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GEOLOGY OF ARTHABASKA MAP-AREA AND THE EAST HALF OF LYSTER MAP-AREA (COMTES DE MEGANTIC ET D'ARTHABASKA)

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EXPLORATION GEOLOGIQUE

MINISTÈRE
DES RICHESSES
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DIRECTION GÉNÉRALE
DES MINES

GEOLOGY OF ARTHABASKA MAP-AREA AND THE
EAST HALF OF LYSTER MAP-AREA,
EASTERN TOWNSHIPS, QUEBEC.

H.C. COOKE

FINAL REPORT

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GEOLOGICAL EXPLORATION SERVICE

GEOLOGY OF ARTHABASKA MAP-AREA AND THE EAST HALF OF LYSTER MAP-AREA,
EASTERN TOWNSHIPS, QUEBEC

by

H.C. COOKE
1954-1955

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GEOLOGY OF ARTHABASKA MAP-AREA AND THE EAST HALF OF LYSTER MAP-AREA.

by

H.C.Cooke

Introduction.

Arthabaska map-area is part of the Eastern Townships of Quebec, and is situated some sixty miles southwest of Quebec city. More precisely, it lies between $71^{\circ}30'$ and 72° west longitude, and 46° and $46^{\circ}15'$ north latitude. Its area is slightly more than 400 square miles. Lyster map-area, of practically the same size, lies directly north of Arthabaska map-area, and the geology of its east half is described in this report, along with that of Arthabaska.

Access to all parts of the area is easy. The branch of the Canadian National railway from Richmond to Quebec runs diagonally through the west half of Arthabaska map-area and continues through the east half of Lyster map-area; and the main line from Montreal to Quebec passes through the north part of Lyster map-area. The excellent paved highway no. 5 from Richmond to Quebec parallels the branch railroad fairly closely, and the still unfinished highway, no. 9, from Montreal to Quebec, lies a mile or so north of the main line of railway. A good highway, now being paved, runs southeast from Plessisville through St. Ferdinand and continues, east of the limits of the map-area, to Black Lake. Another paved road runs northeast from Desquet village to connect highway no. 5 with highway no. 9. Gravel roads, most of them fairly good, intersect the remainder of the area

at intervals of one to two miles, making it possible to reach any point with a minimum of walking.

The larger towns are strung along highway no. 5. Victoriaville, the principal centre of population, is a city of some in the southwest corner of Arthabaska map-area. It has grown so rapidly of recent years that now it is practically contiguous with the old village of Arthabaska which formerly lay two or three miles east of it. Other towns on the highway are Princeville and Plessisville, in Arthabaska map-area; and Laurierville, Lyster, Ste. Anastasio, and Desquet in the east half of Lyster map-area. Away from the highway are a number of villages that serve as postal and shopping centres. In Arthabaska map-area these include St. Ferdinand, on the Plessisville - Black Lake highway, where a large mental hospital has recently been completed; St. Pierre Baptiste; St. Jean Baptiste, a village in Halifax township, range line II-III, lot 5, so new that it does not appear on the topographic map; Ste. Sophie; Trottier Mills; Ste. Helène de Chester; and Norbertville. In the east half of Lyster map-area are Inverness in the southeast corner, and St. Janvier de Joly in the northern part.

Physical Features.- The northwest part of Arthabaska map-area, together with all of Lyster map-area except some 33 square miles in the southeast corner, is a near-horizontal plain underlain by the unconsolidated deposits of the Champlain sea. In the northwest corner of Lyster map-area this plain is about 300 feet above sea level, and it rises gradually toward the southwest. In Lyster map-area it rises to about 550 feet, where it meets the much higher ground presently to be described. In Arthabaska map-area the plain rises gradually to some 475 feet at a line running

about northeast through Princeville, where a more abrupt rise to 550 feet above sea level takes place within a distance of half a mile. It is probably more than coincidence that this rise takes place along the trace of a great fault. Southwest of Plessisville, and southeast of this line, the plain maintains a height of 550 to 600 feet for a width of two to three miles before it is bounded by higher ground. This band, though much of it is sandy, includes most of the better farming land of the plain. Northwest of the line through Princeville, and of the highland in Lyster map-area, the plain is sandy and infertile, and is largely covered with scrubby, second growth forest, much of it swampy.

