

## DISCLAIMER

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REVISED PROGRAM  
NEW ENGLAND INTERCOLLEGIATE GEOLOGICAL EXCURSION,  
MONTREAL, 1931.

SATURDAY. Oct. 10

- 9.00 a.m. Registration at the Redpath Museum, McGill University.
- 10.00 a.m. Leave Redpath Museum by bus for St. Helen Island; leader, J.J.O'Neill. Return by bus.
- 1.00 p.m. Lunch in McGill Union, corner of Victoria and Sherbrooke Streets, opposite campus.
- 2.00 p.m. Leave on foot from Redpath Museum to cross Mount Royal; leaders, J.J.O'Neill, R.P.D.Graham, J.E. Gill, and others. Return by bus.
- 8.00 p.m. Meeting in McGill Union. Social evening.

SUNDAY Oct. 11

Choice of either of the following excursions.

- 9.00 a.m. sharp Leave Redpath Museum by bus for all day trip to the Pre-Cambrian of the Laurentians. Bring lunches. Leaders, J.J.O'Neill, R.P.D. Graham, F.F.Osborne. Return to Montreal about 5.30
- 9.00 a.m. sharp Leave Redpath Museum by bus for all day trip to examine the stratigraphy of the vicinity of Montreal. Bring lunches. Leaders, T.H.Clark, H.W.McGerrigle.

MONDAY Oct. 12

- 8.30 a.m. Leave Redpath Museum by bus to see the Appalachia front in the vicinity of Phillipsburg, Que. Leaders, T.H.Clark, H.W.McGerrigle.

## ST. HELEN'S ISLAND.

St. Helen's Island, now one of the most beautiful recreation grounds of Montreal, is rich in historical associations as well as being of peculiar geological interest.

It received its name from Champlain about 1611, in honour of his beautiful young wife Helen Boulle, and because of its natural facilities for defence became a stronghold of the French against the Iroquois. It was here that, two hundred years later, the Marquis de Levis, commanding the last French Army, burnt his flags in the presence of his troops the night previous to handing over the colony to the English.

In the days of the British garrisons the island was a very gay place, but nothing remains of its former brilliancy, except the old barrack buildings, a block house, some old cannon, and grass-covered earthworks.

In 1688 the island was acquired by Charles Le Moyne, Sieur de Longueuil, and during the eighteenth century his descendants, the Barons of Longueuil, had a fine manor house there, the ruins of which are to be seen on the east side. The island was acquired from them during the war of 1812, being finally ceded to the city in 1874.

GEOLOGY.- St. Helen's island, Isle Ronde, and part of the adjacent bed of the St. Lawrence are made up principally of a very interesting igneous breccia, apparently the filling of the neck of a volcano subsidiary to Mount Royal.

The breccia occupies an oval shaped area about 1 mile by  $\frac{3}{8}$  of a mile, and the only exposed contact is on the south end of St. Helen's island, where Utica shale occurs containing *Climacograptus*, *Diplograptus*, *Leptobolus*, *Triarthrus becki*, etc. The shale is highly broken and intruded by thin dykes and sheets which include *Camptonites*, *Monchiquites* and occasional *Manaeites*.

The groundmass of this remarkable breccia is highly altered but contains apatite, perovskite, pyrite, hydronephelite, epidote, abundant carbonates and doubtful melilite. While this matrix is too highly altered to permit of exact classification, many other, but much smaller occurrences of somewhat similar breccias occur about Montreal, and these have clearly a base of either *Camptonite*, *Alnoite*, or *Nepheline aplite*.

The fragments contained in the groundmass include samples from practically the whole geologic section from pre-Cambrian to lower Devonian, the latter represented by two large blocks of limestone at the north end of the island, one Lower Helderbergian and the other Oriskanian in age, and both containing numerous fossils. These lower Devonian blocks are now at the horizon of the Utica and are the only remaining evidence that such rocks once covered western Quebec.

### Bibliography.

1. "The Geology of St. Helen's Island", Molan and Dickson, Can. Rec. Sci., Vol. IX, No.1, Montreal, 1903.
2. "Lower Devonian Aspect of the Lower Helderberg and Oriskany Formation", C.Schuchert, Bull. Geol. Soc. Am., Vol. 11, 1900.
3. "On the Fossil Faunas of St. Helen's Island", H.S.Williams, Trans. Roy. Soc. Can., Vol. 111, 1909-10.
4. "On the Origin and Relations of the Palaeozoic Breccias in the Vicinity of Montreal", Robt. Harvie, Trans. Roy. Soc. Can., 111 Series, 1910.

## MOUNT ROYAL

Mount Royal, overlooking the city of Montreal, rises abruptly from a flat plain underlain by rocks of lower Palaeozoic age. It attains an elevation of 796.6 feet above sea-level and has an area of about  $1\frac{1}{4}$  miles, in a N.E. direction, by  $1\frac{1}{3}$  miles.

The Palaeozoic strata are almost everywhere mantled by drift, which has been terraced by a series of beaches marking successive stages of the retreat of the Pleistocene sea. The McGill University campus is situated on one of these terraces (152 feet), and the highest beach is found on Mount Royal at an elevation of 568 feet.

The strata immediately surrounding Mount Royal consist of Trenton limestone, usually nearly horizontal but in places tilted. Outcrops are numerous on the flanks of the mountain and locally the rock has been contact-metamorphosed. In some places, immediately in contact with the intrusive rock of the mountain, are remnants of Utica shale, highly altered to "hornfels". This may be well seen in the cliff immediately beneath the Lookout.

Mount Royal itself is composed of plutonic igneous rocks which have intruded the Palaeozoic strata. Some 18 years ago a tunnel was driven through the mountain, and it was found that contacts observed on the surface were encountered vertically below in the tunnel, showing that the intrusive has the form of a pipe. Mount Royal has been generally regarded as the root of a volcano. It presents an interesting and varied group of rocks, representing a succession of intrusions and all characterized by a high alkali content. In order of intrusion, these are, briefly, as follows:

(1) Essexite (exhibiting several facies), with its dyke sequence. By far the major portion of the igneous mass of the mountain consists of essexite. A very little nepheline has been observed in thin sections of the rock near the Lookout. Elsewhere, this mineral is absent, but the amphibole and pyroxene are typically sodic varieties, and chemical analyses of the rock invariably show normative nepheline. Olivine is present in some facies of the rock.

(2) Nepheline Syenite, with associated dykes and sills. This rock forms the western portion of the mountain and is best seen in the Corporation (or Forsyth) quarry. It contains abundant nepheline and an amphibole nearly related to hastingsite.

(3) Camptonite, which forms the matrix of a striking breccia that is well exposed somewhat to the west of the mountain proper. This was followed by still later dykes.

Eastward from the Lookout may be seen seven other isolated hills rising from the plain, the furthest being 50 miles from Mount Royal. All consist of rocks similar to those of Mount Royal, and as a group they constitute the Monteregian Hills.

At Mount Royal, the youngest rock cut by the intrusive is the Utica shale, but on St. Helen island nearby is a breccia with igneous matrix probably related to the Mount Royal intrusives and containing fragments of lower Devonian limestone. In the case of Shefford Mountain, the intrusion probably took place before late Carboniferous time. It is probable, therefore, that the Monteregian intrusions date back to the late Devonian or early Carboniferous period.

## PHYSIOGRAPHIC FEATURES IN THE VICINITY OF MONTREAL.

The city of Montreal is located in an extensive plain, which rises gently from sea level near Quebec city to an elevation of about 125 feet at Montreal. It also rises from the river toward the Canadian Shield on the one hand and toward the Appalachian front on the other. While somewhat irregular in detail, in contrast with its surroundings this plain is remarkably flat and regular. It is the most northeasterly division of the St. Lawrence Lowlands Province and is conveniently referred to as the St. Lawrence Plain. Its general form was established during the Tertiary by sub-aerial erosion which cut rapidly into the weak Paleozoic sediments forming its floor. A mantle of drift was spread over the surface during the Pleistocene and a subsequent marine invasion (Champlain Sea) served to smooth out many of the irregularities by reworking of drift already present and deposition of clay and silt carried in from adjacent land areas. Many details of the late Pleistocene and post-Pleistocene history have still to be worked out. Well formed terraces and many other features due to wave and current action and stream erosion on these soft surficial deposits may be seen on the trips north and south of Montreal.

