the barren rock eliminated. The work of the pickers is facilitated by washing the dirt and dust from the pyrites by water from the mine pump. Plans are being made to transfer the pyrites a distance of about 300 feet from the bins to the railway cars by a gravity tram.

The pyrites, at present, is being shipped by contract to The Grasselli Chemical Company, Hamilton, and to The Nichols Chemical Company, Sulphide. The buyers purchase the pyrites as "run of mine," and do their own sizing.

The Operating Company is the Canadian Sulphur Ore Company, Limited, of which Mr. A. Longwell is president and Mr. A. B. Willmott secretary and treasurer. The head office is 404 Lumsden Building, Toronto, and the mine address is Queensboro. Thanks are due to Mr. Willmott for permission to make use of the mine plans.

Fig. 52.—Queensboro (Blakely) Iron Pyrites Mine, near Queensboro.

Blakely or Queensboro Pyrites Mine

The Blakely or Queensboro iron-pyrites mine, which was the first mine of the kind to be opened in this area, is situated in lot 11 of the eleventh concession of Madoc township, Fig. 52. The mine lies about a mile west of the village of Queensboro, and about a mile north of the Canadian Sulphur Ore Company's property. The mine, up to the autumn of 1906, shipped 65 carloads of pyrites running about 45 per cent. sulphur.

Mr. E. L. Fraleck described the property in 1907 as follows:*

"The deposit lies in a depression at the contact of a garnetiferous crystalline schist to the south, resembling that at Hungerford, and an intrusion of light grey granite [felsite] to the north.

"A small spring creek ran through the depression over a part of the deposit. This it was necessary to divert, and a shaft has been sunk, at the edge of the old creek bed, to a depth of eighty-five feet. At fifty feet in depth, water came in to such an extent that a drift was driven to the east for thirty feet and a cistern constructed into which,

*Ont. Bureau of Mines Report, 1907, Vol. XVI, pp. 160-161.

by means of wall plates and troughs, the water was trapped. At the bottom of the shaft a drift has been run to the west for twenty-five feet, and a cross-cut made twenty feet to the north. At the present time work in this shaft consists of drifting to the west from the fifty-foot level.

"One hundred and fifty feet to the west another shaft has been sunk to a depth of thirty feet.

"About one hundred feet southwest of the main shaft a zone of highly pyritous rock is being worked. Through this run several lenses up to four or five feet thick of medium-grade pyrite shading off into leaner ore. One lens contains disseminated copper pyrites. This is being worked by an open pit.

. . . .

"The pyrite is hauled by teams to Queensboro station and there shipped to the Contact Process Company of Buffalo. The first twenty-one cars shipped averaged forty-seven per cent. of sulphur, and shipments up to the fall of 1906 amounted to sixty-five carloads.

"The highest-grade ore comes from a series of lenses close to the granite contact. That on which the main shaft is sunk has at the shaft a width of fifteen feet and a length of about fifty feet, thinning out towards the ends. To the west is a similar lens, as yet undeveloped, which shows a width, in a surface trench, of twenty feet of very high grade pyrite. The iron pyrites in these lenses is a hard, heavy, dense ore resembling a massive magnetite, the only impurity being thin veinlets of quartz. To the south is an extensive area of more or less imperfect impregnation, yielding places from which a thirty-five per cent. sulphur ore can be quarried.

"A noteworthy feature at this deposit is a small vein to the west of the workings which has a north-west strike and is about two feet wide. It has been opened by a trench sixteen ... long and four feet deep. It cuts the formation at an angle of 45 degrees an... rs to possess well defined walls. The vein is composed of quartz, pyrite, copper ... and argentiferous jamesonite. This vein is of later age than the pyrite deposit. The jamesonite fills the interstices and is formed around crystals of pyrite. This vein possesses an interest on account of the rare occurrence of jamesonite in this country, and the present high price of antimony."

The above description still applies, except that the granite referred to in Mr. Fraleck's description is a fine-grained felsite which has been described in a preceding paragraph. The main shaft is now said to be 135 feet deep in practically solid pyrites, with a 100-foot drift to the west at the 50-foot level. The mine workings are at present full of water, the operations having ceased in 1908. Some rich mineral, coated with melanterite, still lies on the dumps.

The felsite, near the contact with the garnetiferous schist, is schistose and contains numerous brown crystals which appear to be vesuvianite. Along this contact, in the southwest pit on the property, is a pyrites deposit with a few interbedded layers of zinc blende, a fraction of an inch in width. The deposit passes gradually into the garnetiferous schist, which is impregnated with pyrites some distance from the deposit.

The Palmer Iron Pyrites Deposit

The Palmer property is the west half of lot 10 in the tenth concession of Madoc township. Blue crystalline limestone, interbedded with occasional thin beds of greywacké and quartzite, occurs over the greater part of the property. The limestone is cut by narrow trap dikes. In the limestone, in certain places near the deposit, are small pieces of marble and crushed greywacké presenting the aspect of a conglomerate.

The small open pit was filled with water and débris at the time of my visit. On the surface one or two feet of pyrites occur in the crystalline limestone and greywacké. The pyrites is cut by quartz veinlets, some of which are two inches in width.

Mr. H. Palmer, of Madoc, the owner of the property, discovered the gossan in 1907. After sinking five feet through it he reached pyrites, upon which he sank a pit nine feet deep, which is said to expose a deposit 15 feet wide.

Mr. M. J. O'Brien took an option on the property, and installed a small plant consisting of steam boiler, one drill and a pump. An open pit was sunk, from which a few carloads of pyrites were shipped.

Operations have been suspended and the plant has since been removed; however, some pyrites still lies on the dump. A great part of it is granular and friable, the grains and crystals being lightly cemented by films of calcium carbonate. Much of the pyrites is crystallized in the form of pyritohedrons and cubes. This crystalline character shows that the pyrites is of secondary origin. No graphite was noticed in the pyrites. Mr. Palmer has since uncovered pyrites in a few other places on the property.

Genesis of the Iron Pyrites Deposits

Certain iron pyrites deposits of Ontario are closely associated with the iron ranges, while others are to be found along contacts of igneous rocks with schists or limestones. In this area the pyrites bodies occur along contacts, which are zones of weakness, in the rocks of the Grenville series near a felsite intrusion.

Of the three groups of sulphide deposits in the Queensboro area, those on the Canadian Sulphur Ore Company's property are at the contact of the rusty schist and quartzite, Fig. 53; those on the Blakely at or near the junction of the intrusive felsite and garnetiferous schist, while those on the Palmer are at the contact of the greywacke and limestone. The larger pyrites deposits lie in or near the rusty schist beds, which leads one to associate these rocks with the origin of the pyrite.

No tourmaline was noticed, which would suggest igneous origin; but stringers of quartz, calcite, and highly crystallized pyrites cut the deposits. A few sharp contacts on the edge of the deposits may represent fault planes..

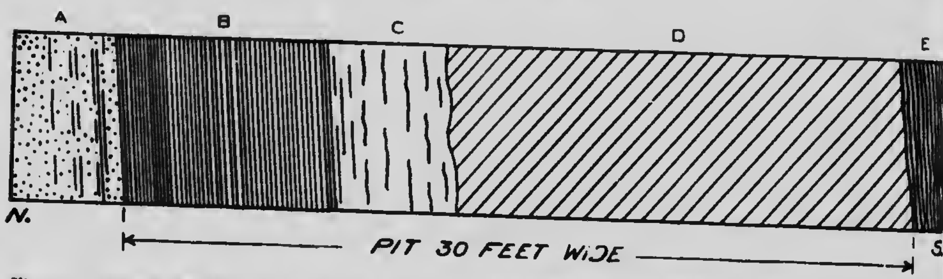

Fig. 53.—Section through west end of pit No. 3, Canadian Sulphur Ore Company's property. (A) Quartzite wall rock; (B) banded, silicious iron pyrites; (C) horse of calcareous quartzite, slightly mineralized; (D) high grade iron pyrites; (E) rusty schist wall rock.

The sulphide was probably originally precipitated in considerable quantity with clays, now rusty schist, in sea water. If the sulphide was deposited after the beds were folded, it would be difficult to account for the sulphide on the whole being somewhat evenly distributed in layers parallel to the banding of the rocks which are not equally porous. On the other hand, if the sulphide in the rusty schist is secondary, pyrites should be found abundantly filling the cracks and surrounding the fragments in the brecciated beds; this condition, however, does not always exist. Nevertheless pyrites, at times, forms the ground mass in this brecciated material and often cuts across the bedding at all angles, showing that part of it was deposited after the rock was formed.

The unleached schist is high in sulphur. One sample, across six feet of rusty schist at the bottom of No. 3 shaft on the Canadian Sulphur Ore Company's property, gave 17.23 per cent. of sulphur. A sample across six feet, near the surface of pit No. 3 on the same property and perhaps on the same rusty schist band, gave 3.73 per cent. of sulphur. A third sample, taken across 20 feet on the surface at pit No gave 0.73 per cent. of sulphur. The low sulphur content near the surface is due to the pyrites having been leached out by surface waters.

It is apparent that the pyrites occurs sufficiently abundantly in the rusty schist bands, or fahlbands, to form large pyrite deposits if suitable conditions for concentration were present. The rusty schist and banded cherty material may be the equivalents of the pre-Cambrian iron formation, jaspilyte, in other areas.

The pyrites has been concentrated along fracture zones, produced by the folding of the schist and by igneous intrusions, which form favorable channels for the percolation of the iron and sulphur-bearing solutions.

That the felsite and lodes are intimately related is indicated by the fact that the iron pyrites deposits are always not far distant from the felsite. After the pyrites was deposited further shearing took place along these lines of weakness which brecciated part of the pyrites together with some of the wall rock. This fracturing probably took place during the intrusion of the various trap dikes in the vicinity. Numerous highly crystallized veinlets of pyrites, together with quartz, calcite, some chalcopyrite and a little pyrrhotite traverse the fractured pyrites and at times penetrate the wall rock. The pyrites appears to occur in at least three generations.

Fig. 54.—Photomicrograph of quartzite, of Grenville series, impregnated with iron pyrites. One nicol in place. Canadian Sulphur Ore Company's property.

The deposits have been greatly enlarged by replacement of the walls with pyrites. The mineral can be clearly seen replacing the quartz grains of the quartzite, Fig. 54, and the microscope shows much of the pyrites to have formed later than the other minerals. The wall rocks generally have pyrites in increasing quantities near the deposits.

Conclusion

In conclusion it may be said that one would expect to find iron pyrites deposits occurring in other areas along these rusty schist beds, where the conditions are similar to those which prevail at the Canadian Sulphur Ore Company's deposits. Pyritous schist areas, in which intrusives are present, are worthy of careful examination. However, the heavy drift over much of the country makes prospecting difficult.

The iron pyrites industry in Ontario, while small compared with the nickel, silver and gold industries, is nevertheless of importance, as the following table of statistics, compiled from Reports of the Bureau of Mines, will show.

Table showing the Production and Value of Iron Pyrites in Ontario for the Thirteen Years 1901—1913.

Year.	Tons.	Value.
1901	7,000	$17,500
1902	4,371	14,993
1903	7,469	21,693
1904	13,451	43,716
1905	7,325	21,885
1906	11,090	40,583
1907	15,755	51,842
1908	20,970	69,980
1909	28,946	78,170
1910	33,812	98,353
1911	43,629	118,457
1912	20,744	71,043
1913	71,620	171,687
Total	286,182	$819,902

Fig. 54a. Cordova gold mine, mill and shaft-houses, Belmont township, Peterborough county.

MISPICKEL

About a decade ago the production of white arsenic from the mispickel and quartz deposits at Deloro, in Hastings county, formed an important part of the white arsenic consumed on the North American continent.* In 1902 the output of this material, which was manufactured wholly by the Canadian Goldfields, Limited, was valued at $48,000.00. The following year, however, it fell to $15,420.00, and by 1904 the Company had ceased operations. But during the last mentioned year 72 tons of arsenic contained in ore from Cobalt, marked a new era in the production of arsenic in Ontario, which, in the year 1912, was valued at about $79,000.00.

In southeastern Ontario there are no deposits of mispickel which are being worked at the present time. During the period when the Canadian Goldfields, Limited, at Delora, was producing gold and white arsenic, several other properties in the immediate area were being operated. These ore bodies, including those of the Canadian Goldfields, which consist of irregular quartz veins containing gold and mispickel, all occur near the contact of the western edge of a bathylith of granite known as the Moira granite, which covers an area of about 18 square miles, and occupies parts of the townships of Marmora and Madoc in Hastings county. The quartz veins and their associated minerals are probably connected genetically with the granite intrusion.

Other deposits of mispickel occur at the following places: (1) The Jeffry prospect, in the ninth concession of Faraday township, seven miles west of L'Amable station, Central Ontario Railway, Hastings county; (2) James property, at the village of Actinolite, Hastings county; (3) Kennefic property, lot 7, in the fifth concession of Anglesea township, Addington county; (4) Rebstock property, lots 2 and 3, in the fifth concession of Kaladar township, Addington county; (5) Cook property, located five miles southeast of Plevna village, Clarendon township, Frontenac county. Details concerning these properties are given in an article by J. Walter Wells, in the Eleventh Report of the Bureau of Mines, pp. 101-105.