Southeast of Plessisville, part of the lowland above 550 feet forms a sort of bay which runs northeast for several miles, almost to the boundary of the map-area. Plessisville therefore lies on the southwest end of what must have been a long point raised above the waters of the Champlain estuary. The rocks of this point belong to a series here recognized for the first time, the Plessisville group. Obviously they are more resistant to erosion than the Melbourne limestones which underlie the bay-like depression to the southeast. The point, of which Plessisville forms the extremity, rises on the northeast to 825 feet above sea level, and has a width of some two miles before joining the general upland.

On the southeast the plain is bounded by an escarpment separating it from a deeply dissected upland in a topographic state of late youth or very early maturity. Near Arthabaska village the escarpment is so steep as to suggest, perhaps, local faulting. Elsewhere the rise is more gradual, and the edge of the upland is dissected by stream valleys that afford easy slopes to the higher land beyond. On the upland, level-crested sky lines broken by occasional low monadnocks are evidence that

it is a dissected peneplain.

The upland may be divided into two distinct parts, which presumably reflect differences in the ease with which the rocks underlying them have been eroded. The part on the northwest is underlain by rocks of the Oak Hill series, that on the southeast by those of the Caldwell group; and in general, elevations on the Caldwell rocks are 250 to 300 feet higher than those in corresponding parts of the Oak Hill. On both, the ordinary relief is 250 to 300 feet. The main streams have, however, cut much deeper.

From the edge of the plain, the upland rises rapidly, usually within about a mile, to a height of 1,000 to 1,100 feet above sea level. The higher parts maintain this general elevation as far as the fault separating the Oak Hill and Caldwell rocks. Beyond this the surface rises further, so that the higher hills are 1,300 to 1,400 feet above sea level. The upland also displays a gradual rise from the northeast to the southwest. This is most pronounced on the Caldwell rocks, the hills of which rise from about 1,400 feet on the northeast to about 1,700 on the southwest. One or two peaks on the Caldwell rise even higher, to about 1,900 feet. These are probably monadnocks.

The main streams have cut deeply into the upland, deeply enough to have graded valleys for the most part, with narrow valley flats beside them. Here and there, it is true, short, deep narrow canyons appear, as on many streams of the Eastern Townships, but their very youthful characters prove them much younger than the rest of the valleys, so that they are clearly due to local glacial displacement of the stream courses, and appear to have been formed in an interglacial epoch.

The main streams, in addition, cut at large angles across the strike of the underlying rocks; some, in fact, almost at right angles. None

displays any adjustment to the underlying structure. In previous reports (4) it was inferred that these streams were established in their present courses before the mid-Pliocene (?) uplift of the peneplain that gave rise to the present upland area; and the evidence obtained in the area appears to confirm the inference.

The district is drained by a number of streams, all of which fall into the St. Lawrence river. One branch of Nicolet river crosses the extreme southwest corner of Arthabaska map-area, passing close to Arthabaska village and Victoriaville; a few brooks are tributary to this stream. Bulstrode river, another branch of the Nicolet, crosses the middle of the upland in a valley some 600 feet deep, running northwest; but shortly after reaching the lowland it turns at right angles to run southwest and joins the main Nicolet somewhat beyond the boundary of the map-area. The northeast half, approximately, of Arthabaska map-area, and much of the east half of Lyster map-area are drained by Becancour river. The main stream comes from Black Lake, and expands in Arthabaska map-area into Trout Lake, Lake William, and Lake St. Joseph. A fairly large tributary rises near Wolfstown, beyond the limits of the map-area, and flows north to enter Becancour river near Maple Grove.