From the top of Mount Royal an excellent view may be had of the surrounding country. Here it is seen that the general flatness of the plain is broken by a prominent group of residuals, etched out in bold relief. On a clear day seven of these may be seen toward the east and southeast. These are the Monteregian hills. In order, starting with the nearest they have the following names and elevations: St. Bruno 715 ft., St. Hilaire 1437 ft., Rougemont 1250 ft., Mt. Johnson 875 ft., Yamaska 1470 ft., Shefford 1725 ft., Brome 1755 ft. The skyline beyond is formed by the Notre Dame Mts., the extension of the Appalachian system into Canada. To the west, two other low hills appear within the St. Lawrence Plain. These are outlying masses of Precambrian rocks, projecting as islands through the Paleozoic and Cenozoic sediments. Looking northwest one sees the great mass of the Laurentians, while to the south it may be possible to discern the Adirondacks in New York State. The higher levels in the skyline are considered to represent the peneplain developed throughout the region during the Cretaceous or early Tertiary.

On the slopes of Mount Royal are to be found numerous beaches of shell-bearing sands and gravels as well as terraces interpreted as due to wave action during temporary halts as the waters of the Champlain Sea were gradually withdrawn from the area. The amount of post-glacial uplift varied from place to place. This is shown by the present warped character of the upper marine limit as reconstructed from the positions of the beaches found along the St. Lawrence valley. The highest beaches at Quebec city stand at 632, at Montreal 617 (or 574) and at Covey Hill 525 ft. The McGill campus and Sherbrooke Street are situated on the most prominent of the post-glacial marine terraces. Some of the higher beaches will be seen during the trip over Mount Royal.

Closer examination of the Laurentian escarpment and the Appalachian front will be possible on the trips to Ivry and Phillipsburg.

## STRATIGRAPHY OF MONTREAL

The Island of Montreal and the St. Lawrence Lowland consist of Upper Cambrian and Ordovician strata dipping very gently to the southeast, and resting upon a Pre-Cambrian basement which outcrops in the Laurentians and is found in wells some 2500' below Montreal. This complex has been intruded by the igneous masses of Mount Royal and the other Monteregian Hills.

Our route takes us through Westmount, Montreal West, Lachine, along the shore of Lake St. Louis to Ste Anne de Bellevue, where Macdonald College, part of McGill is situated. Here we cross the Ottawa River, and, returning, later cross the St. Lawrence by ferry from Lachine to Caughnawaga, an Indian village. Thence along the Lachine Rapids to Delson, and to Chambly, on the Richelieu R. Fort Chambly, recently restored, once barred the way from New England and New York to Montreal. Back to Montreal by St. Hubert airport, with the mooring mast used for the R-100, and the new Harbor Bridge.

1. ISLE PERROT. POTSDAM SS. Clomeric and cross-bedded. Hard enough for building stone. No fossils here, but Climactichnites, Protichnites and Lingulepis acuminata occur nearby.
2. STE. ANNE. BEAUHARNOIS DOL. Dark gray with irregular masses of calcite. Fossils rare. Ophileta complanata present. In neighboring quarries, now inaccessible, Hormotoma anna, Leperditia anna, and several trilobites have been found.
3. PTE. CLAIRE. LOWVILLE AND BLACK RIVER (LERAY) LS. The upper part of the cliff is Leray. Good fossils rare. Columnaria halli, Bathyrurus extans, with a few others. The Lowville, richly fossiliferous, is best seen on the flat nearer the road. Tetradium cellulosum, Cyrtodonta huronensis, Lophospira arachne.
4. CAUGHNAVAUGA. CHAZY LS. Thick-bedded, fragmental, cross-bedded, crystalline. Whole fossils rare. Hebertella vulgaris, H. costalis, Malocystis, Bolboporites americanus, Cheirocrinus forbesi.
5. DELSON. UTICA SH. Dip normal in direction but abnormal in amount. Giant concretions. Climacograptus typicalis, C. bicornis, Glossogr. quadrimucronatus, Leptobolus insignis, Triarthrus becki.
6. CHAMBLY. LORRAINE LS. & SH. Exceedingly fossiliferous. Catazyga headi outnumbers all others combined. Large Plactambonites sericeus common. Clidophora praevoluta, Lyrodesma poststriatum.

NOTE. The Trenton, already seen on Mount Royal, will not be again visited unless time permits.

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- RAYMOND, P.E. C.G.S. Guide Book # 3, 1913. Gives bibliography  
Foerste, F. U. Ord. of Ont. & Que. -- C.G.S. Mem. 83, 1916  
Notes on Lorraine faunas of N.Y. & Que. Bull.  
Sci. Lab. Denison Univ., vol. 17, 247-340, 1914

## THE LAURENTIAN AREA NORTH OF MONTREAL.

From Montreal our route is northwest across the Island of Montreal and Ile Jesus to St. Jerome. As far as St. Jerome, we pass over the successively older Ordovician beds that here underlie the St. Lawrence Lowland. Along our route, however, bedrock is mantled by till, sand, and gravel.

At St. Jerome, a fault probably separates the Precambrian rocks of the Canadian Shield from the Palaeozoic rocks. Our route leads up the valley of the R. du Nord to Piedmont. This section of the valley is largely drift covered but is underlain by meta-sedimentary rocks of the Grenville series and by Laurentian gneisses, except for the small boss of gabbroid anorthosite with its transition zone near St. Jerome.

Near Piedmont, we pass over a topographic break onto the Morin intrusive complex. This igneous complex is characterized by the very large development of anorthosite and has gabbro, diorite, quartz diorite, and more acidic rocks as other facies within it. All the rocks have hypersthene as the mafic mineral and plagioclase as the predominant feldspar. Potash feldspar occurs as antiperthite. The mafic and iron-ore minerals as well as quartz, where it occurs, are interstitial to the plagioclase.

The ages of all these rocks are uncertain: rocks of the Grenville series are the oldest recognizable; the Laurentian gneisses contain fragments of the Grenville and possibly other series; the Morin complex cut the Laurentian and is cut by granites and syenites.

STOP 1, - 15 minutes. At St. Martin Chazy limestone is shown in the quarry west of the road.

STOP 2, - 30 minutes. Hebert Garage near Shawbridge. The Laurentian gneisses show some of their characteristic variations and here include fragments of amphibolite and other rocks.

STOP 3, - 20 minutes. Desgrosbois Siding. A body of gabbro rich in ilmenite and magnetite intrudes anorthositic gabbro of the Morin complex. This has been regarded as a titaniferous iron ore deposit.

STOP 4, - 1 hour LUNCH. Ivry Mine. A body of ilmenite with intergrown hematite cuts mauve anorthosite. The plagioclase is labradorite and is filled with minute inclusions, which give the feldspar its color. The thin sections show a few grains of quartz.

STOP 5, - 30 minutes. Grenville crystalline limestone is exposed midway between St. Sauveur and Piedmont. It contains graphite and apatite as well as silicate minerals. A hypersthene quartz-diorite is exposed in the small quarry back of the hill.

STOP 6, - Montreal.

### References:-

1. Logan, Geology of Canada, 1865.
2. Adams, Geology of a portion of the Laurentian area, etc., Geol. Surv. Can. Summ. Rept. 1895 J.
3. Robinson, Titanium, Can. Mines Branch, Publication 579.