FLUORITE

Several veins of fluorite, or fluorspar, varying in width from a few inches to six or seven feet, occur within a radius of two or three miles of the village of Madoc, on lot 11, concession XIII, and lot 10, concession XIV, Huntingdon township, lot 1, concession IV, and lot 2, concession III, Madoc township. They are all probably post-Ordovician in age, since one of them intersects limestone beds of the Black River formation. The others occur in various rocks of pre-Cambrian age, including felsite and crystalline limestone. Associated with the fluorite is barite in subordinate quantity.

The uses† of fluorspar depend primarily on its chemical composition and its neutral fluxing power. In the first instance it serves for the production of hydrofluoric acid and hydrofluosilicic acid—the latter serving as the electrolytic solution used in the production of electrolytic lead and antimony. As a flux it is used to reduce the melting heat and assist in elimination of impurities in the manufacture of enamels, glass and metals, especially in the manufacture of iron and steel. The open-hearth steel process consumes 75 per cent. of the production of fluorspar, while the remaining iron and steel processes consume 5 per cent. The mineral is used in increasing quantity in foundry practice, for which purpose it effects a smelt in about half the time were no fluorspar used. It is also used in the manufacture of sanitary ware and for other purposes.

The effect of fluorspar is, in addition to reducing heat and time of smelt in iron-steel manufacture, to assist elimination of sulphur and phosphorus.

*Fourteenth Report Bureau of Mines, Ont., Part I, p. 25.
†The Mineral Industry, 1912, p. 313.

IRON ORES

The Belmont and Blairton Iron Mines

The Belmont iron mine is in Belmont township, Peterborough county, and lies about three-quarters of a mile south of the Cordova gold mine. Like the ore bodies of the latter, it is associated with the intrusive mass of gabbro-diabase. The ore, which is magnetite, occurs at the contact of this rock with crystalline limestone. The iron deposit has been worked in the past from time to time in a small way, mostly as an open cut, but recently a shaft has been sunk and a shaft-house erected. A branch of the Central Ontario Railway runs from the property to Marmora station.

Several miles to the southeast of the Belmont iron mine, beyond the confines of our map, is located the Blairton iron mine, at the west end of Crow lake, from which has been shipped considerable magnetite from large open pits. The property has been idle for many years. The ore body also occurs at the contact of crystalline limestone, and the mass of gabbro-diabase, referred to in the preceding paragraph. The deposit lies at the northern edge of beds of Ordovician limestone, which lie uncomformably on the ore body and its associated pre-Cambrian rocks.

The Blairton iron mine, formerly known as the Big Ore bed, is one of the oldest mines in the Province of Ontario. In the year 1820 a blast furnace was erected on the Crow river, at Marmora, several miles to the east, to treat the magnetite from this property, and between that year and 1875 various attempts were made to smelt the ore, causing total losses to those engaged in the business of at least $500,000.*

At the present time it is difficult to obtain much knowledge regarding the extent of the deposit or the amount of ore shipped since the mine was first worked. A large, open pit, 250 feet wide by 120 feet long, may be seen, but it is now filled with water, and we did not ascertain its depth. One of the old reports of the Canadian Geological Survey, however, states that in 1873 ore was being hoisted from a depth of 120 feet.† A second opening, also full of water, lies to the south of the first, but is much smaller in size. Like most of the magnetite of southeastern Ontario the Blairton ore contains objectionable amounts of iron pyrites, which, during early attempts to smelt the ore at Marmora, gave rise to difficulties.

Statistics regarding production from the property in past years are very meagre, but the following information, which is derived from Reports of the Canadian Geological Survey, will give some idea of the amount of ore shipped. In 1867, for instance, a section of railway eight miles long, was built from Blairton to Healy's Falls, on the Trent river; the ore was transported from this point on the river by steamers to Rice lake, and from the latter place to Cobourg by road, a distance of twelve miles. During that year 300 men were employed in mining and sorting the ore, and towards the end of the season 150 tons per day were carried to Cobourg, and there shipped to the American side, where the cargo was forwarded to Pittsburg. In 1870 there were employed 135 men who produced 17,120 tons of ore valued at $44,300 at the mine.

A few years later, in 1873, the output of the Blairton was greater than that of any other iron mine in the country, and is said to have amounted to nearly 30,000 tons. In July of that year the ore was being shipped to Pittsburg at the rate of 300 to 400 tons a day. Incomplete as these statistics are, it is evident that the mine probably produced 100,000 tons of ore; how much more it is difficult to estimate.

The cost of labor in those days makes an interesting contrast with present day wages. During the year 1873, for instance, 150 men were employed at the Blairton, receiving $1.20 to 1.30 per day, according to the special kind of work in which they were engaged. They were furnished with cottages at the rate of $1.50 per month. And yet, in spite of these low labor costs, compared with present day schedules, a writer at about that time referred to the high cost of labor as one of the burdens which militated against the successful mining and smelting of iron ores in Canada.

*Report of the Royal Commission on The Mineral Resources of Ontario; 1890, pp. 321-322.
†Geol. Sur. Can., 1873-4, p. 244.

The difficulties under which these pioneers in the smelting of iron ore labored may be realized if we consider the case of one of them, Mr. Van Norman.* "In the fall of 1847 he moved to Marmora, and after expending a large sum in fitting up the furnaces, putting in machinery, ovens and blowing apparatus, erecting and repairing buildings, cutting cordwood and making charcoal for fuel, he got the furnace started in the summer of 1848. But the amount of iron produced from a given quantity of fuel was a sad disappointment, and nothing but disappointment and loss attended every effort. After the iron was made it had to be carted a distance of 32 miles to Belleville, over rocks and log-crossings and roads so rugged that waggons were constantly breaking, and the shoes of the horses were pulled off between the logs and stones. The obstacles were such that it was found impossible to bear up under them, and a new route was tried. A road nine miles long was built from the ore bed on Crow lake to Healy's Falls, on the Trent river; a steamer on the river carried the pig iron to Rice lake, and thence it was carted twelve miles to the dock at Cobourg. The cost of carriage by this route was cheaper than the other, and the pig iron sold readily at $30 to $35 per ton. But about this time the St. Lawrence canals were completed and foreign pig iron began to be brought up and sold at Belleville and Cobourg at $16 per ton. This circumstance alone settled the question of producing charcoal iron in the province except at a ruinous loss to those engaged in the business, and Mr. Van Norman was compelled to close his works with the loss of everything."

Some general notes by Mr. B. J. Harrington on the iron industry in Canada during the early seventies are of interest.† He remarks—"From what has been said it is evident that exceedingly little has been, or is being, done in the way of iron smelting in Canada; nor is there any prospect of an immediate increase in this important industry, except in the Province of Nova Scotia. This is due to a variety of causes, and among them, in some instances, to scarcity of fuel, in others to difficulty and cost of transportation, or to cost of labour. Notwithstanding such drawbacks, however, there seems little doubt that, with proper management, iron might be profitably made in many localities.

"The owners of iron mines, instead of smelting their ores on the spot, are more and more turning their attention to shipping them to the United States, as this has been found, in most instances, to yield a fair profit. During the past year [1873] they were worth from $6.00 to $9.00 a ton in Cleveland. . . . . The total production of iron ore in the year ending June 30, 1873, was, therefore, in round numbers, about 60,000 tons,—a quantity exceedingly small, though far ahead of previous years. Nearly the whole of the ore shipped has been from four or five mines."

It may be added that in the last few years the Blairton mine has been explored by diamond drilling with a view to ascertaining the extent of the ore body. These operations have not as yet resulted in the active working of the property. The Mines Branch of the Department of Mines, Ottawa, has also recently made magnetic surveys of the Blairton and Belmont iron mines. Other magnetite deposits of Ontario have been mapped by the Mines Branch, from which department copies of the maps may be obtained.

A few years ago Mr. G. C. Mackenzie undertook experiments on the magnetic concentration of iron ore from various deposits in Ontario, including the Blairton and Belmont ore bodies.‡

The Mines in the Vicinity of Madoc

Within a few miles of the village of Madoc, in Hastings county, there are several deposits of both magnetite and hematite, none of which are being worked at the present time. Among these may be mentioned the Dominion, the Seymour, the St. Charles, and the Sexsmith, all of which produced magnetite, and the Wallbridge, and what is now known as the Eldorado copper mine, the two latter having produced hematite. These

*Royal Commission on the Mineral Resources of Ontario, 1890, p. 321.
†Geol. Sur. Can., 1873-74, p. 257.
‡The Iron and Steel Industry of Ontario, 17th Report, Bureau of Mines of Ontario, p. 273.

deposits occur in crystalline limestone and other rocks near the contact of the Moira granite. They were comparatively small producers, and it is doubtful if their combined output amounted to 100,000 tons. Some attention was attracted to the Dominion mine, on lot 2, concession II, Madoc township, in 1892, by the discovery of small quantities of smaltite and cobalt bloom,* which minerals at that time were of rare occurrence in Ontario. The magnetite is associated with volcanic fragmental rocks classed with the Madoc andesite and rhyolite. The Seymour mine, on lot 11, concession V, Madoc township, was one of the earliest producers of iron ore in Ontario. Ore from this property was smelted at Madoc village in 1837. In that year a blast furnace was erected by Mr. Seymour, and according to government reports an excellent grade of iron was produced, although the venture, which was operated for about eight years, was not a financial success.† The St. Charles mine, which is situate on lot 4, con. VI, of Madoc township, occurs in a complex of rocks, which to the north a few hundred yards are seen to consist of volcanic fragmental material. To the east of the ore body less than 100 yards, an outcrop of the massive Moira granite occurs. At the Sexsmith mine, on lot 8, concession VII, of Madoc township, the magnetite occurs at the contact of a fine-grained, pink, acidic phase of the Madoc rhyolite, and crystalline limestone. Just to the northeast of the ore body a fine-grained felsite dike intersects the crystalline limestone.

The Eldorado copper mine, near Eldorado village, township of Madoc, was originally worked for hematite, but the ore gradually passed with depth into iron and copper sulphides, proving that the hematite was an alteration product due to the surface weathering of the sulphides. The oxidized zone varied between 60 and 80 feet in depth. Mr. E. L. Fraleck has some interesting remarks on this subject:‡ "Several hematite localities in Eastern Ontario are known to be underlain with pyrites deposits. These have as yet been unexplored, but in years gone by various hematite properties were worked for iron ore, until contamination from pyrite became so great as to prevent further shipments, when in every instance the property was abandoned. The workable depth for iron ore varied between 50 and 70 feet. From the bottom of the largest hematite deposit in Eastern Ontario, the writer has seen pieces of ore with an inner core of high grade pyrite upwards of a foot in diameter. In some instances the ore consists of the soft red hematite, and in others the hard dense pyrite. There seems to be no doubt that these hematite deposits were at one time the gossan capping of the sulphide ore bodies. . . . In only one case of this kind has development taken place, namely, at the Eldorado copper mine, where it has been shown that a hard dense hematite has resulted from the alteration of a copper and iron sulphide underneath. The depth of alteration there varied between 60 and 80 feet."

The deposit occurs in crystalline limestone at the contact of an intrusive mass of Moira granite, oval in surface outline, and about half a mile in length by 500 or 600 feet in width. In other parts along this same contact occur small deposits of magnetite, and it may also be added that the Richardson gold mine, which was worked in the sixties, occurs in crystalline limestone near the contact with the granite.

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*Mr. W. F. Ferrier, in 1892, detected cobalt bloom, or erythrite the hydrous arsenate of cobalt, and smaltite at the old Dominion iron mine, lot 2, concession II, Madoc township, Hastings county. Regarding the occurrence Mr. Ferrier says:—" Blocks of the iron-ore sometimes show surfaces of over nine inches square, coated almost completely with thin-bladed crystals and earthy coatings of the erythrite, which still retains its beautiful peach-red and pink tints of color, although exposed so many years to the action of weather. Little masses of earthy erythrite also occur, filling cavities, and this mineral appears to have been largely derived from the alteration of smaltite, etc. The smaltite, of a tin white color on a freshly fractured surface, is distributed through the iron ore, usually in small, but very perfect, crystals, mainly cubes and octahedrons, which, when weathered, tarnish, and greatly resemble iron pyrites. The massive mineral has also been observed. The minute crystals are often thickly aggregated together so as to form small patches in the iron ore." Report Canadian Geol. Sur., Vol. VIII, p. 129A.

Mr. Ferrier also detected erythrite from the Cross mine, Madoc village, Hastings county. (Report Canadian Geol. Sur., Vol. X, p. 117A.) More recently the mineral has been found elsewhere in the vicinity of the village.

†Geology of Canada, 1863, p. 675.

‡Ont. Bureau of Mines, Vol. XVI, p. 182.

Mr. E. T. Corkill* makes the following notes on the Eldorado copper property: "This mine, which was originally opened for iron, but which has for the last couple of years been worked for copper, is owned by the Medina Gold Mining Company. . . . The ore is chalcopyrite, and was found at a depth of 75 feet, displacing the hematite, which constituted the ore body to this depth. Some very fine samples of chalcocite are also found in the ore. The north or hanging wall of the ore body is granite, and the south or foot wall crystalline limestone. The ore body runs east and west in a wide, open fissure, in the contact between the granite and limestone. The open cut worked for iron is 75 feet in depth. From this level a shaft has been sunk 75 feet, with drifts and cross-cuts at different levels. At a depth of 35 feet in the shaft a level has been driven, and 105 feet of drifting done. Twenty feet deeper in the shaft another level has been run and 170 feet of drifting done. At the 75-foot level there are 175 feet of drifting. The ore body, which occurs as a shoot, dips to the northeast. At the lower level drifts have been run into it and sinking on it has begun. . . . The first copper smelter in eastern Ontario was blown in at this property on June 25th, 1906. The furnace is south of the mine, on the side of the hill, which furnishes ample ground for slag dump, and is so situated that the swinging arm derrick used for hoisting ore from the mine dumps the ore at the door leading to the charging floor. The furnace is four feet in diameter, round, water-jacketed, manufactured by the Allis-Chalmers Company, of Chicago, is equipped with the regular style of settler, and has a capacity of about 50 tons per day. The height from base of furnace to charging floor is 12 feet."