The course of Becancour river is quite unusual. Entering the east side of Arthabaska map-area in Trout Lake, it swings to the north in passing through Lake William. From that point its course is somewhat east of north, so that it passes out of the east side of the map-area about a mile from the northeast corner. It remains east of the area under discussion for some six miles, and enters Lyster map-area about five miles from the southeast corner. This area it crosses on a general east-west course. In range XI, Inverness township, it has cut one of the narrow canyons mentioned

above, known locally as Red Falls because cut mainly in the red slates of the Granby group.

Creeks in the northwest part of Arthabaska map-area, of which the largest are Bourbon creek running through Plessisville, and the St. Rosaire river, reach the Becancour beyond the limits of the map-area.

The northern half of Lyster map-area is drained by Henry river and other creeks tributary to Petit Rivière du Chêne.

Field work.- About 68 years ago R.W.Ells mapped the southeastern part of Quebec on a scale of four miles to one inch, including the area here described. His map, which may be found in geological libraries, accompanied Annual Report III of the Geological Survey of Canada (1887-8), but his remarks on this particular area were very few. Later (1941) H.W.McGerrigle examined for the Quebec Department of Mines the hematite prospect in Chester, range II, lot 12, and mapped geologically several square miles of the country around. In 1942 B.T.Denis examined the copper prospect in Chester, range line II-III, lot line 5-6 approximately. Both these reports may be found in the files of the Quebec Department of Mines.

The field work on which this report is based was done in the summers of 1954 and 1955. In 1954 the writer was assisted by W.B.Skidmore, Michael V.Veilloux, and Benoit St.Laurent; in 1955 by Fernand Benoit, Peter E.Fox, and Jacques Martin.

General Geology

General Statement

The field work here described has done much to clear up several puzzling problems of the geology of the Eastern Townships.

When the writer first studied (3) the geology of Thetford map-area the term Bennett Schist was applied to what appeared to be the schistose equivalents of the Caldwell group of rocks. These schists underlie the central axis of the Townships, and may be termed the disturbed belt. The work of 1953-55 has proved that the "Bennett Schist" includes the Oak Hill series and the Caldwell group; and in the Warwick and Arthabaska map-areas it has been found possible to separate them in spite of the alteration they have undergone. The term "Bennett Schist" can therefore be discarded.

During the summer of 1955 two or three days' work was devoted to a hasty examination of outcrops in the northwest corner of Thetford map-area. Rocks of the Oak Hill series were found to occupy this corner. The band of dolomite mapped there in 1935 proved to be the White Brook dolomite of the Oak Hill, and outcrops in the brook at Kinnear Mills are Scottsmore quartzite.

This revision of previously held views was accompanied by a better understanding of the relations between the Oak Hill and Caldwell groups. It has been proved that a great fault lies between them, and that the Caldwell was thrust west, or northwest, over the Oak Hill for many miles. Probably a long period of erosion then took place before a second westward thrust drove the Oak Hill rocks, more or less reinforced by the remnants of the overlying Caldwell sheet, beneath the rocks west of them. Each movement gave rise to many drag folds in the schists, which indicate the direction of the movements producing them. The overthrust on the east

side, and the underthrust on the west, thus combine to give dips and drag folds in the schists that dip, in the main, southeast on the east side and northwest on the west side; so that the schists have a pseudo-anticlinal structure. Reference to the map will show that the axis of this pseudo-anticline lies about five miles southeast of the main anticlinal axis in the Oak Hill rocks.

The schists maintain these dips southwest to the international border and beyond; and as in that neighborhood so much quartz is injected into them as to render the original rock formations unrecognizable, geologists on both sides of the border (including the writer) have commonly accepted their structure as truly anticlinal. Further north, where the formations can be recognized, on the other hand, it can be seen that the structure has been produced by faulting.