*Granite*    
  *Coquit Limestone*    
  *Anorthosite*    
  *Quartz*    
  *Syenite*    
  *Cambrian*    
  *L. Silurian*

0 1 2 Miles

MONTREAL  
 OF QUEBEC

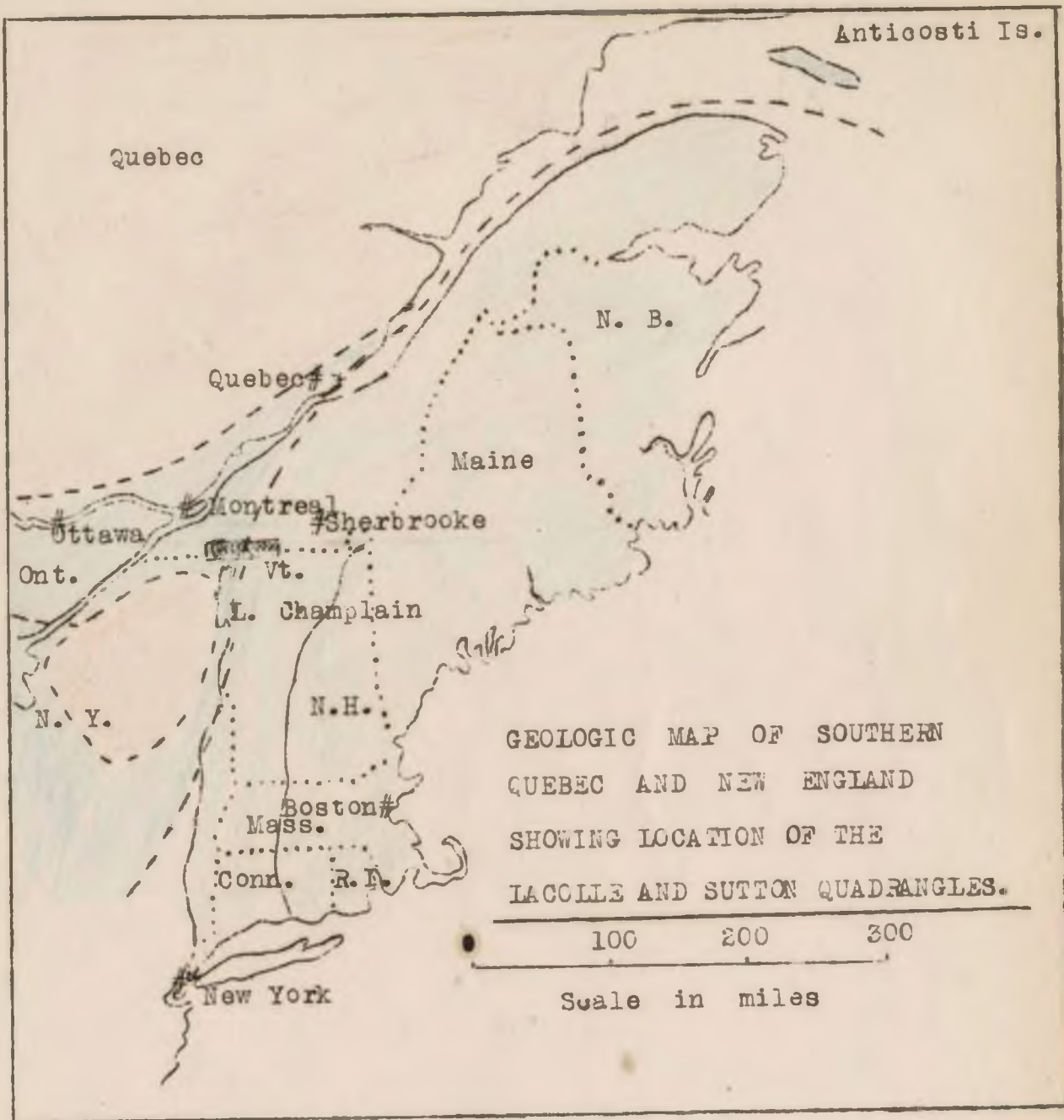
Map of the Anorthosite Area of Morin.



## GEOLOGICAL EXCURSION TO PHILLIPSBURG, P.Q.

We leave Montreal by the Victoria Bridge, travel along the King Edward Highway through Laprairie to St. Johns. Thence across the Richelieu to Iberville and south over the nearly flatlying Ordovician beds of the St. Lawrence Lowland. We pass close to Mt. Johnson.

- STOP 1. One mile N. of Phillipsburg. On the east is a cliff of Rock River dolomite, dipping gently east. The road is on Trenton-Utica shales, here considerably contorted, but less so further west, where they contain characteristic fossils. The Rock River is practically devoid of fossils, what few there are are U. Cambrian. This cliff is, then, the very edge of the present Appalachians.
- STOP 2. Phillipsburg. Shore of Missisquoi Bay. Small but good exposure of the actual thrust plane. Smashed Trenton-Utica shales below the massive U. Cambrian Rock River dolomite
- STOP 3. Phillipsburg Marble Co. Quarry. Said to be the largest "marble" quarry in Canada. Cut in the Strites Pond formation. The Wallace Creek limestone can be seen at the top of the cut.
- STOP 4. One mile south of Phillipsburg. To see the progressive dolomitization of the Strites limestone..
- STOP 5. Naylor Farm. Leave bus and walk one eighth mile North. Section here includes, from W. to E. the Hastings Creek, Naylor Ledge, and Luke Hill limestones. Interest centers chiefly about the N.L. -- L.H. contact. The obvious relationship is a normal unconformity, with a karst topography developed on the underlying N.L. having been filled by debris at the beginning of L.H. time. Owing to difficulties in understanding the succession of faunas Ulrich has suggested that the N.L. is really younger than the L.H. and is a cave filling in the latter, part of which has been removed by the cave making process. Fossils abound, but are hard to get out.
- STOP 6. En route to Stop 6, we pass by the Solomons Corner and the St. Armand formations, which can be seen dipping E. Near the corner of the road at St. Armand however the St. Armand limestone has a West dip, which is in part, if not wholly due to the effect of the overriding thrust block from the east.
- STOP 6.  $1\frac{1}{2}$  miles N. of St. Armand. This is the top of the Phillipsburg Block. The road is on Lower Cambrian dolomite. We walk across it to the shattered Solomons Corners limestone. In places the actual contact can be seen. Thus both top and sole of the Phillipsburg thrust block can be seen.
- STOP 7. Fensters of the Solomons Corners within the Milton. Adjacent to the road is a thick breccia representing the basal part of the Milton broken up as it overrode the Beekmantown. At the edge of the wood part of this latter formation can be seen completely surrounded by Milton.



- Pre-Cambrian. Laurentian and Adirondack mountains.
- Flat lying sediments of the Interior Basin.
- Mountain built rocks of the Appalachian terrane.

2.

PHYSIOGRAPHIC FEATURES IN THE VICINITY OF MONTREAL.