To the south of the Eldorado copper mine two miles, occurs the Wallbridge hematite deposit beside the Hastings road. The large open pit is partly filled with water at the present time, and there is scant reference in the literature to the mine. The ore body has been described† as "a large mass of ore in dolomite with no defined walls." Mr. Courtenay De Kalb‡ inspected the property in the year 1900, and said: "This mine, on the east half of lot 12, concession V, Madoc, is still in operation, with some promise of continuing to be a steady producer. The ore is a soft red hematite. Operations have been carried on for four months, yielding from 15 to 20 tons of ore per diem. The old shaft, extending 35 feet below the present working, is now filled with debris, but will be cleaned out as mining proceeds. The depth from the edge of the pit to the working place is 60 feet."

If it be assumed that the hematite at this property is the gossàn capping of a sulphide deposit, then it may be noted that the oxidized zone in sulphide ore bodies in southeastern Ontario is generally not so deep as that at the Wallbridge and Eldorado mines. This may be due to the fact that at these two properties the oxidized zone was partly protected from glacial scouring by the covering of Paleozoic sediments. The latter completely surround the ore body at the Wallbridge mine, leaving an opening about the size of the pit. The Paleozoic sediments also surround the Eldorado copper mine, but are distant from half a mile to a mile from it.

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*Ont. Bureau of Mines, 1906, Vol. XV, Part I, p. 90.

†Report of the Royal Commission on the Mineral Resources of Ontario, 1890, p. 132.

‡Bureau of Mines, 1901 Vol. X, p. 129.

GOLD MINES AND PROSPECTS

The Cordova Gold Mine

The Cordova gold mine is in the township of Belmont, at the eastern border of Peterborough county. The property was worked for several years by an English company, but operations ceased in the fall of 1903. It then lay idle until about three years ago, when the mine was unwatered and worked by Mr. Peter Kirkegaard, of Toronto. The property is equipped with a mill having 30 stamps of 850 pounds each, 6 Wilfly tables, and a cyaniding plant for treating the concentrates. A compressor, capable of generating 800 horse power, is located at the foot of Deer lake about two and a half miles north of the property, where a waterfall is utilized.

The ore-bodies occur in a coarse-grained gabbro-diabase which invades the Grenville and Hastings series. The veins are of quartz, with which are associated iron pyrites, feldspar and calcite. The wall rock has been altered to a chlorite-schist, or chlorite-mica schist, sometimes 50 feet wide, there being a gradual transition between the fresh gabbro-diabase and the schist. The latter is impregnated with quartz veinlets, parallel to the schistosity. Consequently there is not a definite boundary line between the ore and the shistose wall rock. The ore body is low-grade, the hand-culled material which is treated in the mill averaging between $5.00 and $6.00 per ton.

The deposits may have been formed by hot solutions which followed the intrusion of the gabbro-diabase.

There are several shafts on the property, two of which have reached depths of four or five hundred feet, while some of the stopes connected with shaft No. 1 are twenty feet or more in width. Details of the underground workings will be found in the reports of the Bureau of Mines.

The Deloro Mine

Reference to the Deloro gold and mispickel mine, in Marmora township, has been made on a preceding page. This mine, probably the best known gold property in south-eastern Ontario, is outside the boundari[illegible] any of the areas mapped by us. The deposits that have been worked occur on lot 9 in the eighth concession and on adjoining lots. Numerous notes descriptive of this mine and adjacent properties are to be found in the reports of the Geological Survey of Canada, in those of the Ontario Bureau of Mines and elsewhere.*

The ore bodies at the Deloro mine and adjacent properties lie near the contact of the intrusive granite, of the western edge of the Huckleberry hills, with dark Keewatin schists and associated crystalline limestone of Grenville age. Overlying these rocks unconformably is Black River limestone.

The ore bodies consist essentially of quartz lenses in the schist which contain visible gold and mispickel. The lenses conform to the strike of the schist and cut across dikes of granite which intrude the latter. Near the surface the ore was comparatively rich, but the value gradually decreased in depth. At a depth of 500 feet in the inclined shaft the gold represented only two or three dollars a ton, but massive mispickel was present. Two factors contributed to the closing of the mine, viz.: the encountering of a heavy flow of water in the lower levels, and the discovery of rich arsenical ores at Cobalt. Deloro was the pioneer white arsenic producer in North America, but the ores now treated there all come from Cobalt.

The ore of the Deloro mine and of adjacent properties appears to be genetically connected with the Moira granite intrusion. The openings occupied by the ore bodies were probably formed by the contraction of the granite mass on cooling, and the ores came from the waters that followed the intrusion.

Other mispickel and gold deposits in Marmora and adjacent townships are described in the report to which reference has been made in a preceding paragraph, page 105.

*See Report of Ontario Bureau of Mines, Vol. XI, pp. 195, 196.

The Sophia (Diamond) Gold Mine

This mine, Fig. 55, is on lots 14 and 15 in the tenth concession of Madoc, about one mile west of the village of Queensboro. Gold was discovered here about 1896, and two veins were uncovered in the hornblende and chlorite schist. One was a long vein of rather massive quartz, five feet wide in places, while the other was a narrow mispickel vein containing rich showings of gold.

In a report written a dozen years ago, Mr. Courtenay De Kalb, then Inspector of Mines, said:* "There are two veins on the property, viz., the 'mispickel vein,' with a course due north and south, and the 'free milling vein,' running north-west and south-east. The workings consist of the following: On the mispickel vein, No. 1 shaft, with a cross-section of 9 by 18 feet, and a depth of 60 feet. Drifting has just commenced at that depth. Hoisting is still done by hand windlass operating a bucket on a skidway. On the free milling vein is the principal working shaft known as No. 2. This has

Fig. 55.—Sophia (Diamond) gold mine. Lots 14 and 15, concession 10, Madoc township, Hastings county.

a cross-section of 9 by 18 feet and a depth of 105 feet. There are two levels, the 60-foot and the 100-foot. On the 60-foot level there is a north-west drift 20 feet long and a south-east drift 10 feet long. . . . . A skipway was being installed, and an inclined trestle carried the track to the upper part of the mill, where was located the hoisting engine. The skip will thus be drawn directly from the mine into the mill and then dumped. No. 3 shaft is also on the free milling vein. This is 60 feet deep with the same cross-section as the other shafts. . . . . The equipment comprises a 7 x 10-inch Blake crusher, 10 stamps of 900 lbs. each, a Wilfly concentrator, a 70-h.p. return flue boiler, and a 50-h.p. Corliss engine. There is also a blacksmith shop 100 feet south of shaft No. 2, and an assay office 150 feet south of this shaft."

Operations were suspended from the spring of 1901 until 1908, when Mr. E. T. Corkill states that, at the time of his inspection, July 27th, 1908, the No. 3 shaft was being unwatered and the mill overhauled.

*Tenth Report Bur. of Mines, 1901, p. 117.

No further work has been done. References to this property may be found in the following Bureau of Mines Reports: Vol. 7, pp. 92-93; Vol. 8, pp. 41, 258; Vol. 10, p. 117; Vol. 11, pp. 102, 200, 236; Vol 17, p. 83.

Prospect pits are shown on the map about three-quarters of a mile to the southeast of the Diamond property. Some rich gold samples came out of the pit on the east side of the road, lot 13, concession 11, Madoc township.

Golden Fleece

The Golden Fleece mine, on lot 25 in the sixth concession of the township of Kaladar, was worked in a small way several years ago, but the low-grade nature of the ore body has not encouraged extensive exploration. In 1901 the senior author of this report spent a few weeks in southeastern Ontario examining the gold deposits, and his report was published in the Eleventh Report of the Bureau of Mines, pages 186-207. The following is an extract from this article: "The deposit lies near the contact of the diorite schist and a conglomerate. The ore is found in association with the schist where it occurs in quartz in the form of a vein, and in quartz more or less mixed with the schist. A shaft about 25 feet deep has been put down on the vein, and there is a pit of considerable size in the schist. Material taken from these openings was milled, with what is claimed were satisfactory results. The sulphide in the ore is pyrite. The schist which strikes southwestward contains quartz stringers through it for a considerable distance along the strike. Exposures of quartz also occur on the more northern part of the property. Very rich specimens of gold-bearing quartz were obtained at the top of the shaft when the property was discovered. At the present time there is no difficulty in obtaining 'shows' of gold by panning the quartz and impregnated schist. The deposit cannot be considered a high-grade one. Any attempt to work it should be made on the assumption that it is a large low-grade ore body." Later work has shown that the diorite schist referred to belongs to the Keewatin greenstone series and the conglomerate to the Hastings series.

The plant consists of a 3-drill compressor, a hoist, a 50-h.p. boiler, and a 10-stamp mill. In 1907 the shaft was sunk to a depth of 85 feet vertically, and about 50 feet of cross-cut driven. No development was done in drifting on the vein on the 85-foot level. The ore milled in that year was taken from surface workings.*

Other Gold Deposits

Descriptions of other gold deposits of the district, most of which do not lie in the areas we have mapped, will be found in the reports of the Ontario Bureau of Mines and in those of the Geological Survey of Canada.

*Report, Bureau of Mines, Vol. XVII, p. 83.

TALC

A large body of talc, known as the Henderson talc mine, Fig. 57, is located on the southern outskirts of the town of Madoc, its position being shown on the map of the area. Until about two years ago this mine was the only important producer of talc in Canada, and it has therefore attracted considerable attention. The existence of the deposit has been known for fifteen years or more, but it is only within the last five years that it has developed into a large producer. The success of the talc industry at Madoc is due to the untiring efforts of Mr. George H. Gillespie.

The material, of which there is little or no waste, is drawn in wagons to the talc mill at the railway station in the village of Madoc, where it is ground and separated into various grades. The talc is the massive variety, with a prevailing white color.

The deposit occurs in a brown, quartzose, crystalline limestone of the Grenville series, an analysis of which shows it to have the following composition: CaO 29.29 per cent., MgO 15.52 per cent., CO_2 43.67 per cent., insoluble 4.62 per cent. The talc has a width which varies from 25 feet or less to 40 feet, and it has been mined a distance of about 500 feet horizontally, but the extent of the body has not yet been determined in the underground workings. The surface on every side of the hill on which the property is located is covered with drift. The crystalline limestone on both sides of the deposit contains bands of white quartz several feet or more wide, often having the eozoon structure shown in Fig. 4. A horizontal plan shows the talc to occur in the form of a horseshoe, or the letter "V," due to the strata having been sharply folded.

It is certain that the talc has resulted from the alteration of the magnesian limestone, since many parts of the occurrence still show distinct traces of the original bedding. But the various changes which took place, before the deposit reached its present condition, are not altogether clear. It is probable that the limestone was first altered to tremolite, which later became changed to talc. At any rate this process can be seen to have played at least some part in the formation of the material, as may be observed in the crystalline limestone fifty or a hundred feet from the deposit. Here hand specimens may be obtained which show tremolite in the limestone, and it may be seen that the tremolite is altering to talc.

The ultimate production of talc from magnesian limestone requires the introduction of silica and water and the removal of lime. The silica and water may have been supplied through the intrusion of the Moira granite, which no doubt gave off silica-holding waters. The granite occurs several hundred yards to the east and west of the deposit. If, however, the original magnesian limestone contained sufficient quartz, the talc might have been formed through the agencies of regional metamorphism, i.e., heat, pressure, and circulating water, in which case it would not be necessary to suppose that the granite intrusion had any genetic connection with the deposit.

The Connolly talc property, owned by the Canadian Talc and Silica Company, occurs a few hundred feet to the northeast of the Henderson talc mine, on an adjacent lot. Very little work has been done on this deposit, but, although the intervening area is drift-covered, it would appear that the two deposits may be continuous.

Powdered talc* is used in the manufacture of toilet powders, of soap and of various kinds of paper. It is readily incorporated, and its fibrous structure makes it superior to clay on account of its strength. Powdered talc is also coming into use for admixture in wall plasters, in waterproof paints, and in steam-pipe coverings. It is also used for foundry facings and facings of rubber moulds, and for the dressing of skins and leathers. For the sizing of cotton cloth, freedom of grit is more essential than any particular color, so as not to dull the cutting knives.

In the form of soapstone, it is used for griddles, hearth stones, gas tips, marking pencils, switchboard panels and other electrical uses.

*The Mineral Industry, 1912, p. 819.

Fig. 56.—Henderson talc mine, Madoc, Hastings county.

The statistics regarding talc, prepared by the Bureau of Mines, show that some 40,000 tons of the material have been mined during the years 1899-1913, inclusive, almost all of which came from the Henderson talc mine. The balance was obtained from deposits at Eldorado and Gananoque. It was not until September, 1908, that the material was ground in Ontario. In that year the talc mill began operations at Madoc under the management of Geo. H. Gillespie, and the following table shows the rapid increase in the production of the material after this date. It may be added that in 1911 a plant for grinding talc was erected at Eldorado by the Canadian Talc and Silica Company, Limited, which is now producing, the crude talc being obtained near the village.