In addition to the new conclusions described above, four previously undescribed series of rocks have been found in the areas under discussion; they will undoubtedly continue into other areas to the northeast. The most widespread is the Plessisville group, consisting of dark and pale grey banded slates somewhat resembling the Sweetsburg, associated with some basic lavas, dolomite, black limestone, etc. Some poor fossils were found in these rocks, which may prove of Ordovician age. The second group, termed the Inverness series, was found on and near the boundary between the Arthabaska and Lyster map-areas. It consists of well-bedded sandy limestones, and overlies the Oak Hill rocks with great structural unconformity. No fossils have yet been found except a few crinoid stems, but the rocks have been folded into a succession of closely spaced anticlines and synclines, and on this account they are considered as probably Silurian in age. Of the third group only two small outcrops have been found, both

near Inverness village. No name has yet been given to these rocks which are limestone breccias displaying no deformation whatever, and which may therefore be of Devonian age. The fourth group of rocks outcrops in the bed of Henry river, in the north part of Lyster map-area. They are mainly limy shales or shaly limestones with a strong oily smell, accompanied by a few beds of limestone conglomerate and sandstone. Dr.T.H.Clark, who has examined these rocks, found numerous fossils which indicate them to be of Utica age. They have been termed the Joly series.

The northwest part of Arthabaska map-area, and the middle part of Lyster map-area (east half) are underlain by the Granby group of rocks, in faulted contact with the Plessisville group on the southeast, and, in Lyster map-area, with the Joly series on the north.

The age relations of these different rocks is indicated in the following Table of Formations.

Table of Formations

Pleistocene and Recent	Moraine, Marine clays and sands, stream gravels, swamp mucks.
Devonian (?)	Limestone breccia or conglomerate.
Devonian or Silurian	Inverness series..	Quartzite, sandy limestone, limestone.
Ordovician (Utica)	Joly seriesLiny shale mainly, a little limestone conglomerate and sandstone.
Ordovician (?)	Plessisville groupBanded slate with some andesite, limestone and dolomite.
Cambrian (?)	Granby groupQuartzite, greywacke, red slate.
	Caldwell group	.. Schistose quartzite, greywacke, siltstone, slate, and lava.
Cambrian	Oak Hill series..	Melbourno graphitic limestone Sweetsburg slate Dunmore dolomitic quartzite Gilman formation West Sutton slate Frochette quartzite White Brook dolomite Pinnacle quartzite Call Mill slate Beta quartzite Tibbit Hill lavas Alpha quartzite

CAMBRIAN

Oak Hill series

General discussion.- The Oak Hill series forms a band running northeast through the middle of Arthabaska map-area. The band is nearly twelve miles wide in the south part of the sheet, but narrows to about seven miles near the north edge. In the east half of Lyster map-area only some twelve square miles of the extreme southeast corner are underlain by the series.

In Arthabaska map-area the Oak Hill series again displays the full succession from the Tibbit Hill schistose lava at or near the base to the Melbourne Limestone at the top. Near Ste.Helène de Chester the Tibbit Hill plunges south and disappears beneath the younger formations of the series. It is not seen again until a reversal of plunge brings it again to the surface near the south boundary of Drummondville map-area. From its appearance near Ste.Helène de Chester, the Tibbit Hill band continues northeast to pass out of the east side of Arthabaska map-area about four and a half miles from the northeast corner. A rapid reconnaissance has shown that it continues across the northwest corner of Thetford map-area in an east-northeast direction and may enter St.Sylvestre map-area about the middle of the south side.

One new member, and two others possibly new, appear in the Oak Hill succession of Arthabaska map-area. The new member, termed the Frochette quartzite, lies between the White Brook dolomite and the West Sutton slate; its thickness ranges from nil to 100 feet. The possibly new members are quartzites to which no name has yet been given. Bands of one are found within the band of Tibbit Hill lava, but it has not been found possible to determine its relations to the lava. The other appears to lie between the lava and the Call Hill, but relations are poor.