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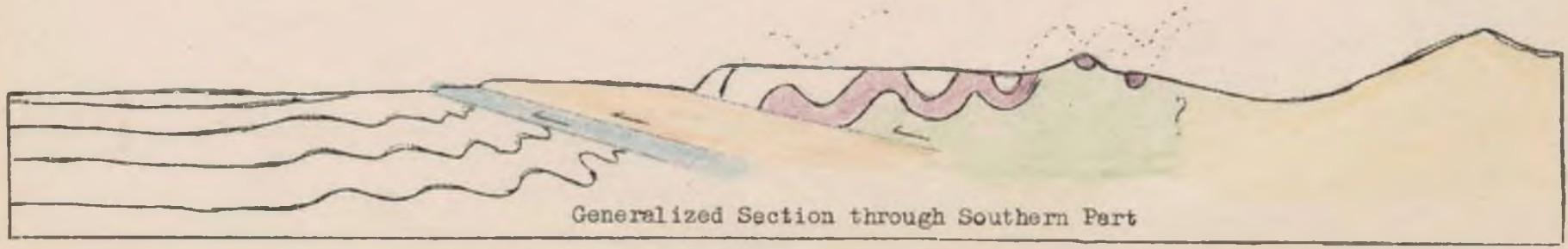
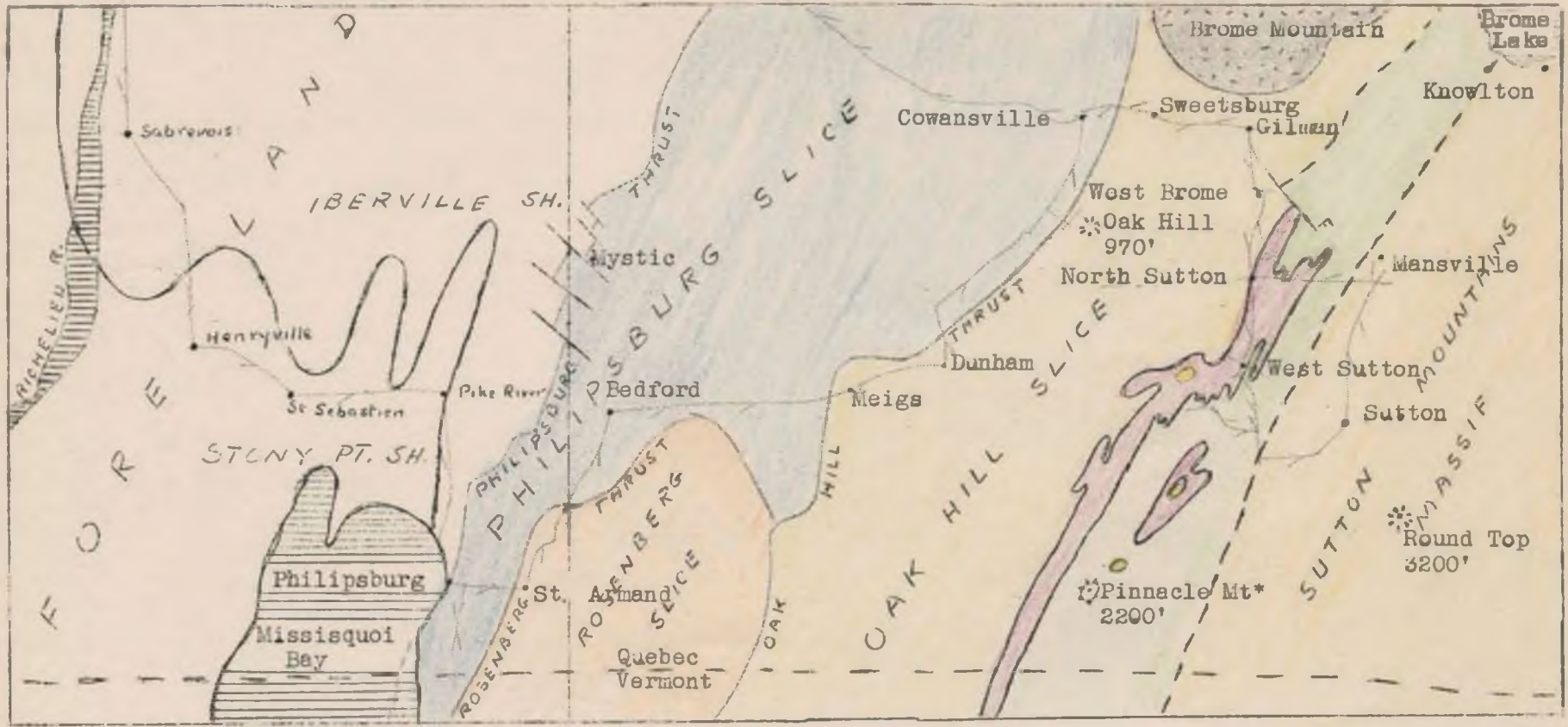
From the top of Mount Royal an excellent view may be had of the surrounding country. Here it is seen that the general flatness of the plain is broken by a prominent group of residuals, etched out in bold relief. On a clear day seven of these may be seen toward the east and southeast. These are the Monteregian hills, the name being taken from Mount Royal, 730 feet above sea-level. In order, St. Bruno 715 ft. above sea-level, St. Hilaire 1437 ft., Rougemont 1250 ft., Mt. Johnson 875 ft., Yamaska 1470 ft., Shefford 1725 ft., Brome 1755 ft. The skyline beyond is formed by the Notre Dame Mts., the extension of the Appalachian system into Canada. To the west, two other low hills appear within the St. Lawrence Plain. These are outlying masses of Pre-Cambrian rocks, projecting as islands through the Paleozoic and Cenozoic sediments. Looking northwest one sees the great mass of the Laurentians, while to the south it may be possible to discern the Adirondacks in New York State. The higher levels in the skyline are considered to represent the peneplain developed throughout the region during the Cretaceous or early Tertiary.

On the slopes of Mount Royal are to be found numerous beaches of shell-bearing sands and gravels as well as terraces formed by wave action during temporary helts, as the waters of the Champlain Sea were gradually withdrawn from the sea. The amount of post-glacial uplift varied from place to place. This is shown by the present warped character of the upper marine limit as reconstructed from the positions of the beaches found along the St. Lawrence valley. The highest beaches at Quebec City stand at 632, at Montreal 617 (or 574) and at Covey Hill 525 ft. The McGill Campus and Sherbrooke Street are situated on the most prominent of the post-glacial marine terraces.

Farnham

LACOLLE SHEET

SUTTON SHEET



Generalized Section through Southern Part



Scale in miles

TABLE OF FORMATIONS EXPOSED IN THE LACOLLE AND SUTTON AREAS

	FORELAND	P'BURG SLICE	ROSENBERG SL.	OAK HILL SL.	SUTTON MTS.
LORRAINE	Lorraine	Stanbridge	Various		SUTTON SCHISMS - These are the metamorphosed equivalents certainly of the Oak Hill Series, and possibly of others
UTICA	Iberville				
TRENTON	Stony Point Lacolle				
CHAZY	Chazy	Mystic	shales		
BEEKMANTOWN	Beauharnois	Basswood Cr. Corey St. Armand Solomons Cor. Luke Hill Naylor Ledge Hastings Cr. Morgan Cor. Wallace Cr. Strites Pond	called  "Georgia"		
UPPER CAMBRIAN	Potsdam	Rock River	Highgate Milton		
M. CAMBRIAN					
LOWER CAMBRIAN			Mallett	Vail Sweetsburg Scottsmore Oak Hill Dunham Gilman West Sutton White Brook Pinnacle Call Mill Tibbit Hill	

PHILIPSBURG, QUEBEC

We leave Montreal by the Victoria Bridge, travel along the Taschereau boulevard to Laprairie, where there are brickyards developed in the Utica shale, and thence to St. Johns, crossing the Richelieu R. to Iberville and proceeding south over the nearly flat-lying beds (Ordovician) of the St. Lawrence lowland. We pass close to Mt. Johnson.

STOP 1. -- One mile north of Philipsburg. On the east is a cliff of Rock River dolomite, dipping gently east. The road is on Iberville (Utica) shales, here considerably contorted, but less so further west, where they contain characteristic fossils. The Rock River is practically devoid of fossils, what few there are are Upper Cambrian. This cliff marks the very edge of the present Appalachians.

STOP 2. -- Shore of Missisquoi Bay, Philipsburg. Small but good exposure of the actual thrust plane at the base of the mountain-built complex. Smashed Trenton-Utica shales below massive Rock River dolomite.

STOP 3. -- One mile south of Philipsburg. Dolomitization of the Strites Pond limestone. On top of the outcrop there are numerous solution pits and cavities in the limestone.

STOP 4. -- Naylor Farm. Three quarters of a mile east of Philipsburg. The section includes, from west to east, the Hastings Creek, Naylor Ledge, and Luke Hill limestones. Interest centers around the Naylor Ledge - Luke Hill contact. The obvious relationship is an unconformity, a karst topography developed upon the Naylor Ledge having later been filled by debris at the beginning of Naylor Ledge time. Note modern karst topography on the Naylor Ledge outcrop. Fossils abound, but are difficult to extract. The details of the Hastings Creek - Naylor Ledge contact are interesting.