Table Showing Production of Talc in Southeastern Ontario, 1899-1913.

Year.	Tons.	Value.
1899	100	$ 500
1900	1,000	5,000
1901	400	1,400
1902	697	930
1903	920	2,625
1904	1,313	2,919
1905	1,120	2,240
1906	1,235	3,030
1907	1,870	5,010
1908	1,016	3,048
1909	4,350	8,700
1910	5,824	46,592
1911	5,404	47,725
1912	6,726	61,358
1913	8,238	74,500
Total	40,213	$265,577

Fig. 87.—Open pit, Henderson talc mine, Madoc, Hastings county.

ACTINOLITE

Large bodies of actinolite occur in the townships of Elzevir and Kaladar in Hastings and Addington counties. Hundreds of tons of the material, with which is often associated serpentine or talc, have in past years been ground, and used for roofing purposes. Buildings in several cities of the United States are roofed with this material. None of the occurrences are at present being worked.

Seven of the more important open cuts, from which the actinolite has been shipped, are shown on the map.* Some of these occur on lots 4 and 5 in the seventh concession of Elzevir township, about three miles east of the village of Actinolite. The material here is clearly a metamorphosed basalt, or other greenstone, of the Keewatin series, which has been altered by the great intrusian of Laurentian granite-gneiss. The latter sends immense dikes into the greenstone and holds great blocks of it. In places the greenstone has been entirely altered to serpentine, which contains stringers of asbestos a fraction of an inch in width. This may be seen on lot 4 in the seventh concession of Elzevir.

The largest belt of actinolite occurs on lots 7 and 8 in the eleventh concession of Elzevir, crossing into lots 8 and 9 in the first concession of Kaladar. The actinolite here has associated with it little or no serpentine. The origin of this belt is not as clear as that described in the preceding paragraph. As will be seen from the map, it occurs in the form of a lens a mile and a half long and six or seven hundred feet wide, closely infolded in the Hastings conglomerate. Here and there parts of the belt show small patches which in their textnre suggest that the lens was originally an altered gabbro or other basic rock. There is, however, considerable ferruginous carbonate or dolomite intimately associated with the actinolite of this lens, and the authors have kept in mind the possibility that the lens is an altered crystalline limestone.

Some of the actinolite appears to be suitable for decorative purposes, as, for example, the lens which occurs on lot 12 in the second concession of Kaladar, four miles southwest of the village of Flinton. This occurrence is found at the contact of a mica and chlorite schist and granite. The actinolite here has a beautiful radiated texture and some large blocks have been quarried and shipped from Kaladar station.

Actinolite was first ground in Ontario for roofing in 1883 at the village of Actinolite, which, at that time, was called Bridgewater. The process consisted of crushing in a Blake crusher and grinding in attrition mills to 60 mesh without destroying the fibre, water power being obtained from the Skootamatta river. A proportion of mica was added to increase the bond. When applied to a roof, eleven gallons of coal tar, or its equivalent, were mixed with 100 pounds of the ground material and the mixture was spread on the roof while hot, the total thickness, including the felt on which it was spread, being half an inch. For six or seven years after operations began in 1883 the value of the output was $6,000 per annum. Following this the mill was operated at intervals, but statistics regarding production are not available until the years 1901, 1902 and 1903, when the output was valued at $3,126, $6,150, and $1,650, respectively. The industry was brought to a standstill in June, 1904, by the destruction of the mill dam.

It may be added that a new mill, at Actinolite railway station, has recently been constructed, but the output to date has been very small, some 32 tons being produced in 1910.

Mr. Joseph James has been closely associated with the actinolite industry since its inception.

ROAD MATERIAL AND BUILDING STONES

Of the various materials which are used for road "metal" trap rock is unsurpassed. The trade name "trap" is given to various fine-grained, dark-colored igneous rocks which are generally basalt or diabase. In southeastern Ontario there is an unlimited supply of this material.

In the Belmont Lake area, in Peterborough county, there occur several square miles of a dark, fine-grained basalt, detailed descriptions of which have already been given in

*Actinolite-Cloyne sheet.

Fig. 58.—Plant and quarry of Ontario Rock Company, three miles east of Havelock, Peterborough county.

another part of this report. The rock is being quarried and crushed by the Ontario Rock Company, Fig. 58, at a point three miles east of Havelock, a divisional station on the Canadian Pacific railway. The company built a spur line, three-quarters of a mile long, from the railway, which gives direct connection with the large centres of population. The company has also installed a crusher having a capacity of four or five hundred tons per day. While at present the demand for this high-grade road metal is limited, there is little doubt that in a few years a much larger market will develop, on account of the good roads movement recently inaugurated.

Other areas of good road metal occur north of Crow lake, which lies a few miles to the east of Belmont lake, and also in the vicinity of Cordova gold mine, at both of which places there are outcrops of gabbro-diabase. Suitable material may also be obtained about two miles northwest of the village of Madoc, on lot 6 in the fifth concession of the township of Madoc, and, still farther east, on lot 6 in the tenth concession of the last-mentioned township, and in the vicinity of lot 10 in the second concession of the township of Elzevir. All of these areas lie either immediately adjacent to a railway, or within a few miles of one.

Large supplies of Paleozoic limestone for use in concrete and for other purposes are available, at points convenient for shipping. In various parts of the district near Belleville, on Lake Ontario, this limestone is extensively employed in the manufacture of Portland cement.

Granite, as will be seen from the maps, occurs in various parts of the district. A pink, medium-grained variety of this rock is exposed on the south shore of Moira lake, Madoc township. Prominent hills in the vicinity consisting of the rock, near the line of the Grand Trunk railway, offer sites for quarries. Other outcrops of granite that are fairly accessible for shipping purposes are to be found in vicinity of the village of Actinolite and of the Deloro mine.

LITHOGRAPHIC STONE

The occurrence of limestone of lithographic character in Ontario has been known for many years. Several quarries have been opened with a view to establishing an industry, and those near Marmora, Hastings county, may be particularly mentioned. The senior author of this report has dealt with this subject in another publication.*

The following extract, giving the general characteristics of the Black River limestone, as well as its lithographic qualities, is taken from this report:

" The only limestone which has been found to be perfectly suited for use in the lithographic art, is, peculiarly enough, that first employed for the purpose, which is obtained from the Upper Jurassic strata at Solenhofen, in Bavaria. The stone is not only rare, but valuable. It has been sought for in many parts of America, but with little success. Stone from various States has been used to a limited extent. Ontario has probably produced as much as any other part of America. Although, however, attempts have been made to establish an industry here during the last fifty years, little progress has been made, and no lithographic stone has been quarried for some years.

" The requirements for a good stone are that it shall be fine in grain, of a homogeneous texture, not too dark in color, and free from quartz, pyrite and other minerals which are commonly found in limestone. It should, moreover, possess sufficient porosity to absorb ink and be soft enough to be worked readily with an engraver's tool. Varieties which possess most of the other requisites are often brittle and cannot be gotten out in pieces with large surfaces.

" In Ontario lithographic stone has been quarried chiefly in the Black River formation near the village of Marmora, in Hastings county. This formation, which bounds, on the south, the Laurentian area, runs in a band from Kingston city to the Georgian bay. Certain strata in the formation through the whole distance possess lithographic properties, but usually are defective owing to the development of small crystals of calcite. In the township of Rama, on Lake St. John and Lake Couchiching, similar strata to those of Marmora have been tested. Thin sections taken respectively from the Marmora and Bavarian stone showed considerable difference when examined microscopically by the writer. The Marmora stone exhibited a more uneven texture owing to the presence of secondary crystals of calcite, while the Bavarian was uniform in character."

*Ont. Bureau of Mines, Vol. XIII, Part II, p. 6.

The lithographic stone near Marmora, on lot 9, concession III, of Marmora township, was studied by C. W. Volney,* who made two analyses of the material, which are given in the following table. A third is added, for comparative purposes, from Solenhofen.

	1.	2.	3.
Insoluble silicate	3.71	3.60	2.00
Organic matter	.40	1.29	.72
$CaCO_3$	89.98	88.03	90.93
$MgCO_3$	2.78	2.50	3.57
Soluble silica	.73	.49	.52
Al_2O_3	...	.57	.58
Fe_2O_3	.15	.35	.23
FeO	.10	.04	.13
H_2O	1.25	1.36	.40
Total	99.10	98.23	99.08

1. Light blue-grey stone from Crow lake, near Marmora, Hastings county.
2. Dark blue stone from Crow lake, near Marmora, Hastings county.
3. Dark blue stone from Solenhofen.

Mr. Volney says: "The dark blue variety of Canadian stone is from a layer about 70 feet below the general surface of the country near Marmora, showing at the borders of Crow lake. Here some fifty feet of the overlying strata have been broken and washed away, not only exposing on the faces the different layers, but also enabling me to reach those underneath to the level of the lake. Of some twenty-seven layers examined by me only one gave encouraging results, and this is the dark blue variety [No. 2], analyzed by me as above."

Half a mile west of the quarry examined by Mr. Volney, on lot 7, concession III, of Marmora township, there is another quarry.† "The ground where the quarry was opened is ten feet above the level of the lake, and the rock is covered with only a few inches of drift . . . . The quarry is 100 feet long by 50 wide, and has been opened to a depth of 25 feet. The jointings are in straight lines, and far enough apart for blocks to be taken out of any size that is likely to be required. The first layer of lithograph stone is seven feet from the surface, and has a thickness of ten inches. It is marked with a white cloud, and is not of uniform texture. Three inches below it is the second layer 7 inches in thickness. The third layer has a thickness of 16 inches, the fourth 12 inches, the fifth 15 inches, and the sixth, seventh, eighth and ninth, from 6 to 8 inches. All these layers are separated from each other by beds of limestone ranging from 3 to 14 inches in thickness, and suitable for building stone. The several layers below the first differ from each other more or less in color and texture, one being of a dark cream color, and the others of varying darker shades from grey to blue. The fifth is a dark blue stone, but very fine in texture."

MARBLE

Varieties of crystalline limestone suitable for decorative material, known as marble, are found in various parts of the district. The quarries at Bancroft have demonstrated that there occur in southeastern Ontario marbles of striking beauty, having great variety of color and texture. These marbles are now being used with success for interior decorative purposes, and a fine example of the effects obtained may be seen in the main

*Report of the Bureau of Mines. Vol. II, pp. 182-183.
† " " " Vol. III, p. 137.

office building of the Standard Bank, Toronto. There is, undoubtedly, in this part of the province an inexhaustible supply of marble both for ornamental and building purposes. Government reports describing these marbles have been published.*

Crystalline limestone is also being employed for the production of a material known as Roman stone, which is used for building purposes. Limestone for this purpose is quarried at the Hastings quarry on the Bay of Quinte railway one mile south of the village of Actinolite.

The chemical composition of the crystalline limestones has been given in other parts of this report.

*Report of Ontario Bureau of Mines, Vol. XIII, Part II, by W. G. Miller. Memoir No. 6, by F. D. Adams and A. E. Barlow, Geological Survey of Canada. Building and Ornamental Stones of Canada, by W. A. Parks, Mines Branch, Ottawa.

Fig. 59—Map showing distribution of pre-Cambrian and Paleozoic rocks in the Province of Ontario.

APPENDIX

CORRELATION OF THE PRE-CAMBRIAN ROCKS OF ONTARIO. WESTERN QUEBEC AND SOUTHEASTERN MANITOBA

During their study of the pre-Cambrian geology of southeastern Ontario, the authors have attempted to correlate the rocks of this district with those of other areas which they have examined in considerable detail within recent years. On page four a general account of the conclusions arrived at is given. In comparing the descriptions by other authors of various areas in Ontario, western Quebec and southeastern Manitoba, some of which the present authors have not had the opportunity of examining, a striking similarity in the character and age relations of the groups is found. It was, therefore, thought that it would serve a useful purpose if the pre-Cambrian rocks of all the areas that have been described in some detail, especially those that contain conglomerates as well as the older igneous and sedimentary rocks, were shown on one table. The accompanying table has accordingly been prepared. In making use of this table the reader should, however, remember that the classification of the rocks of certain areas is based on descriptions in reports which the present authors may not have correctly interpreted, and which they have not had an opportunity to verify.

The following notes, in reference to the table, give the reasons which have induced the authors to adopt the classification made use of and the names employed for the various groups of rocks.

The Huronian.—In the table the authors have not employed the classic name Huronian. There are several reasons for this, among which may be mentioned:—

The rocks to which this name has been applied include representatives some of which occur above and others below a profound unconformity. In addition to their being separated by the unconformity, which represents a great time interval or period of erosion, the so-called Huronian rocks, as will be seen from the first two vertical columns on the left hand side of the table, bear different relations to an intrusion of granite and gneiss, here called Algoman, which occupies large areas and is regional in its distribution. Certain so-called Huronian rocks are intruded by the Algoman, while others lie on its eroded surface.

During recent years the Huronian rocks have been sub-divided into (a) Lower, (b) Middle, (c) Upper or Animikie. It has generally been held that the Middle Huronian is of minor significance, the unconformity between it and the Lower having been considered by many authors to be local. Hence, only the Lower and Upper will here be considered.