Alpha quartzite

A quartzite outcropping over widths of 250 to 300 feet has been found in many places in the middle of the band of Tibbit Hill lava. The outcrops succeed one another in a fairly regular linear manner, suggesting that they form parts of one continuous band, though in places a second band is found, possibly indicating repetition by folding. The rock weathers white or light grey. One thin section shows that the rock consists mainly of grains of quartz, with a good deal of albite and microcline and some white mica. All the minerals have been badly crushed and fragmented, and in many places the rock is intensely sheared. Absolutely no bedding has been detected in it.

The relation of this rock to the Tibbit Hill lava is still in doubt. The structure of the lava band is anticlinal, as shown by the presence, in places, of younger members of the series on each side, thus suggesting that the unnamed quartzite in the middle may underlie the lava. On the other hand, a synclinal downfold may be present in the middle of the lava band, so that the quartzite may overlie it. No sharp contacts have been found, and even if present would probably be of little value, as both limbs of the anticline dip northwest.

In Halifax township, range VI, lot 12, the quartzite displays a small drag fold with an amplitude of five or six feet. This drag fold plunges southwest at 25 degrees, and lava outcrops about thirty feet to the southwest, on strike. These relations suggest that the quartzite underlies the lava. If so, an important lithological change has taken place, as it was inferred (5,1) that some 40 miles to the southwest the lava is underlain by limestone.

Tibbit Hill Lava

The Tibbit Hill lava, along with the above-described quartzite, forms a band half a mile to a mile wide through the middle of Arthabaska map-area. Its precise distribution has already been described (ms.p.11).

The lava is a green, rather schistose rock, the composition of which suggests that most of it was originally andesitic to basaltic. A more acid variety was found in one place (Halifax, range II, lot 10, about a hundred yards south of range line II-III). There a small road cut shows a thin flow of hard, relatively fresh trachyte which has escaped the prevailing deformation. About 75% of it consists of laths of oligoclase-albite, in a matrix of secondary minerals. Amygdules filled with carbonate, plagioclase, and hornblende are numerous.

Excellent exposures of the Tibbit Hill can be seen on the hill in Halifax, range VI, lot 12; on the hill in Halifax, range IX, lot 10; and on the north side of the road west of Trottier Mills, Chester, range I, lots 11-12. Clean glaciated surfaces show that the rock is a succession of flows ranging from several inches to a few feet in thickness. Well developed flow textures can be seen in many places, and parts of the rock are highly amygdaloidal. Some bands are massive on one side and amygdaloidal on the other, from which the writer would infer that the amygdaloidal side was originally the top. Epidote lumps several inches in diameter are moderately numerous.

In Chester township, range I, lot 12, the west side of the Tibbit Hill band displays excellent pillow structures. Some of the pillows are highly amygdaloidal, and all have been stretched and flattened, so that the long axes strike N 35° E, and dip steeply northwest. The deformation has rendered them useless for structural determination. Almost opposite,

on the east side of the band (Halifax, range I, lot 11) structures appear that were taken for pillows even more deformed and elongated.

The schistose lava contains a great deal of magnetite, so much that its course can readily be followed on the aeromagnetic map of the district. Nevertheless, although a magnet applied to a crushed specimen of the rock commonly proves that much magnetite is present, parts of the band, similarly crushed and treated, contain no magnetite. In this they resemble bands of Caldwell lava, which likewise contain little or no magnetite.

At St. Ferdinand a narrow band of lava extends about a mile southwest of the village, appears to cross Lake William, and runs a couple of miles northeast of it. This lava is like the Tibbit Hill both in composition and in containing a high percentage of magnetite. It has therefore been mapped as Tibbit Hill, although it is surrounded by rocks of the Caldwell group.