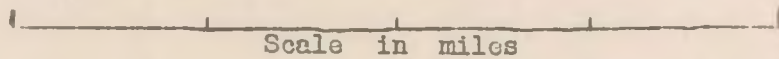
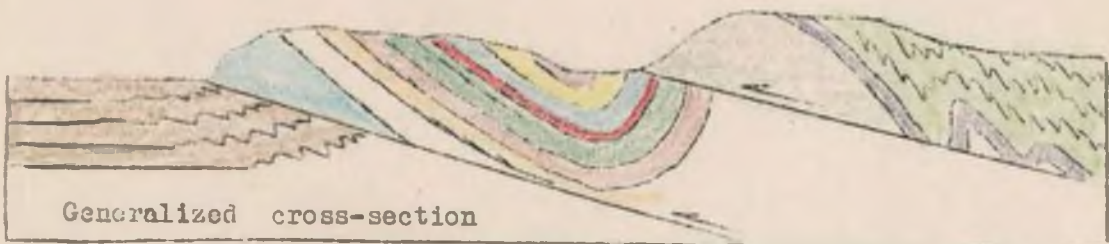
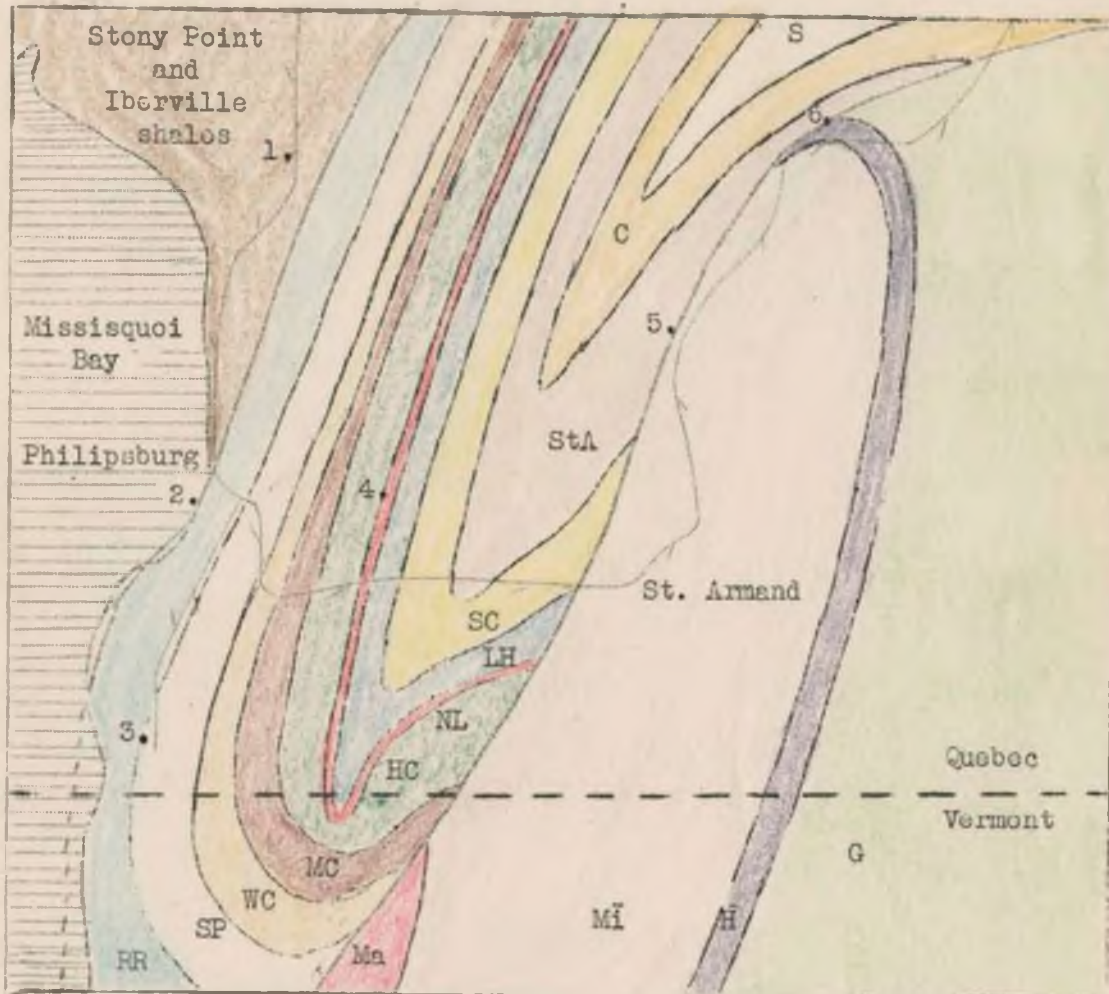
EN ROUTE TO STOP 5. -- We pass by the Solomons Corners and St. Armand formations, which can be seen first dipping east, and later nearly horizontal. At the corner of the road going down to St. Armand village the dip changes to the west. This is due in part, at least, to the overriding thrust slice from the east.

STOP 5. -- One and one-half miles north of St. Armand. The top of the Philipsburg slice in contact with the base of the Rosenberg slice. The road is on Upper Cambrian (Milton) dolomite. The shattered St. Armand lies to the west. In places the actual contact can be seen. Within one or two hundred feet of the thrust the Milton dolomite is nearly everywhere brecciated. The wind-blown sand grains are so abundant in parts of the Milton dolomite as to make it a sandstone.

STOP 6. -- Adjacent to the road is a thick breccia representing the basal part of the Milton dolomite broken up as it overrode the Beckmantown. At the edge of the woods to the northwest part of this latter formation can be seen completely surrounded by the Milton - a 'fenster'.

STOP 7. -- Deformed St. Armand limestone in contact with the nose of a southward pitching anticline, with Milton dolomite in the center, partly surrounded by crumpled limestones of the Highgate formation.

MAP AND STRUCTURE SECTION, PHILIPSBURG, QUEBEC.



EN ROUTE - BEDFORD TO OAK HILL

For six miles east of Bedford the road passes over a plain underlain by the crumpled and contorted Stanbridge slates of the Philipsburg slice. At Meigs we approach an escarpment, trending in general N.20° E., and held up by the resistant beds of the Oak Hill slice, though the actual trace of the Oak Hill thrust is half a mile west of Meigs. The steep slope is due to the unequal resistance to weathering of the Sweetsburg slate on the one hand and the Dunham dolomite and the Gilman quartzite on the other. The road stays within the Oak Hill slice as far as the fork three quarters of a mile north of Dunham, where it passes out again into the Philipsburg slice, and runs along on the Stanbridge slate for three miles. We then turn to the east, and near the end of the road again cross the Oak Hill thrust, and soon begin the climb up Oak Hill.

OAK HILL.

The formations to be seen on Oak Hill are listed below.

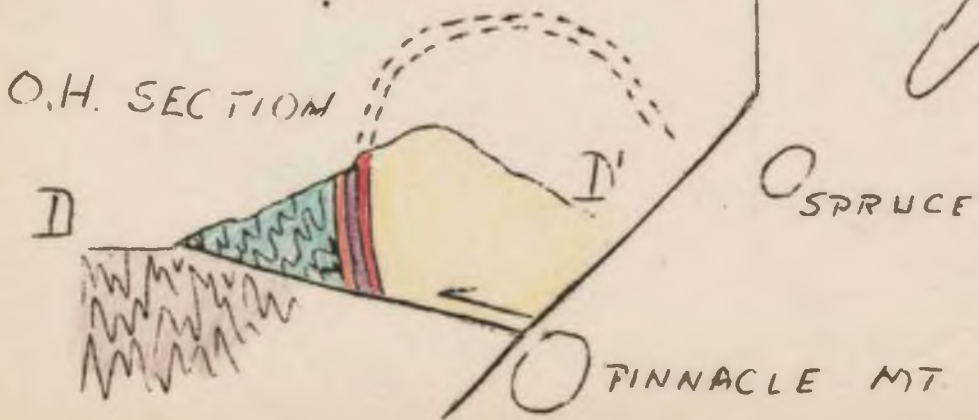
	Vail slate
	Sweetsburg slate
	Scottsmore quartzite
	Oak Hill slate
	Dunham dolomite
	Gilman quartzite

The problem of the order of succession, which always arises in the consideration of a series of sedimentary beds in a folded terrane, especially if their dip approaches ninety degrees, can be solved by a study of the cleavage of the Gilman quartzite, and also, elsewhere, by the cross-bedding in the Scottsmore quartzite.

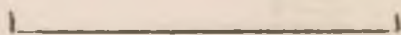
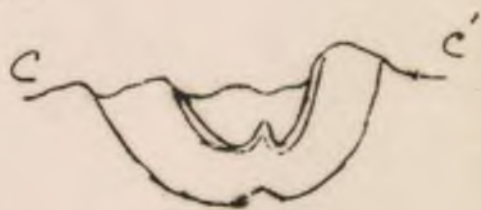
The crumpling of the Sweetsburg slate is noteworthy, as is also its stratification. The crumpling is doubtless due to a combination of its lack of competence and to its position at the base of a large overthrust slice. Both the Scottsmore and the Oak Hill are discontinuous formations. The Dunham dolomite always carries abundant quartz, either as segregations or as quartz veins. Note the virtual lack of apparent bedding in both the Dunham dolomite and the Gilman quartzite. The cleavage of the latter may easily be mistaken for bedding.