The Upper or Animikie rocks occur characteristically around Thunder Bay on the north shore of Lake Superior. With them should be grouped, in the opinion of competent observers, the sediments, Whitewater series, of the Sudbury basin (*See* A. P. Coleman, Ontario Bureau Mines, Vol. XIV, part 2, pp. 10 and 14, and The Nickel Industry, Mines Branch, Ottawa, 1913, p. 9; Van Hise and Leith, U.S.G.S. Bulletin 360, pp. 424 and 439).

On the other hand the fragmental rocks on the north shore of Lake Huron, in the vicinity of Thessalon and elsewhere, and the Cobalt series of Cobalt and surrounding region have been classed as Lower Huronian. The present authors, however, have come to the conclusion that the Whitewater series, or Animikie, of the Sudbury basin, the Ramsay Lake conglomerate of the same area, the Cobalt series, and the less disturbed pre-Cambrian sedimentary rocks on the north shore of Lake Huron should all be classed as Animikean. Thus rocks are grouped together some of which, heretofore, have been called Lower Huronian and some Upper Huronian or Animikie. While all the rocks to which we apply the name Animikean may not be of exactly the same age, they are all of post-Algoman age.

A. Animikean sediments in horizontal beds.

B. Temiskamian sediments with vertical dip.

C. Contorted Grenville sediments.

Fig 60.

A shows Animikean sediments in characteristic horizontal beds; B, more or less schistose Temiskamian sediments with vertical dip; C, contorted, schistose Grenville sediments. There is a normal progression in metamorphism from the Animikean through the Temiskamian to the Grenville.

Moreover, the authors group together, under the name Temiskamian, the Temiskaming series of Cobalt, the Sudbury series, the so-called Huronian rocks of the Lacloche mountains and elsewhere of Lake Huron, and the Hastings series of southeastern Ontario. These rocks are of pre-Algoman and post-Laurentian age.

It is seen, therefore, that according to the view of the authors, there has been considerable confusion in the use of the names Upper and Lower Huronian, and that the Huronian has been made to include rocks that are separated by a profound unconformity. It has accordingly been considered advisable not to employ the name Huronian in the table.

It may be added that Animikean is more closely related, as regards age, to the Keweenawan than to the group to which we have applied the name Temiskamian in the table. If the name Huronian is to be retained, the question arises as to whether it should be applied to the Animikean or to the Temiskamian or to both. If it is applied to both, then it should include the Keweenawan as well, since the latter is more closely connected with the Animikean as regards age relations than is the Animikean with the Temiskamian. But it does not appear advisable to group together rocks that are separated by such a profound unconformity as are the Animikean and Temiskamian.

Moreover, the older writers applied the name Huronian indiscriminately to the Animikean rocks of Lake Huron and of Lake Temiskaming (the Cobalt series) as well as to the Temiskamian rocks of Lake Huron (Lacloche mountains and elsewhere), of Lake Superior (the Doré series) and of Lake Temiskaming (the Temiskaming series). It would therefore appear that, if the name Huronian is to be retained, the Temiskamian rocks are as much entitled to the appellation as are the Animikean, and *vice versa*. But the authors prefer, for the present at least, not to make use of the term Huronian.

In the authors' opinion there appears to be no logical reason for a dual sub-division of the pre-Cambrian into Archean and Algonkian, or Archeozoic and Proterozoic, either on the basis of proportion of sediments or on that of life development. As regards metamorphism, there is a normal progression downward from that of the younger to the older groups, Fig. 60. The Temiskamian rocks are more highly metamorphosed than are the Animikean, and less metamorphosed than the Grenville. Moreover, the thickness of the pre-Laurentian sediments is great.

The Keweenawan.—No comment, in addition to the notes in the table, is required concerning the definition of the name Keweenawan (Kē-wēen-ă'-wăn). It is here employed in the sense made use of by practically all authors in recent years.

The Animikean.—The name Animikean (Ăn-ĭm-ĭ-kē'-ăn) is employed by Chamberlin and Salisbury (Geology, Vol. II, pages 60 and 183), and by other authors, for the series of rocks to which the name Animikie is commonly applied. In our table, as has been said in a preceding paragraph, the name is applied not only to the Animikie of the north shore of Lake Superior and of the Sudbury basin, but also to certain rocks of the north shore of Lake Huron and to the Cobalt series of Cobalt and surrounding region. Thus in the Animikean, or so-called Upper Huronian, are placed certain rocks that have heretofore been classed as Lower Huronian. Further reference is made to the Animikean in the notes on localities.

The Algoman.—(Ăl-gō'-măn). This name, introduced by A. C. Lawson (Int. Geol. Congress, 1913), appears to the authors to be a good one. Their investigations in southeastern Ontario, as well as at Cobalt and surrounding region, have proved that granite and gneiss of post-Temiskaming and pre-Animikie age are of wide extent. Ten years ago the authors gave to granite of this age in the Cobalt area the name Lorrain granite, and later they gave to a granite of similar age in southeastern Ontario the name Moira. On the north shore of Lake Huron granite of similar age has been called Killarney. Algoman now being preferred, although not having priority, Lorrain, Moira and Killarney may be discarded or used locally. In the descriptions of many areas Algoman granite and gneiss have in the past been classed as Laurentian, age relations not being definitely known.

Fig. 61—Index Map showing Localities named in Table of Correlation of the Pre-Cambrian Rocks of Ontario, Western Quebec and Southeastern Manitoba.

Table Showing Correla

	Names that have been employed for Rocks of various Localities.	Degree of Metamorphism, &c.	1 NORTH SHORE OF LAKE HURON	2 COBALT	3 TEMA
KEWEENAWAN	*Upper Copper-bearing Rocks of Lake Superior, Upper Group (Geol. Can., 1863).* *Nipigon, Kaministiqua (obsolete names).* *Keweenawan (name at present in use in Canada and United States).*	*The Keweenawan igneous rocks are massive. The sediments are little altered and rest in almost horizontal positions.*	Nipissing diabase	Nipissing diabase	Nipissing di
ANIMIKEAN	*Upper Copper-bearing Rocks of Lake Superior, Lower Group (Geol. Can., 1863).* *Includes Middle and part of Lower Huronian of Lake Huron of various authors (U.S.G.S. Bull. 360).* *Animikie or Upper Huronian of Lake Superior, and of the Sudbury basin, Whitewater and Ramsay Lake series.* *Cobalt series of Cobalt and surrounding region.*	*The Animikean rocks are usually only gently folded. Locally, at times, they are much disturbed.*	Quartzite Limestone Conglomerate *(Unconformity.)* Limestone Quartzite Conglomerate	*Cobalt Series.* Quartzite Arkose Conglomerate Quartzite Greywacké Conglomerate *(Local unconformities.)*	*Cobal* Quartzite Arkose Conglomera Quartzite Greywacké Conglomera *(Local* *ties.)*
Intrusives (ALGOMAN)	*Algoman of Lawson (Int. Geol. Con., 1913).* *Laurentian, in part, of some authors and Huronian granite of others.* *Lorrain granite of Cobalt.* *Moira granite of Hastings county.* *Killarney granite of north shore of Lake Huron.*	*Generally massive, sometimes gneissoid; color typically pink.*	Killarney granite, (various outcrops between Killarney and Thessalon)	Lorrain granite	Lorrain gra
				Lamprophyre dikes	Basic dike
TEMISKAMIAN	*Includes part of the Huronian of Logan and Murray and of many other authors.* *Part of the Lower Huronian of Van Hise and Leith (U.S.G.S. Bull. 360).* *Temiskaming series of Miller (Eng. and Min. Jour., Sept. 30, 1911, and Ont. Bur. of Mines, Vol. XIX, part 2).* *Sudbury series of Coleman (The Nickel Industry, Mines Branch, Ottawa, 1913).*	*Dip at high angles; schistose in part.*	Quartzite Greywacké Arkose Conglomerate	*Temiskaming Series.* Slate Greywacké Quartzite Conglomerate	*Temiskami* Greywacké Quartzite Conglomera
Intrusives (LAURENTIAN)	*Laurentian (granite and gneiss).*	*Generally gneissoid; color typically grey.*	Granite and gneiss		Granite and
LOGANIAN	Grenville: *(Sedimentary)* *Includes most of the Hastings and Grenville of older authors, and the Couchiching of Lawson.* Keewatin: *(Igneous)* *Keewatin complex.*	*The Grenville sediments and Keewatin igneous rocks are highly metamorphosed.*	Iron formation Keewatin complex	Iron formation Keewatin complex	Iron formati Greywacké Keewatin co

…orrelation of the Pre-Cambrian Rocks of Ontario, Western Quebec and Southeas…

Compiled by WILLET G. MILLER and CYRIL W. KNIGHT.

To Accompany Part II of the 22nd Report of the Ontario Bureau of Mines, 1913

Localities, Names and Characters of Rocks

3 TEMAGAMI	4 GOWGANDA	5 KIRKLAND AND LARDER LAKES AND SWASTIKA	6 PORCUPINE	7 ABITIBI LAKE	8 WESTERN QUEBEC	9 SUDBURY	10 MICHIPICOTEN	11 THUNDER BAY	12 LAKE N…
Nipissing diabase	Nipissing diabase	Nipissing diabase	Diabase	Nipissing diabase	Nipissing diabase	Nickel eruptive (Norite, &c.)	Diabase Tuff.	*Keweenawan.* Diabase Marl Sandstone Conglomerate	*Keween…* Diabase Marl Sandstone Conglomerat…
Unconformity									
Cobalt Series. Quartzite Arkose Conglomerate Quartzite Greywacké Conglomerate (*Local unconformities.*)	*Cobalt Series.* Quartzite Arkose Conglomerate Quartzite Greywacké Conglomerate (*Local unconformities.*)	*Cobalt Series.* Quartzite Arkose Conglomerate Quartzite Greywacké Conglomerate	*Cobalt Series.* Conglomerate		*Cobalt Series.* Quartzite Arkose Conglomerate Quartzite Greywacké Conglomerate	*Whitewater & Ramsey Lake Series.* Sandstone Slate Tuff Conglomerate		*Animikie Series.* Slate Iron formation Conglomerate	
Great Unconformity									
Lorrain granite	Lorrain granite	Lorrain granite and syenite, Porphyries	Lorrain granite	Lorrain granite	Lorrain granite and gneiss	Granite	Granite	Granite	Granite
Basic dikes		Lamprophyre dikes				Pillow lavas	Lamprophyre dikes	Greenstone	
Temiskaming Series. Greywacké Quartzite Conglomerate	*Temiskaming Series.* Greywacké Quartzite Conglomerate	*Temiskaming Series.* Slate Quartzite Conglomerate	*Temiskaming Series.* Slate Greywacké Quartzite Conglomerate	*Temiskaming Series.* Conglomerate	*Temiskaming, Matagami and Broadback Series.* Greywacké Quartzite Conglomerate	*Sudbury Series.* Greywacké Slate Quartzite Conglomerate	*Doré Series.* Slate Greywacké Quartzite Conglomerate	Greywacké Quartzite Conglomerate	Slate Greywacké Quartzite Conglomerate
Great Unconformity									
Granite and gneiss					Granite and gneiss		Granite and gneiss	Granite and gneiss	Granite and gn…
Iron formation Greywacké	Iron formation	Iron formation	Iron formation	Iron formation	Crystalline limestone Iron formation	Crystalline limestone Iron formation	Iron formation	Iron formation	Iron formation
Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin comp…

-Cambrian Rocks of Ontario, Western Quebec and Southeastern Ma

Compiled by WILLET G. MILLER and CYRIL W. KNIGHT.

any Part II of the 22nd Report of the Ontario Bureau of Mines, 1913

Localities, Names and Characters of Rocks

5 …KLAND AND …DER LAKES …SWASTIKA	6 PORCUPINE	7 ABITIBI LAKE	8 WESTERN QUEBEC	9 SUDBURY	10 MICHIPICOTEN	11 THUNDER BAY	12 LAKE NIPIGON	13 LAKES … AND A…
…ng diabase	Diabase	Nipissing diabase	Nipissing diabase	Nickel eruptive (Norite, &c.)	Diabase Tuff.	*Keweenawan.* Diabase Marl Sandstone Conglomerate	*Keweenawan.* Diabase Marl Sandstone Conglomerate	Diabase
Unconformity								
…obalt Series. …ite … …merate …ite …ack… …merate	*Cobalt Series.* Conglomerate		*Cobalt Series.* Quartzite Arkose Conglomerate Quartzite Greywacké Conglomerate	*Whitewater & Ramsay Lake Series.* Sandstone Slate Tuff Conglomerate		*Animikie Series.* Slate Iron formation Conglomerate		
Great Unconformity								
…granite and …te, …ries	Lorrain granite	Lorrain granite	Lorrain granite and gneiss	Granite	Granite	Granite	Granite	Granite
…ophyre dikes				Pillow lavas	Lamprophyre dikes	Greenstone		
…ming Series. …ite …merate	*Temiskaming Series.* Slate Greywacké Quartzite Conglomerate	*Temiskaming Series.* Conglomerate	*Temiskaming, Matagami and Broadback Series.* Greywacké Quartzite Conglomerate	*Sudbury Series.* Greywacké Slate Quartzite Conglomerate	*Doré Series.* Slate Greywacké Quartzite Conglomerate	Greywacké Quartzite Conglomerate	Slate Greywacké Quartzite Conglomerate	Slate Greywacké Quartzite Conglomerat…
Great Unconformity								
			Granite and gneiss		Granite and gneiss	Granite and gneiss	Granite and gneiss	Granite and g…
…mation	Iron formation	Iron formation	Crystalline limestone Iron formation	Crystalline limestone Iron formation	Iron formation	Iron formation	Iron formation	Iron formatio…
…n complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin complex	Keewatin com…