Along the northwest side of the main band of Tibbit Hill there appears to have been a good deal of movement. Beyond it there should outcrop in succession the Call Mill slate, the Pinnacle quartzite, the White Brook dolomite, and the Frechette quartzite. Only scraps of these formations are now present, the remainder of the bands being apparently faulted away. The Call Mill slate was found only near the south end of the band. What is presumed to be the Pinnacle quartzite outcrops close to the lava on both the north and south ends of the band, but in Halifax, range VI, it disappears and the White Brook dolomite is in knife-edge contact with the lava. Still farther south, in Halifax, ranges III and IV, the lava is in direct contact with West Sutton slate.

Beta-quartzite

In Halifax, range III, lot 13, close to range line II-III, there is

a single outcrop of quartzite that appears to underlie Call Mill slate, and is between that rock and the Tibbit Hill lava. However, the first outcrops of the latter are three or four hundred feet to the east, so that this information has little value. The beta-quartzite is dark grey, and weathers dark grey, and thus appears definitely more basic than either the alpha-quartzite or any of the quartzites younger than the Call Mill. It is mentioned here in the hope that it may be more largely developed farther to the northeast.

The outcrop is strongly sheared, and is of medium grain, though this may be due to crushing. The thin section shows that about 25% of it consists of quartz fragments up to 1 mm. diameter, the larger of which are cracked with the component parts slightly rotated. Those not equidimensional show evidence of having been rotated so that the long axes now parallel the cleavage, or of having been stretched into this shape.

The groundmass of the quartz fragments is a directed aggregate of mica flakes and laths, including remnants of plagioclase and rather numerous small grains of quartz.

This quartzite, about 20 feet thick, lies directly west of Call Mill slate, and some 300-400 feet to the west the Tibbit Hill lava outcrops. The Call Mill is well exposed, and in direct contact with the White Brook dolomite, the Pinnacle quartzite being absent here. The White Brook in turn is directly in contact with the Frechette quartzite, and this in turn with the West Sutton slate. The whole succession is well exposed, except for the gap between the beta-quartzite and the Tibbit Hill.

Call Mill slate

In Chester, range II, lot 11, a few feet of gray slate lie between

the Tibbit Hill lava and the Pinnacle quartzite. It was identified from its stratigraphic position, as it has no lithologic resemblance to the more common Call Mill slate, which is dark bluish-black in colour.

Call Mill slate, similarly identified, also appears in Halifax, ranges II and III, lot 13, close to range line II-III. The slate so identified is dark grey, like that in the first-mentioned outcrop, and does not appear to be more than a few feet thick, probably of the general order of 20 feet. It lies directly beneath White Brook dolomite, which occurs here in three rather gentle folds. The slate therefore was identified as Call Mill, with the Pinnacle locally absent.

Pinnacle Quartzite

In Sutton map-area the formation directly overlying the Call Mill slate was termed by Clark (2) the Pinnacle groywacke, and was described by him as a quartzite containing much feldspar and a good deal of magnetite in places. The formation does not outcrop through Cranby map-area and about half of Orford map-area; but about the middle of the latter a coarse, very pure white quartzite appears in the same stratigraphic position. Hence, in spite of the lithologic differences, the name Pinnacle was retained for it. In the new Pinnacle no feldspar was found in the thin sections examined, but bands rich in magnetite are still present.

In Arthabaska map-area quartzite with similar composition and little or no bedding has been mapped as Pinnacle. The stratigraphic position seems to be about the same, but the very poor exposures along the west side of the Tibbit Hill band prevent a definite verification; and the appearance of the Frechette quartzite just above the White Brook dolomite renders it possible that some Frechette may have been mapped as Pinnacle. However, the latter, where definitely identified, contains much feldspar

but little magnetite; whereas the rock mapped as Pinnacle contains a good deal of black iron ore, and two thin sections show no feldspar whatever. Nevertheless, the faulting known to have taken place along the west side of the Tibbit Hill band has made errors possible.