From the summit of Oak Hill the course of the escarpment developed along the trace of the Oak Hill thrust can be well seen. To the north it runs into Brome Mountain, one of the Montereian Hills. Most of the other Montereians can be seen, even Mount Royal. To the east, the lower beds of the Oak Hill slice outcrop almost to the base of the Sutton Mountains, which are made up of schists metamorphosed from rocks similar to, or nearly contemporaneous with, those of the three slices to the west.





SYNCLINE  
MAP  
AND  
SECTION



ONE MILE

HILL

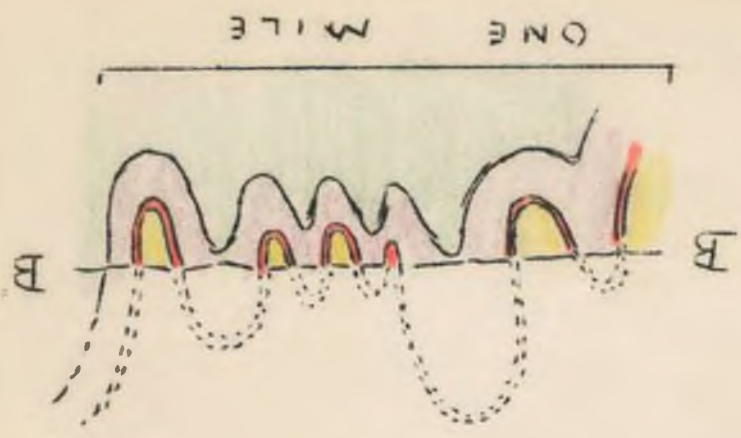
LOWER FORMATIONS OF THE OAK HILL SLICE

The Gilman quartzite is a very thick formation, with a breadth of outcrop of from two to six miles. East of it are the basal beds of the Lower Cambrian series and the basement of Chlorite schist. The stratigraphic succession is as follows.

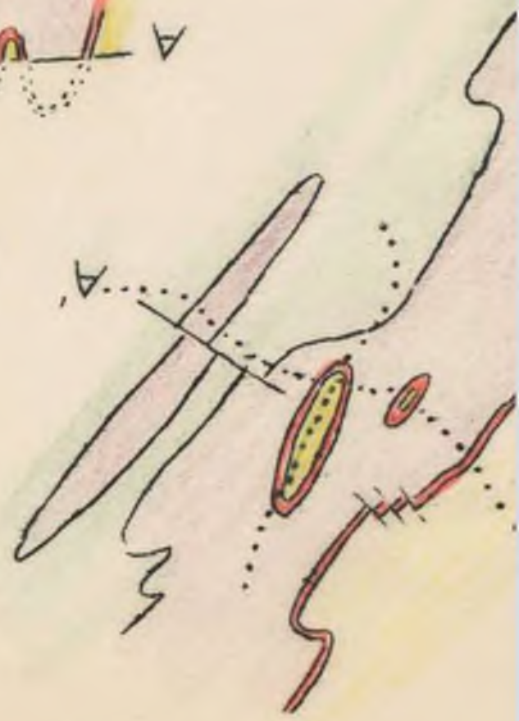
- Gilman quartzite
- West Sutton slate
- White Brook dolomite
- Pinnacle graywacke
- Call Mill slate
- Tibbit Hill chlorite schist

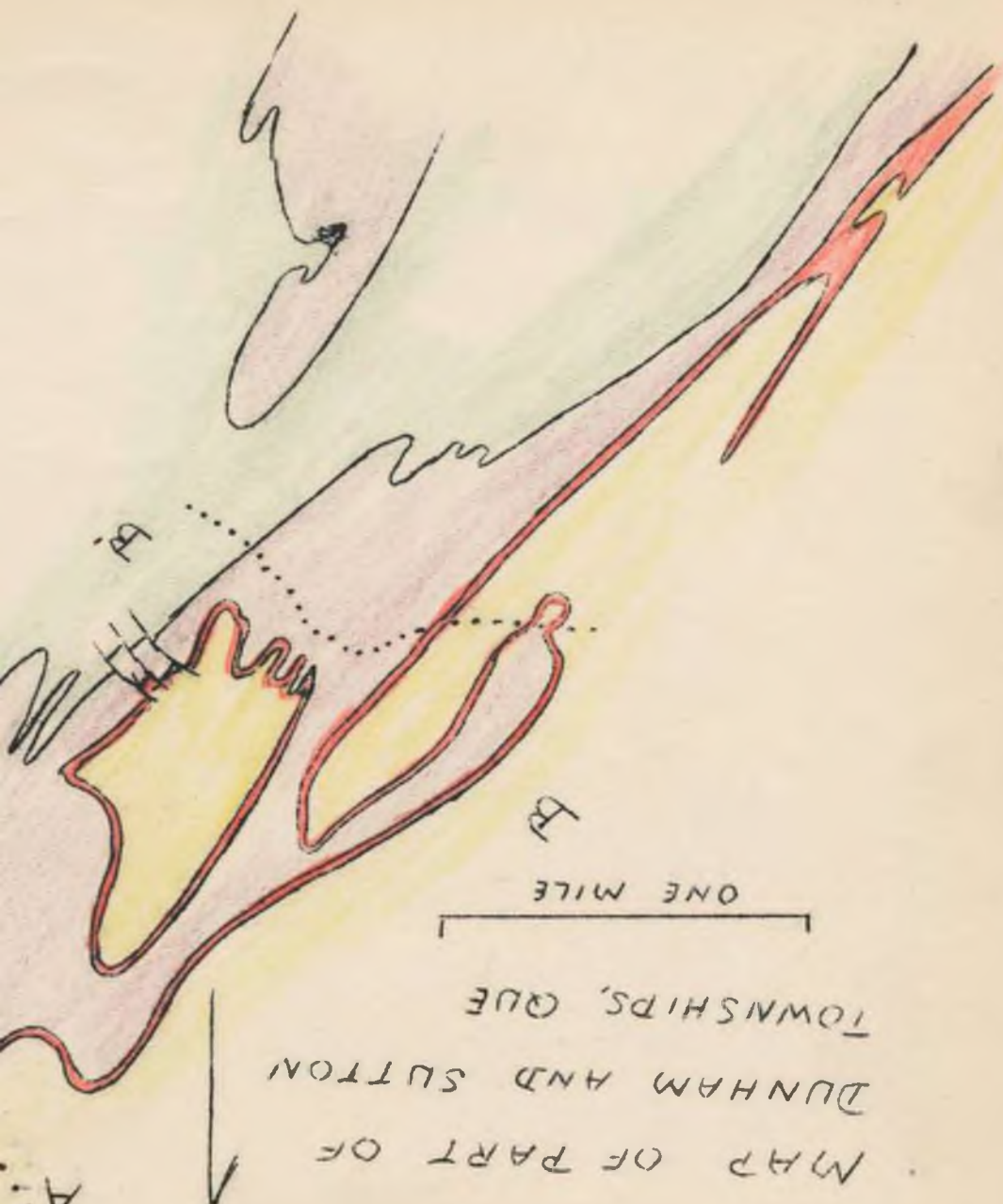
The basement, Tibbit Hill is an altered extrusive rock, in places richly amygdaloidal, in others consisting of little else but dense chlorite. Lying upon it is the Call Mill slate, followed by the Pinnacle graywacke, which in many places is rich in detrital magnetite-ilmenite grains. It is coarsely cross-bedded. In several places it has been quarried as an iron ore, but without success. The White Brook dolomite is almost indistinguishable from the Dunham dolomite, except that it contains a fairly great amount of chlorite and hematite stringers. Succeeding this is the West Sutton slate, which can, when the stratigraphic order of succession is not clear, be distinguished from the Call Mill by its characteristic impregnation with hematite, especially in its basal few inches. Save for a few beds of quartz pebbles at its base the Gilman quartzite is remarkably uniform in composition and grain, though the latter is so fine as to make it almost impossible to see any of the component grains.

At the West Sutton schoolhouse locality the details of the contact between the chlorite schist and the Call Mill slate are not very clear, but the order of succession is unmistakable. The cleavage and stratification of the Pinnacle graywacke are both interesting. The fault which runs along the road here is easily demonstrable. Northward from the four corners is an outcrop showing the Pinnacle, White Brook, and West Sutton formations, in stratigraphic succession. West of the four corners, if time permits, a similar section can be seen, in which local crumpling of the heavy, iron-rich beds of the Pinnacle graywacke is particularly remarkable.