Manitoba

13 LAKES SAVANT AND ABRAM	14 STEEP ROCK LAKE	15 RAINY LAKE	16 EASTERN MANITOBA (Wanipigow River)	17 WUNNUMMIN LAKE	18 SUTTON MILL LAKES	19 SOUTHEASTERN ONTARIO, HASTINGS COUNTY, &c
Diabase					Diabase	Basic dikes
Unconformity						
					Slate Iron formation Sandstone	
Great Unconformity						
Granite	Granite	Granite	Granite and gneiss			Moira granite
						Gabbro-diabase and basic lavas
Slate Greywacké Quartzite Conglomerate	***Steep Rock and Seine Series.*** Limestone Slate Greywacké Quartzite Conglomerate (*Relations of two series not definitely determined.*)	***Seine Series.*** Mica schist Conglomerate	***Wanipigow Series.*** Arkose Greywacké Conglomerate	Conglomerate		***Hastings Series.*** Limestone Slate Greywacké Quartzite Conglomerate
Great Unconformity						
Granite and gneiss	Granite and gneiss	Granite and gneiss	Granite and gneiss			Laurentian granite and gneiss
Iron formation	Iron formation	Iron formation Quartz schists				***Grenville Series.*** Limestones Iron formation and schistose Quartzite and Greywacké
Keewatin complex	Keewatin complex	Keewatin complex	Porphyries Green schists	Chlorite schists Hornblende schists		Keewatin complex

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The Temiskamian.—The name Temiskamian, (Tem-is-kā'-mi-ăn), as used by the authors, covers the pre-Algoman and post-Laurentian sedimentary rocks including the Temiskaming, Sudbury and Hastings series, together with part of the so-called Huronian of the north shore of Lake Huron. From the table it will be seen that the Temiskamian rocks are even more widespread than the Animikean.

The Laurentian.—The name Laurentian, as used in the table, has the meaning given to it by the International Committee of 1904 (Journal of Geology, 1905, pp. 89-104). It is applied to granite and gneiss of pre-Temiskamian and post-Loganian age.

The Loganian.[1]—Since the relation between the Grenville and Keewatin is such that, for the most part, they are not separated by an unconformity or an eruptive contact, it seems best to group them under one general heading, Loganian, giving to the sediments the old name Grenville and to the igneous material the name Keewatin.[2] Moreover, since similar sediments to those to which Lawson gave the name Couchiching are found as one of the members of the Grenville, it does not seem to be necessary to retain the name Couchiching, except for use locally in northwestern Ontario. It is held by Lawson that the Couchiching in certain northwestern Ontario localities is older than the Keewatin represented there, but the authors are of the opinion that on the whole the pre-Laurentian sediments, Grenville and Couchiching, are younger than the Keewatin, although a minor part of the Keewatin may be intrusive into the sediments. In this connection it should be noted that, especially in localities where Temiskamian sediments are absent, certain post-Temiskamian igneous rocks may readily be mistaken for Keewatin rocks.

Localities

The index map, Fig. 61, shows the localities that are numbered from 1 to 19 in the table. In the following notes are given references to literature on the various localities, together with comments.

1. NORTH SHORE OF LAKE HURON

The pre-Cambrian rocks of the north shore of Lake Huron were divided by Logan and Murray into two major groups: (1) The Laurentian, consisting of granite and gneiss, and (2) the Huronian, consisting of conglomerate and other sediments, with which were grouped certain greenstones.

The name Laurentian was here given to granite and gneiss, similar in appearance to the rocks farther to the east, in the Ottawa valley and elsewhere, to which it had been applied. From statements such as the following, however, it is seen that Logan and Murray did not claim to have definitely determined the relations between the Laurentian and Huronian on the North Shore of Lake Huron, but that they knew that certain parts of the areas there mapped as Laurentian contain granite that is intrusive into the gneiss and into certain of the so-called Huronian sediments:

"In that part of the country on the north shore of Lake Huron which lies between the Mississagui and St. Mary's Rivers, where the Huronian series has been more completely examined, the immediate contact of the gneiss with the overlying rocks has not been observed. . . . The gneiss extends to the vicinity of a small stream about a mile and a half above Les Grandes Sables, and what is supposed to be the lowest Huronian mass of that part occurs about half a mile above the stream. It consists of a grey quartzite which abuts against one mass of gneiss and runs under another and appears to be much broken by and entangled among the intrustive rock."[3]

"The intrusive granite occupies a considerable area on the coast of Lake Huron, south of Lake Pakowagaming [Pakowkami]. It there breaks through and disturbs the gneiss of the Laurentian series, and forms a nucleus from which emanates a complexity of dikes, proceeding to considerable distances. As dikes of a similar character are met with intersecting the rocks of the Huronian series, the nucleus in question is supposed to be of Huronian age, as well as the greenstone dikes which intersect it."[4]

[1] The name Ontarian was proposed by A. C. Lawson (Bull. G.S.A., Vol. I, pp. 176-177) for the pre-Laurentian rocks of northwestern Ontario. But the name Ontaric, introduced in 1843, is employed by the geological survey of an adjoining state, New York, as synonymous with Siluric. In order to avoid confusion, it does not seem advisable to retain Lawson's name.

Since the Grenville, especially, is characteristic of the district in southeastern Ontario and the adjoining part of Quebec first described by Logan, we propose the name Loganian for the pre-Laurentian rocks.

[2] The relation of the Grenville to the Keewatin is described in preceding pages. *See* p. 50.

[3] Geology of Canada, 1863, p. 55.

[4] Ibid., p. 58.

Fig 62—Sketch map, North Shore of Lake Huron.

Fig. 62a—Interbedded quartzite and slate of the Temiskaming series. North Dome mine, Porcupine.

"On Lake Huron the rocks of this [Huronian] series occupy the coast from Shebahahnahning [Killarney] to the mouth of the Mississagui River; and in the valley of the Spanish River they appear to have a breadth northward from Lacloche of about ten miles. The rock which there limits them on the north is probably a part of the Laurentian gneiss, though it has been found difficult to distinguish the gneiss in that part from an intrusive granite."[1]

While these extracts show that Logan and Murray recognized granite and gneiss of at least two ages, they also bring out the fact that these investigators intended that the name Laurentian should here be applied to only the older granite and gneiss and not to that which is intrusive into the sediments. But they, like later workers, did not recognize that the pre-Cambrian sedimentary rocks in the region, to all of which they gave the name Huronian, are divisible into two great groups, separated by a pro-

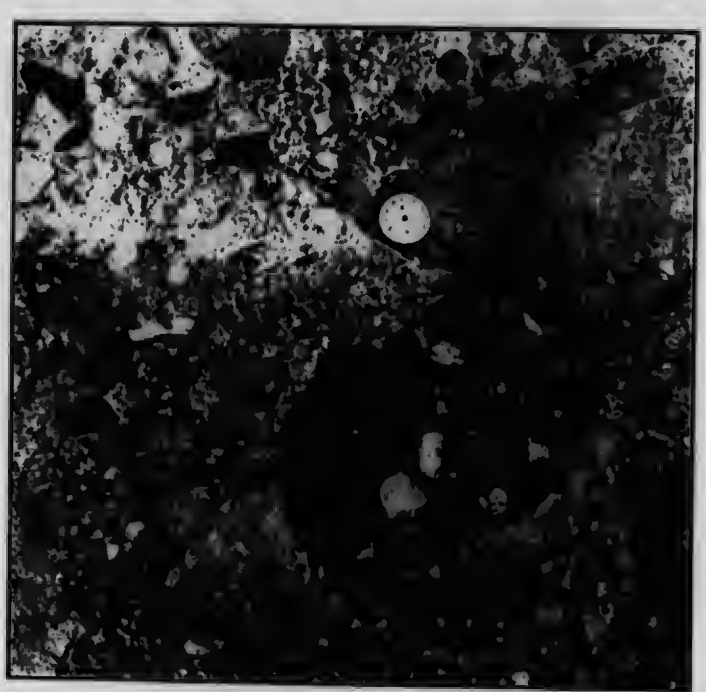

Fig. 63—Boulder of conglomerate of Temiskaming series enclosed in conglomerate of Cobalt series (Animikean), lot 7, con. 4, township of Bucke, near Cobalt. During the period of erosion that produced the sediments of the Cobalt series, the Temiskaming rocks in certain localities were completely removed.

found unconformity. Had this unconformity been recognized, it is scarcely likely that a stratigrapher of Logan's ability would have applied the name Huronian to all of the sediments. Distinct names would doubtless have been given to both the older and the younger groups.

There is an older group of sediments, called by the present authors the Temiskamian, which, as shown by the preceding quotations, Logan and Murray recognized as being younger than the Laurentian gneiss and older than the later (Algoman), or as they called it, the Huronian granite. But these workers did not recognize, nor did their successors, that part of the pre-Cambrian sediments along the north shore of Lake Huron are younger than the later granite (Algoman) which intrudes the earlier sediments. This failure to recognize the stratigraphic position of the later sediments has led to great confusion, not to say amusing controversies. It so happens that the con-

[1] Geology of Canada, 1863, p. 61.

glomerate and other rocks of the later group of sediments (Animikean) are in the more conspicuous outcrops, or in localities that have been examined by most investigators, and these rocks have, in almost all cases, been classed as Lower Huronian, indicating that they are at the base of the pre-Cambrian sedimentary series of the region. The younger granite or gneiss (Algoman), on the eroded surface of which this later conglomerate has been found to rest, has been mistaken for the Laurentian (*See* Van Hise and Leith, Bull. 360, U.S.G.S., pp. 414-415, 425-426, 435 *et seq.*, and A. C. Lawson, "A Standard Scale for the pre-Cambrian Rocks of North America," Int. Geol. Congress, 1913, pp. 12 and 21).

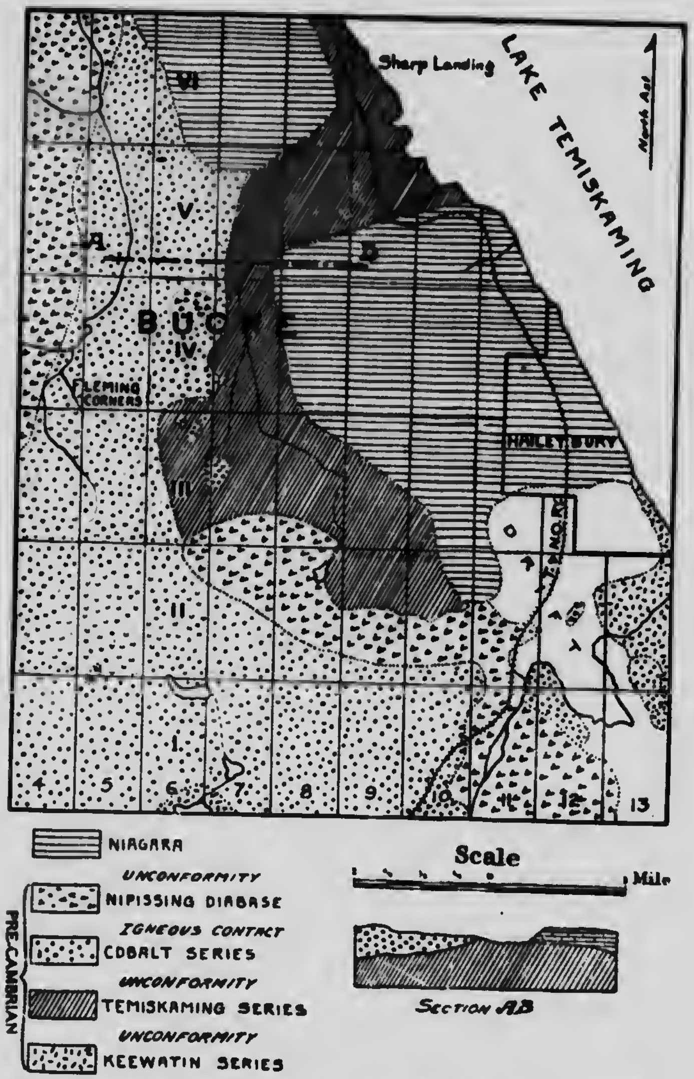

Fig. 64—Geological map of area a few miles north of Cobalt, showing distribution of the Temiskaming, Cobalt and other series.

The Thessalon greenstones, a volcanic series, grouped with the Huronian by Logan and Murray, have in recent years been classed as Keewatin, but it seems to the present authors that these rocks may be post-Temiskamian, and that they may occupy a place in the geological column similar to the pillow lavas, "older norite," of Sudbury and the lamprophyre dikes of Cobalt.

Unconformities between the sediments in certain localities along the north shore of Lake Huron have been described. These unconformities are of two kinds. In one case they separate Temiskamian rocks from Animikean; in the other they are what have been called interformational or local unconformities, similar to those found within the Cobalt series in the region to the northeast.

Much arduous and detailed work remains to be done on the north shore of Lake Huron.

The list of Animikean rocks placed in the vertical column in the table under the heading, North Shore of Lake Huron, is provisional. The relations to the Laurentian and Algoman of those that lie beneath the unconformity have not been definitely determined.