The rocks mapped as Pinnacle outcrop over widths of 200 feet or more, but the thickness is probably less than half of that figure. Bedding is difficult to detect, and where found the beds appear to be one to three feet thick.

White Brook dolomite.

This formation is a white crystalline dolomite mottled in places with pinkish or purplish tints. In other places it contains a good deal of crystalline limestone and effervesces vigorously with cold dilute acid. It weathers to rather warm brown tints. It forms a more or less continuous band along the west side of the Tibbit Hill, particularly in the southern part; it rarely outcrops in the northern half of the Arthabaska map-area.

The formation varies widely in width of exposure. On the northwest side of the hill in Halifax township, range VI, lots 12-13, it is in knife-edge contact with the Tibbit Hill lava, the intervening formations being presumably faulted away. There it displays a width of approximately 200 feet. Less than half a mile to the southwest, and indeed in most places where observed, the band is only ten to twenty feet wide. These variations may be due to flowage under shearing stresses.

An analysis of the dolomite from Chester, range II, lot 12, is given in J. Obalski's Report of the Commissioner of Crown Lands for 1895, p.49.

It is

Lime	30.97%
Magnesium	17.41
Carbonic acid	33.79
Iron	4.73
Silica	2.07
Aluminium	0.09
Organic material	1.90
S, P	Traces
Total	<hr/> 90.96

Frechette quartzite

The Frechette quartzite has been found in three places, but is presumably present in others. In fact, as already mentioned, there is doubt that some outcrops mapped as Pinnacle may properly be Frechette.

In Halifax, range VI, lot 13, the Frechette lies between the White Brook dolomite and the West Sutton slate. There it is light grey and medium-grained, weathering a dazzling white. It is well-bedded, the beds ranging from six inches to a foot in thickness. A thin section showed about 50% of quartz, and about the same amount of orthoclase and microcline, with a little albite and a few shreds of white mica. Most of the feldspar was remarkably fresh. At this place the quartzite is 150 to 200 feet thick.

The formation was found again in Halifax township, range line I-II, lot 13, in the bed of a small brook about 1/50 feet northwest of its junction with another. It lies visibly between the White Brook dolomite and the West Sutton slate, each of which is in knife-edge contact with it. But for this fact its recognition would have been impossible or unlikely. The thickness here is only four feet, and the rock is a quartz pebble conglomerate instead of a quartzite. The pebbles are all of quartz - no

feldspar was recognized - and are mostly between one quarter inch and half an inch in diameter, with a few larger. Though a few of the pebbles are fairly well rounded, rounding is in general not pronounced, and quite a number have one or more moderately sharp angles. These features, like the fresh feldspars of the first occurrence, suggest rapid accumulation.

The formation was found a third time on both sides of the road that lies close to range line II - III, lot 13, Halifax township. Here a band of quartzite about ten feet thick can be followed for several hundred feet, lying between the White Brock dolomite on the west and the West Sutton slate on the east. Here the formation is a medium grey, coarse quartzite. In places a thickness of two or three feet of the base is badly sheared and impure, and carries rounded nodules of dolomite three to six inches in diameter.

Thus it is obvious that the Fréchette quartzite varies greatly in its lithology from place to place, so that unless a good section can be obtained, indicating definitely its stratigraphic position, its determination can easily be in doubt.

West Sutton slate

The West Sutton slate is a moderately dark grey or greenish-grey slate, large parts of which have dark reddish or purplish tints. Its hardness is about 2 to 2 1/2 on the Mohs' scale: greenish schists of similar appearance, but harder, usually prove to belong to the Gilman formation. On glacially polished surfaces it is common to find greenish-white bands rarely more than two or three inches wide. Bedding has usually been obliterated or obscured by shearing, but beds where seen are a few inches thick.