W. SUTTON  
SCHOOL HOUSE  
SECTION





MAP OF PART OF  
 DUNHAM AND SUTTON  
 TOWNSHIPS, QUE

ONE MILE

B

A

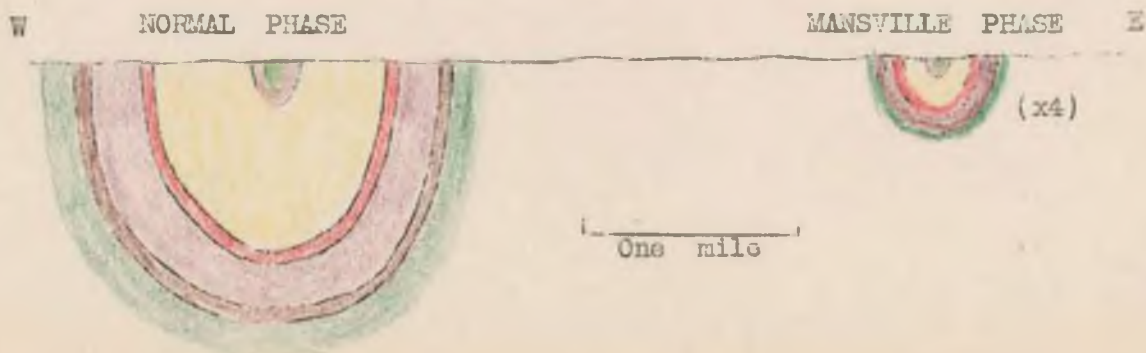
C

THE MANSVILLE PHASE OF THE OAK HILL SERIES

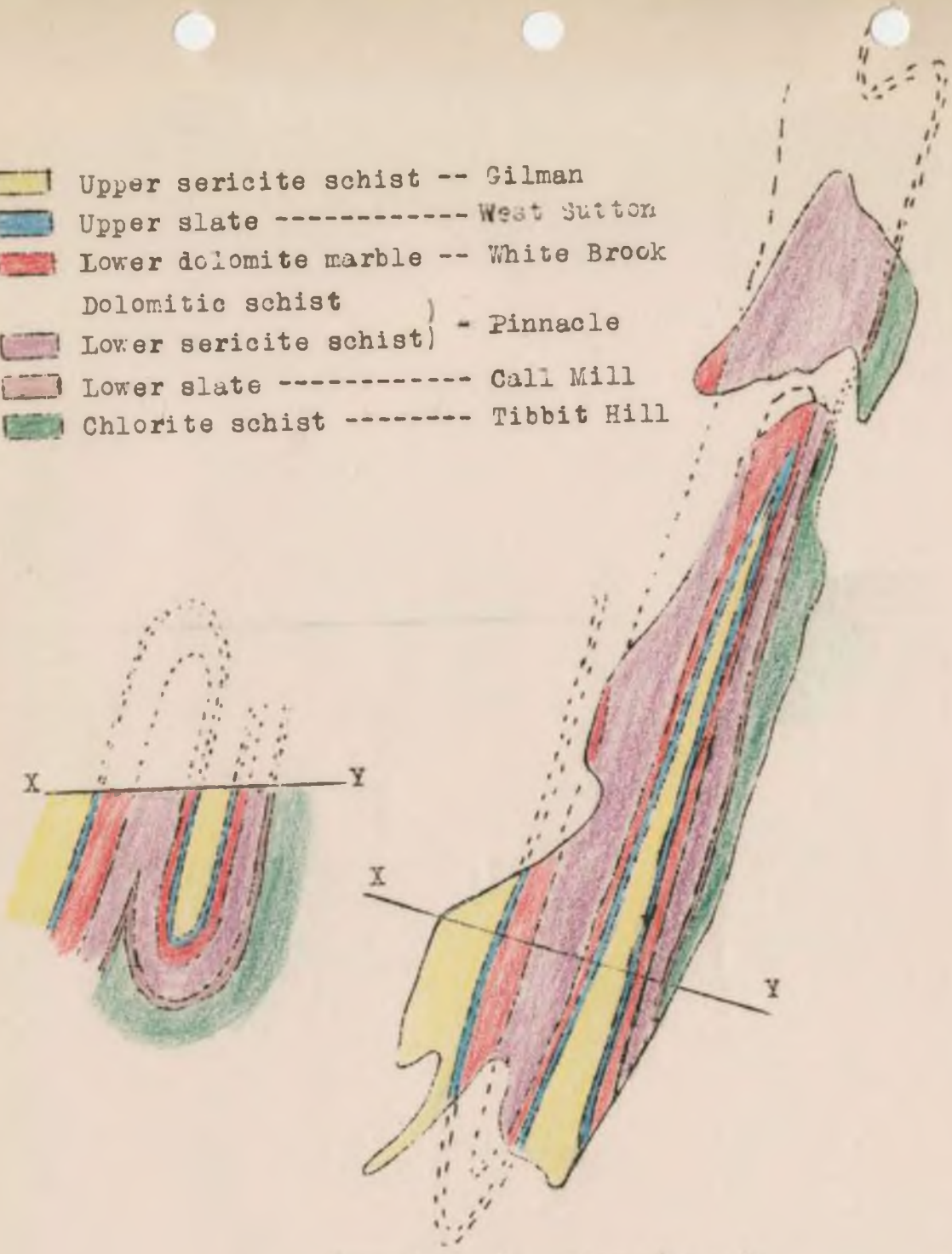
The Sutton Mountain massif (see map, p. 3) consists of a complex of schists, all more or less crumpled. Close to its western limit this schist body includes a succession of low grade metamorphics which show by their petrographic character, their order of succession, and their common basement of chlorite schist that they are in reality the metamorphosed equivalents of the beds of the normal Oak Hill Series, but in a much attenuated form. A table showing the comparison of the normal and the metamorphosed phases follows.

OAK HILL SERIES			
NORMAL PHASE	THICKNESS		MANSVILLE PHASE
Vail slate Sweetsburg slate Scottsmore qzts. Oak Hill slate	300	60	Phyllite and slate
Dunham dolomite	40 - 150	10'	Upper dolomitic marble
Gilman quartzite	2000	35 - 100	Upper sericitic schist
West Sutton slate	40 - 250	0 - 1	Upper slate
White Brook dol.	20 - 75	10 - 70	Lower dolomitic marble
Pinnacle graywacke	400	6 - 30	Lower sericit schist
Call Mill slate	1 - 100	1	Lower slate
Tibbit Hill schist	-----	-----	Chlorite schist
	2801 - 3275	122 - 272	

A problem arises concerning the contiguity of these two phases differing from each other so widely in thickness and metamorphism. The geological setting can be expressed diagrammatically in the following section in which, however, the right hand syncline is enlarged four times. Complete the diagram, showing a logical structure by which one can explain the otherwise anomalous association.



- Upper sericite schist -- Gilman
- Upper slate ----- West Sutton
- Lower dolomite marble -- White Brook
- Dolomitic schist
- Lower sericite schist ) - Pinnacle
- Lower slate ----- Call Mill
- Chlorite schist ----- Tibbit Hill



● 100 200 300 400 500

Scale in feet.

Map and section of an outcrop of the Mansville Phase of the Oak Hill Series. One mile south of Maneville. Brome Co., Que.

## THE SUTTON MOUNTAINS AND THE SUTTON SCHISTS

East of the chlorite schist is a belt of low-grade metamorphic rocks, nine to thirteen miles wide across the strike, occupying the Missisquoi (West Branch) Valley and the Sutton Mountains. These rocks consist of sericitic, siliceous, and carbonaceous schists, with, here and there, beds of dolomitic marble and quartzite. The Mansville Phase of the Oak Hill Series, described on page 11, outcrops close to the western border of these schists and is considered to be part of them. Everywhere the sedimentary origin of these schists is apparent. Locally throughout the mountains the rocks have been so impregnated with albite as properly to be called gneisses. This albite is interpreted as resulting from the recrystallization of the soda content of the original sediments under the influence of metamorphosing agencies. Analyses show a relatively high content of both soda and potash in the albite-free schists. That this albitization succeeded the folding of the sediments forming the schists is proved by the lack of straining in the individual albite crystals. These schists are for the most part intensely deformed, but in general have an anticlinal form, which is locally greatly complicated by drag folds. These drag folds are in accord with the general anticlinal nature of the series -- that is, the movement was upward on both flanks. In the central part of the range, deep gorges show practically horizontal beds of metasediments.