2. COBALT

The base of the geological column at Cobalt consists of pillow lavas and of other rocks of Keewatin age. Associated with these are remnants of iron formation.

Unconformably on the lavas and iron formation rests a thick series of slates, quartzites, greywackés, and conglomerates, which now lies in highly inclined attitudes and holds, in addition to fragments of Keewatin lavas and iron formation, pebbles and boulders of Laurentian granite and gneiss. The Laurentian, however, is not exposed in the Cobalt area proper but occurs in the surrounding region. These sediments are known as the Temiskaming series. They are well exposed along the west shore of Lake Temiskaming between Haileybury and New Liskeard.

The Temiskaming series and all of the older rocks were fissured and intruded by lamprophyre dikes and masses of diabase. Following this igneous activity an enormous batholith of granite, called the Lorrain granite, invaded all of the rocks mentioned.

The Temiskaming sediments, the stratigraphic position of which was first worked out in the Cobalt area, have been found to be widespread throughout Ontario, western Quebec and southeastern Manitoba, and are correlated with the Sudbury series of Sudbury, the Doré series of Michipicoten, and with rocks in other areas, as shown in the table.

After the intrusion of the Lorrain (Algoman) granite there followed a prolonged period of erosion and there was laid down on the older rocks a series of slates, greywackés, quartzites and conglomerates which was named, ten years ago, the Cobalt series. It resembles in lithology and in degree of metamorphism the younger pre-Cambrian sediments in the area surrounding Thessalon and Bruce Mines on the north shore of Lake Huron; limestone, however, does not occur at Cobalt. Logan showed in 1847 that the rocks which we now call the Cobalt series rest unconformably on the adjacent granite and gneiss along the shores of Lake Temiskaming.

All of the previously mentioned rocks were intruded by the Nipissing diabase, and later by dikes of olivine diabase. The Nipissing diabase is regarded by most writers as Keweenawan in age.

Literature

The Cobalt-Nickel Arsenides, and Silver Deposits of Temiskaming, fourth edition, by Willet G. Miller, 19th Report, Bureau of Mines, Ontario, Part 2.

Notes on the Cobalt Area, by Willet G. Miller, "Engineering and Mining Journal," Vol. 92, Sept., 1911, pp. 645-649.

3. TEMAGAMI

The pre-Cambrian succession in the area surrounding Lake Temagami is one of the most complete of the nineteen areas mentioned in the table. In addition to the rocks occurring at Cobalt, which have been briefly described above, the Laurentian granite and gneiss are present.

There are local unconformities in the Cobalt series, one of which may be seen at the boat landing on the northeast arm of Lake Temagami, near the railway station.

Literature

Summary Report, Geol. Survey of Canada, 1902, pp. 127-128 A.
Map No. 944, published by the Geol. Survey of Canada.
The Laurentian System, by Willet G. Miller and Cyril W. Knight, 20th Report, Bureau of Mines, Ontario, Part I, pp. 280-284.
The Cobalt-Nickel Arsenides and Silver Deposits of Temiskaming, fourth edition, by Willet G. Miller, 19th Report, Bureau of Mines, Ontario, Part 2, p. 60.

4. GOWGANDA

The succession of rocks in the Gowganda area is the same as that at Cobalt if two exceptions be made: (1) The lamprophyre dikes have not been found at Gowganda; (2) Crystalline limestone, according to W. H. Collins, occurs in the Cobalt series at Gowganda, while it is absent at Cobalt.

There are local unconformities in the Cobalt series at Gowganda which have been described by A. G. Burrows.

Literature

Report on the Geology of the Area along the T. & N. O. Railway Trial Line between Gowganda and Porcupine, by J. G. McMillan, Toronto, 1912.
The Geology of the Gowganda Mining Division, by W. H. Collins, Memoir No. 33, Geol. Survey of Canada.
The Gowganda Silver Area, by A. G. Burrows, 19th Report, Bureau of Mines, Ontario, Part 2, pp. 165-186. See also 18th Report, Part 2, pp. 1-20.
The Shining Tree Silver Area, by R. H. Stewart, 19th Report, Bureau of Mines, Ontario, Part 2, pp. 187-193.

5. KIRKLAND AND LARDER LAKES AND SWASTIKA

The geology of this area is similar to that of Cobalt and requires little comment. The rocks have been mapped in detail by A. G. Burrows and P. E. Hopkins who found that lamprophyre dikes are of very common occurrence and occupy the same stratigraphic position as do similar rocks in the Cobalt area.

Literature

The Larder Lake District, by R. W. Brock, 16th Report, Bureau of Mines, Ontario, Part I., pp. 202-218.
The Swastika Gold Area, by E. L. Bruce, 21st Report Bureau of Mines, Ontario, Part I., pp. 256-265.
Geology and Economic Resources of the Larder Lake District, Ont., and adjoining Portions of Pontiac County, Que., by M. E. Wilson, Memoir 17-E., Geol. Survey of Canada.
Map No. 23a., Kirkland Lake and Swastika Gold Areas, by A. G. Burrows and P. E. Hopkins. Published by the Ontario Bureau of Mines, Nov., 1913.

6. PORCUPINE

The rocks of this area are also similar to those at Cobalt. The greenstones of the Keewatin occur in large volume, but the Cobalt series is sparsely represented.

Literature

The Porcupine Gold Area, by A. G. Burrows, 20th Report, Bureau of Mines, Ontario, Part 2, pp. 3-33.
The Porcupine Gold Area, by A. G. Burrows, 21st Report, Bureau of Mines, Ontario, Part I, pp. 205-249.
Notes on the Cobalt Area, by Willet G. Miller, "Engineering and Mining Journal," Vol. 92, Sept., 1911, pp. 645-649.

7. ABITIBI LAKE

The rocks surrounding Abitibi lake are almost wholly of igneous origin, and consist of Keewatin greenstones, Lorrain granite and Nipissing diabase. But the area is of interest owing to the presence of schistose conglomerate of the Temiskaming series which is intruded by the Lorrain granite. M. B. Baker, who mapped the area, was one of the first to recognize the stratigraphic relations of this conglomerate.

Literature

Lake Abitibi Area, by M. B. Baker, 18th Report, Bureau of Mines, Ontario, Part I, pp. 263-283.

8. WESTERN QUEBEC

Several distinct areas, somewhat widely distributed, are included under the heading "Western Quebec." These areas lie in: (1) the Keekeek and Kewagama Lakes region; (2) the basins of the Harricanaw and Nottaway rivers; (3) the Chibougamau region; (4) Broadback river area; (5) Fabre township; and (6) other parts of Pontiac

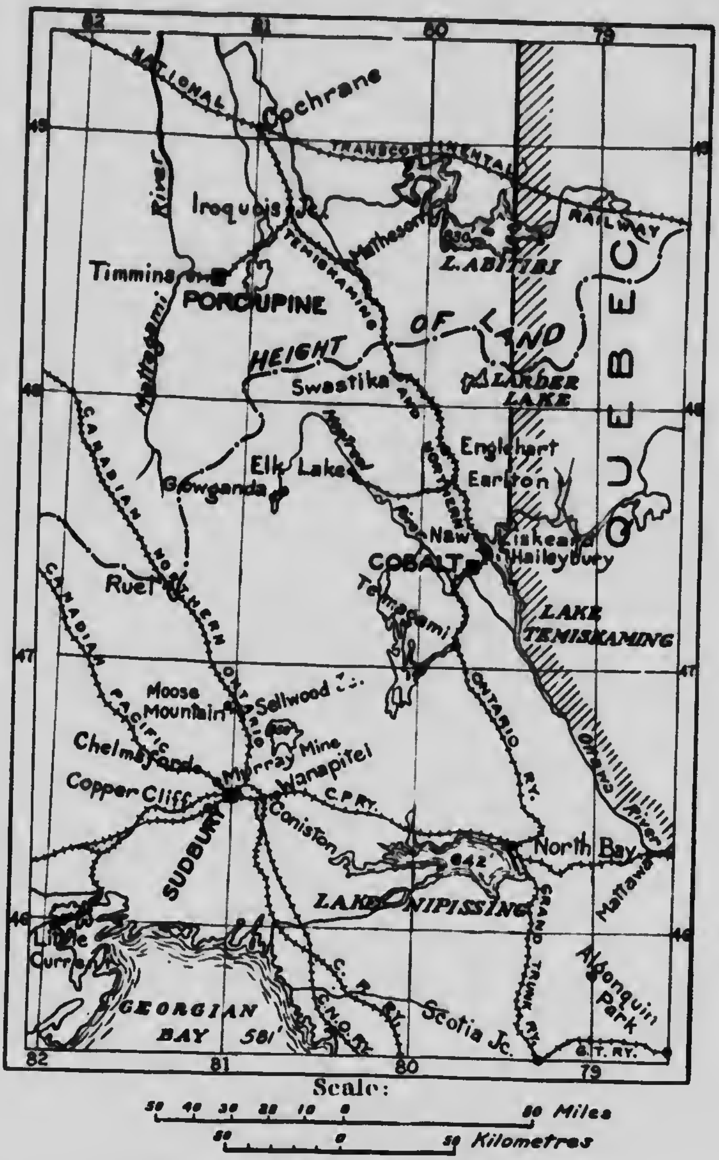

Fig. 68—Map of the Sudbury-Cobalt-Porcupine region.

county. The Temiskaming series appears to occur in large volume in some of these areas. The Matagami series resting unconformably on granite gneiss, the relationships of which have been so well described by J. A. Bancroft, and the Broadback series of H. C. Cooke should apparently be correlated with the Temiskaming. Both series are invaded by

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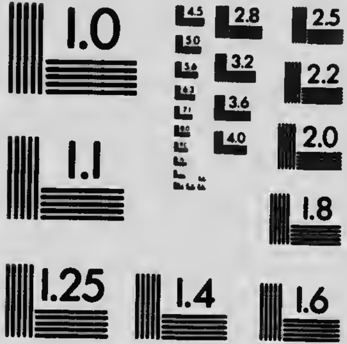

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granite which appears to be of Algoman age. Thus it is seen that there are also pre-Cambrian granites or granite-gneisses of two ages in this part of the province of Quebec.

The Animikean rocks are of common occurrence in parts of western Quebec. In their lithological character and in their degree of metamorphism they are similar to the Cobalt series at Cobalt and surrounding region. The unconformity between these rocks and the older Temiskamian is profound.

The crystalline limestone[1] of the Grenville series, referred to in the table, was discovered some years ago by the senior author on Kipawa river, which lies to the east of Lake Temiskaming in the province of Quebec.

Literature

Report on the Geology and Mineral Resources of the Chibougamau Region, Quebec, by E. R. Faribault, J. C. Gwillim, and A. E. Barlow, Mines Branch, Quebec, 1911.

Geology of a Portion of Fabre Township, Quebec, by R. Harvie, Mines Branch, Quebec, 1911.

Report on the Geology and Mineral Resources of Keekeek and Kewagama Lakes Region, by J. A. Bancroft, Report on Mining Operations in the Province of Quebec during the year 1911, pp. 160-207, Mines Branch, Quebec.

A Report on the Geology and Natural Resources of Certain Portions of the Drainage Basins of the Harricanaw and Nottaway Rivers, to the North of the National Transcontinental Railway in Northwestern Quebec, by J. A. Bancroft, Report on Mining Operations in the Province of Quebec during the year 1912, Mines Branch, Quebec.

Geology and Economic Resources of the Larder Lake District, Ont., and adjoining portions of Pontiac County, Que., by M. E. Wilson, Memoir 17-E., Geol. Survey of Canada.

Map. No. 95a (Issued 1913), Broadback River, Mistassini Territory, Quebec; by H. C. Cooke, Geol. Survey of Canada.

9. SUDBURY

The pre-Cambrian groups in the Sudbury area are almost complete, but the Laurentian granites and gneisses, i.e., those granites and gneisses which are older than the Sudbury series, have not been identified.

The Keewatin greenstones and iron formation occur at Moose mountain, to the north of the Sudbury area proper, and near the north shore of Lake Wanapitei. Several miles to the south of the Sudbury area, in the township of Dill, A. P. Coleman has described crystalline limestone, coarse white quartzite and fine-grained grey gneiss and schist which he has classed with the Grenville series. He remarks that the grey gneiss is not unlike the Couchiching of western Ontario.

Succeeding these rocks there is a series of sediments, 30,000 feet in thickness,[2] consisting chiefly of quartzite but including arkose, greywacké, slate, and conglomerate. This series has been named by Coleman the Sudbury series, and has been correlated by the present authors with the Temiskaming series. The basement on which this Sudbury series rests has not been discovered, but, judging from the composition of the sediments, it is almost certain that the series was deposited in part on, and largely derived from, Laurentian granites and gneisses.

After the deposition of the Sudbury series there were erupted various greenstones, including "older norite" and pillow lavas, which appear to be approximately of the same age as the lamprophyre dikes of Cobalt and other areas. The recognition of these pillow lavas as post-Sudbury in age is important, and gives rise to surmises that some of the pillow lavas classed as Keewatin in other areas may really be much younger in age than the Keewatin. The volcanic rocks at Thessalon should be considered in this connection.

Later than the "older norite" and pillow lavas there occurred great intrusions of granite and gneiss, which are probably of Algoman age.