Along the eastern border of the Sutton Schists there is a falling off in the grade of metamorphism until, approximately along the Mansonville - Bolton Centre highway, the schists give way to slates. Because there is good reason for believing that these slates are Upper Cambrian, and because the Mansville Phase is known to be Lower Cambrian, the Sutton Schists are without doubt a composite group, and not improbably include metamorphosed sediments of Ordovician age also.

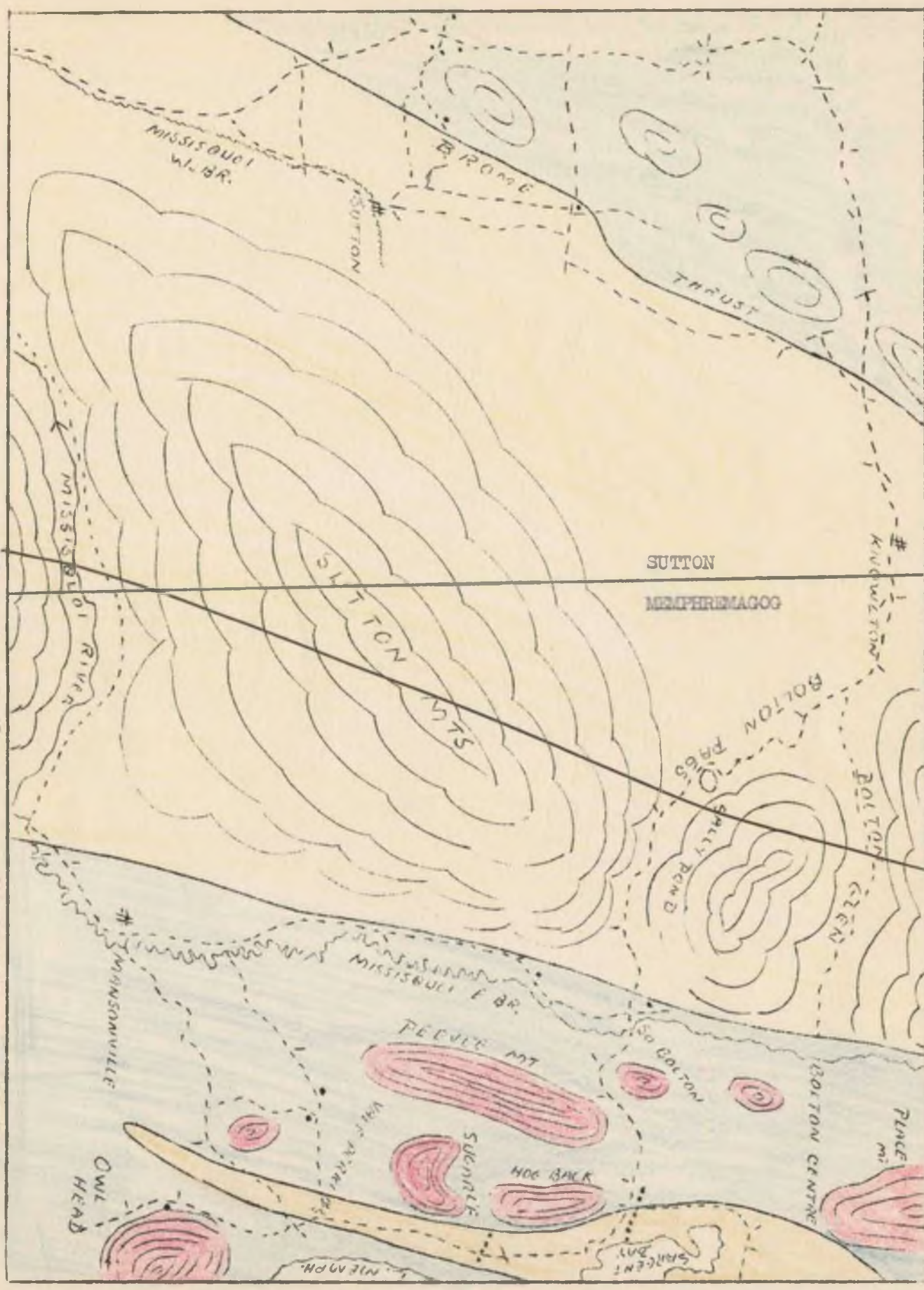
The Sutton Mountains, rising to 3200 feet (Round Top) in their southern part (they continue southward as part of the Green Mountains of Vermont) can be followed for 70 miles north-eastward, diminishing in height and width and finally disappearing altogether. In the Sutton - Memphremagog area they have been transected in two places. In the south the Missisquoi River traverses the whole range at an elevation of about 500 feet. Further north, Bolton Pass is drained by two streams flowing in opposite directions, the divide being just west of Sally Pond. The steepness of the rock walls along this latter trench and the fact that the summits reach an elevation of about 300 feet higher on the south side than they do on the north makes it probable that this rock is controlled, basically at least, by faulting.



OAK HILL SLICE

SUTTON MOUNTAIN MASSIF

- OAK HILL SLICE
- SUTTON SCHISTS
- MANSONVILLE AND MAGOG SLATES
- MEMPHREMAGOG COMPLEX
- BOLTON METAPERIDOTITE, ETC.
- SILURIAN AND DEVONIAN SERIES



Structural Axis

SUTTON

MEMPHREMAGOG

SUTTON

BOLTON PAGES

SALT POND

BOLTON GREEN

PEEVE MT

SUGARLOAF

HOG BACK

OWLE HEAD

MANSONVILLE

MISSISSIPPI W. BR.

SUTTON

BOLTON CENTRE

PLICE M.

S. MEMPH.

SARGENT BAY

KNOXVILLE

MISSISSIPPI RIVER

MISSISSIPPI W. BR.

SUTTON

BROME

THRUST

## THE MEMPHRETAGOG COMPLEX

### MANSONVILLE AND MAGOG SLATES

In the Memphremagog quadrangle there is a considerable variety of formations. The Sutton schists occupy the western part and grade eastwards into the Mansonville slates and quartzites, presumably Upper Cambrian. These are succeeded, with no observed unconformity, by a thick series of carbonaceous mudstones, the Magog slates, which contain Trenton graptolites, and occur on both sides of Lake Memphremagog.

### BOLTON IGNEOUS SERIES

Along the west side of Lake Memphremagog there are large outcrops of metabasalt, metagabbro, and metaperidotite, which are collectively called the Bolton Igneous Series. They stand up, in places, as sub-conical hills, and have the physiographic appearance of volcanic necks, or stocks. Hitherto they have invariably been considered intrusions. However, pillow structure is common in many places - the pillows being inclined at high angles - and breccias of the fragmented roof type are known. Flow structure, too, can be identified. The Bolton Series is known to be younger than the Magog slates, because in one or two places the igneous rock occurs as dikes cutting the slates. The metaperidotite intrudes the Sutton Schists, where it is associated with deposits of magnesite and talc. This series is known to be older than the Silurian beds, because blocks of the metabasalt occur in the basal breccias beneath the Silurian series.

### SILURIAN SERIES

Let down into the complex of Magog slates and Bolton Igneous Series are several narrow synclines of Silurian, and possibly Devonian, beds. These strata rest with a basal conglomerate on both the Magog slates and the Bolton series. In one place a coarse breccia with blocks of quartzite and metabasalt intervenes between the older rock and the quartz conglomerate, and resembles a talus accumulation. The Silurian Series begins with a basal conglomerate varying in thickness up to forty feet. The pebbles are all small, rarely more than two inches in diameter, most of them quartz, some slate. Succeeding the conglomerate is a thick series of sandstones and shales about 1500 feet thick, which is interbedded with a dark carbonaceous limestone in which may be found an abundance of corals, including Halysites, and is succeeded by a pure, practically unfossiliferous, dove-colored limestone.