All of the rocks mentioned were subjected to a prolonged period of erosion and the Whitewater series and the Ramsay Lake conglomerate were laid down. The Whitewater series is classed as Animikie by Coleman and other writers. In the accompanying table it is correlated with the younger sediments along the north shore of Lake Huron, as is also the Ramsay Lake series.

The deposition of the Whitewater series was followed by the intrusion of the nickel eruptive (norite and micropegmatite), which occurs, according to Coleman, in the form of a boat-shaped sill about a mile and a quarter in thickness.

Dikes of olivine diabase and a few dikes of granite penetrate all of the older rocks in the area.

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[1] American Geologist, January, 1901.

[2] The Nickel Industry, by A. P. Coleman, Mines Branch, Ottawa, 1913.

Literature

The Sudbury Nickel Field, by A. P. Coleman, 14th Report, Bureau of Mines, Ontario, Part 3.

The Nickel and Copper Deposits of Sudbury, Ontario, by A. E. Barlow, Geol. Survey of Canada, Vol. 14, Part H.

The Nickel Industry with Special Reference to the Sudbury Region, Ontario, by A. P. Coleman, Mines Branch, Ottawa, 1913.

Sudbury, Cobalt and Porcupine Geology, by Willet G. Miller and Cyril W. Knight, The Engineering and Mining Journal, June 7, 1913.

Map of the Sudbury-Cobalt-Porcupine Region, Province of Ontario, published by the Ontario Bureau of Mines, July, 1913.

Guide Book No. 7, 12th Int. Geol. Congress, 1913, Excursions to Sudbury, Cobalt and Porcupine.

10. MICHIPICOTEN

The Keewatin series and iron formation are well developed in this area. In addition, there is an important belt of schistose conglomerate, the pebbles of which are clearly derived from Keewatin greenstones and Laurentian granite and gneiss. An actual contact between the conglomerate and the greenstone-granite complex has not been found. This conglomerate, which is locally called the Doré conglomerate, is correlated with the Temiskaming series. The conglomerate is penetrated by dikes of quartz-porphyry, which Coleman considers to be off-shoots of granitoid gneiss.

Literature

The Michipicoten Iron Region, by A. P. Coleman and A. B. Willmott, 11th Report, Bureau of Mines, Ontario, pp. 152-185.

The Iron Ranges of Michipicoten West, by J. M. Bell, 14th Report, Bureau of Mines, Ontario, Part I, pp. 278-355.

Iron Ranges of Eastern Michipicoten, by A. P. Coleman, 15th Report, Bureau of Mines, Ontario, Part I, pp. 173-206.

The Geology of the Lake Superior Region, by Van Hise and Leith, Monograph LII, U. S. Geol. Survey, pp. 150-155.

11. THUNDER BAY

The succession of rocks in the Thunder Bay area is almost complete, though the Laurentian is not present. It is thought, however, to occur in the granitic hills to the north.

The Temiskaming series is present, and it has been intruded by greenstone, which may be of about the same age as the lamprophyre dikes of Cobalt and Kirkland Lake and the post-Sudbury pillow lavas of Sudbury. It will be seen from the notes on various areas and from the table that these lamprophyre dikes, altered greenstones and pillow lavas are widespread in the pre-Cambrian of Ontario and occupy a well-defined position in the geological column. At Thunder Bay, as in the other areas, these igneous rocks are older than the Algoman granite.

Unconformably on these rocks rests the Animikie series. The name Animikie was first applied by T. S. Hunt to these rocks in 1873. The authors correlate with the Animikie series, the Cobalt series, the Whitewater series, the Ramsay Lake series, and the younger sediments on the north shore of Lake Huron at Bruce Mines, Thessalon and other areas. They are all of post-Algoman age.

Above the Animikie sediments rests the Keweenawan series. Unconformities between the two occur at Loon Lake, 25 miles east of Port Arthur.

Sills of diabase, known as the Logan sills, intrude all of the rocks in the area. These sills, which are of Keweenawan age, are correlated with the Nipissing diabase of Cobalt and surrounding region, the nickel eruptive at Sudbury, and with the diabase sills on the north shore of Lake Huron.

Literature

Report of the Special Committee on the Lake Superior Region, with Introductory Note, Journal of Geology, Feb.-Mar., 1905, pp. 97-98.

The Animikie Iron Range, by L. P. Silver, 15th Report Bureau of Mines, Ontario, pp. 156-172.

The Geology of the Lake Superior Region, by Van Hise and Leith, Monograph LII, U. S. Geol. Survey.

12. LAKE NIPIGON

The geology of the Nipigon basin is given in a monograph by A. W. G. Wilson. A series, called Lower Huronian by Wilson, occurs in important volume, and consists principally of schistose conglomerate. The authors have not had an opportunity of examining this conglomerate, but, judging from Wilson's descriptions, it appears to be similar to the Temiskaming series.

Literature

Iron Ranges East of Lake Nipigon, by E. S. Moore, 16th Report, Bureau of Mines, Ontario, pp. 105-135.

Iron Ranges East of Lake Nipigon, by A. P. Coleman and E. S. Moore, 17th Report, Bureau of Mines, Ontario, pp. 136-189.

Geology of the Nipigon Basin, by A. W. G. Wilson, Memoir No. I, Geol. Sur. of Canada.

13. LAKES SAVANT AND ABRAM

In the vicinity of these two lakes there occur prominent areas of a schistose conglomerate called by E. S. Moore Lower Huronian. It contains numerous boulders of Laurentian granite and gneiss, and apparently should be correlated with the Temiskaming series. In the Lake Savant area the conglomerate was discovered by Moore to rest unconformably on the Laurentian granite, the granite showing a weathered surface. This contact was considered by Collins[1] to be an igneous one. Moore also suggests that there may be granites of two periods of eruption in this area, since part of the granite looks much fresher and less metamorphosed than does the greater portion. The younger granite, if present, is probably of Algoman age.

Fig. 66—Schistose conglomerate of Temiskaming series, Lake Savant area.

Literature

Lake Savant Iron Range Area, by E. S. Moore, 19th Report, Bureau of Mines, Ontario, pp. 173-193.

Vermilion Lake Pyrite Deposits, by E. S. Moore, 20th Report, Bureau of Mines, Ontario, Part I, pp. 199-213.

14. STEEP ROCK LAKE

om the descriptions of this area the writers consider that the Temiskaming ser is present. One series, consisting of conglomerate and fossiliferous limestone which rest unconformably on the Keewatin and Laurentian, is known as the Steep Rock. In addition to the Steep Rock series there is a series of conglomerates and other rocks which Lawson has named the Seine series and of which the Shoal Lake conglomer-

[1]A Geological Reconnaissance of the Region Traversed by the Nat. Trans. Ry. between Lake Nipigon and Clay Lake, Ont., Rep. Geol. Sur. Canada, 1909, p. 34.

ate forms a part. Lawson believes that the Seine series lies unconformably on the Steep Rock series, but this is not as yet proved. Therefore, both the Seine series and the Steep Rock series are correlated, provisionally, in the accompanying table with the Temiskaming. The Seine series is penetrated by granite gneiss, to which Lawson has applied the name Algoman.

Literature

Structural Geology of Steep Rock Lake, Ontario, by H. L. Smyth, Am. Jour. Science, Third Series, Vol. 42, 1891, pp. 317-331.

The Geology of the Lake Superior Region, by Van Hise and Leith, Monograph L11, U. S. Geol. Sur., pp. 147-149.

The Geology of Steep Rock Lake, Ontario, by A. C. Lawson, Memoir No. 28, Geol. Sur. of Canada.

A Standard Scale for the Pre-Cambrian Rocks of North America, by A. C. Lawson, Published by the 12th Int. Geol. Congress, Toronto, 1913.

Fig. 67—Trap of Keweenawan age, Sutton Mill Lakes, District of Patricia

15 RAINY LAKE

In the Rainy Lake area a series of conglomerates and other rocks, named by A. C. Lawson the Seine series, occurs at Shoal lake and Rat Root bay. These sediments rest unconformably on the Keewatin and Laurentian series, and apparently should be correlated with the Temiskaming.

In 1887 Lawson described a series of rocks, consisting mainly of mica-schists, which he named the Couchiching series. He considered that this series occurs structurally below the Keewatin. Later, in 1904, the International Committee found that part of Lawson's Couchiching, namely, the Shoal Lake conglomerate, is post-Laurentian in age. Since the committee's report was published, Lawson has recognized the correctness of their conclusions regarding the Shoal Lake conglomerate, but after spending the summer of 1911 in re-examining the area, he concluded that the Couchiching rocks in the vicinity of Bear's Passage and Rice Bay "underlie the Keewatin and that this relation is due to sequence of deposition."

Literature

Report on the Geology of the Rainy Lake Region, by A. C. Lawson, Geol. Sur. of Canada, Annual Report, 1887, Part F.

Report of the Special Committee on the Lake Superior Region, with Introductory Note, Journal of Geology, Feb-Mar., 1905.

A Standard Scale for the pre-Cambrian Rocks of North America, by A. C. Lawson. Published by the Int. Geol. Congress, 12th Session, Toronto, 1913.

16. SOUTHEASTERN MANITOBA

In that part of the Province of Manitoba situated between the southern portion of Lake Winnipeg and the western boundary of Ontario there occurs, along the Wanipigow river, a schistose conglomerate which appears to belong to the Temiskamian group. Locally the series has been named by E. S. Moore the Wanipigow series. It contains granite pebbles, but is intruded by granite and gneiss which is probably of Algoman age.

The presence of granite fragments shows that the Laurentian is present in the area, but R. C. Wallace remarks in this connection that "when more detailed work is done on the mapping of the acid intrusives of this and other districts it may be found that the Laurentian in the sense of pre-Huronian [Temiskamian] plutonics occupies—in some areas, at any rate—a very unimportant place."

Wallace describes an iron formation which belongs structurally with the conglomerate series and probably should be correlated with the Temiskamian iron formation mentioned by the senior author at Cobalt.

Literature

The Rice Lake Gold District of Manitoba, by R. C. Wallace. Transactions Canadian Mining Institute, Vol. XVI, 1913, pp. 533-544.

Map No. 9 A, Wanipigow, Manigotagan and Oiseau Rivers, Manitoba, by E. S. Moore, Geol. Survey of Canada, issued 1913.

17. WUNNUMMIN LAKE

Wunnummin lake is situated about the centre of the district of Patricia, its position being shown on the map, Fig. 61. Regarding the rocks on this lake, William McInnes says: "The most conspicuous rocks occurring in the belt are heavy beds of coarse conglomerate, very similar to that of Abram Lake on the English River below Minnitakie Lake." Judging from this description it would appear that the conglomerate should be correlated with the Temiskaming series.

Literature

Report on a Part of the North-West Territories of Canada drained by the Winisk and Attawapiskat Rivers, by William McInnes, Geol. Survey of Canada, Vol. XV, Part AA, pp. 100-108; and Vol. XVI, Part A, pp. 153-160.

The District of Patricia, 21st Report, Bureau of Mines, Ontario, pp. 119, 131.

18. SUTTON MILL LAKES

Rocks comparable to the Animikie, at Thunder Bay, Lake Superior, or to the Nastapoka series of the east coast of Hudson Bay, are found at Sutton Mill lakes, and outcropping through the Paleozoic on the Winisk river, 26 miles from its mouth. At the former locality they are intruded and overlain by diabase, thus giving rise to conditions similar to those which exist in the silver area at Thunder Bay and at Cobalt. These sediments at Sutton Mill lakes may be correlated with the Animikean, and the diabase with the Nipissing diabase and Logan sills.

Literature

Report on a Survey of the Ekwan River and of the Route through Sutton Mill Lakes Northward, by D. B. Dowling, Geol. Survey of Canada, Vol. XIV, Part F.

The District of Patricia, 21st Report, Bureau of Mines, Ontario, pp. 149-153.

19. SOUTHEASTERN ONTARIO (HASTINGS COUNTY, ETC.)

A description of the pre-Cambrian geology of southeastern Ontario is given in the accompanying report.

GENERAL REPORTS ON PRE-CAMBRIAN GEOLOGY

Geology of Canada, 1863.

Report of the Special Committee on the Lake Superior Region, with Introductory Note. Jour. Geol. Feb.-Mar., 1905.

A Summary of Lake Superior Geology with Special Reference to Recent Studies of the Iron-bearing Series, by C. K. Leith. Trans. Am. Inst. Min. Eng., Vol. 36, 1906, pp. 101-153.

Report of a Special Committee on the Correlation of the pre-Cambrian Rocks of the Adirondack Mountains, the 'Original Laurentian Area' of Canada, and Eastern Ontario, Jour. Geol. April-May, 1907.

The Problem of the pre-Cambrian, by Chas. R. Van Hise, Bulletin of the Geological Society of America, Vol. 19, pp. 1-28.

The basis of pre-Cambrian Correlation, by Frank D. Adams, Journal of Geology, Vol. XVII., Feb.-Mar., 1909.

Pre-Cambrian Geology of North America, by Van Hise and Leith, Bulletin 360, U.S. Geol. Survey.

The Geology of the Lake Superior Region, by Van Hise and Leith, Monograph LII, U. S. Geol. Survey.

A Standard Scale for the pre-Cambrian Rocks of North America, by A. C. Lawson. Published by the 12th Int. Geological Congress, Toronto, 1913.

The Cobalt-Nickel Arsenides and Silver Deposits of Temiskaming, fourth edition, by Willet G. Miller, 19th Report, Bureau of Mines, Ontario, Part 2.

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