An interesting variation was noted in two places. In the creek valley at Mailhot, just southwest of the bridge (Halifax, range VII, lot line 24-25 approx.) the formation contains white siliceous beds about half an inch thick. Similar material was found in Halifax, range XI, lot 27, forming a lens-shaped bed about two feet thick. The rock is very light gray, almost white, extremely fine grained, and has a hardness nearly 5 on the Mohs' scale. A thin section was too fine grained for determination, but the material is probably a highly siliceous variant.

Gilman formation

The Gilman formation is in general a greenish schist, commonly distinguished by the presence of white or light gray siliceous bands less than a quarter inch in width. The bands of greenish schist between the lighter bands usually have widths of an inch or so and a hardness about 3 1/2.

Some changes of lithology take place in the northern part of the Arthabaska map-area. Just north of St. Pierre Baptiste the formation is a rather massive silt rock with thick beds in tones of darker and lighter grey and with none of the rather thin banding above described. It was identified from its stratigraphic relations to the overlying Dunmore and Sweetsburg formations.

Northwest of St. Pierre Baptiste, in Inverness, range I, lots 23-24, the Gilman contains beds of medium-grained, somewhat limy quartzite up to a foot wide. These were at first thought to be narrow infolds of the Dunmore formation, but are so numerous that they were eventually considered to be an integral part of the Gilman.

In Inverness township, range III, north end of lot 18, Gilman beds are magnificently exposed on small cliffs, beneath Sweetsburg and Dunmore

beds. The Gilman is made up of mudstone or siltstone beds several feet thick, separated by siliceous or feldspathic beds one to four inches thick.

The total thickness of the Gilman in this district appears to be small. At Mailhiot the Gilman and Sweetsburg are folded together in tight folds with near-vertical axial planes and near-horizontal plunges. The thickness of the Gilman does not seem to exceed 50 feet. Southeast of this point, in Halifax, range line VII-VIII, lot 23, good exposures show Gilman lying between West Sutton and Sweetsburg strata, with a width of only 25 feet. It is thought, however, that shearing may account for part, at least, of this lack of width.

Dunmore Formation.

The Dunmore formation is found in many parts of the area in its normal position between the Gilman and Sweetsburg. In some places, as near Ste. Sophie de Megantic, it is absent and the Sweetsburg lies directly on the Gilman.

The Dunmore is a dolomitic quartzite, with the lower part highly dolomitic, the upper part very quartzitic. Besides quartz and carbonate, a moderate number of plagioclase grains, smaller in size than those of quartz, are commonly present.

Along the road through range IV of Inverness, lots 16 to 19, the Dunmore appears as a succession of canoe-shaped anticlines projecting through Sweetsburg slate. In these the formation is a quartz-pebble conglomerate interstratified with some beds of coarse grit. The conglomerate is made up almost entirely of quartz pebbles in a dolomitic matrix which near the surface is badly weathered and rotted. In some beds the pebbles average more than an inch in diameter, and are crowded together with a

minimum of matrix; in others they are smaller. Few, if any, of the pebbles are well rounded. Most of them have irregular shapes, and a great many have sharp angles.

In lot 18 the conglomerate and grit lies between Gilman and Sweetsburg beds, and its thickness is about 20 feet.

In addition to quartz pebbles, an occasional chunk of slate or schist is present, angular in shape and six to eight inches in diameter. A few rusty masses were also noted; they may have been boulders of ferruginous carbonate.

In a cut on the road running southwest from St. Ferdinand, just south of range line V-VI of Halifax, the Dunmore is metamorphosed to a gneiss made up of white bands one eighth to one quarter inch wide, separated by irregular and discontinuous coarse chloritic bands. The white bands are mainly carbonate, and the chlorite is secondary after pyroxene, of which some remnants still remain. Perhaps 2% of clear fresh albite, together with some quartz, is present, mainly as grains included in large carbonate crystals.

Though there may be some doubt as to the propriety of identifying the gneiss as altered Dunmore, no Caldwell beds capable of yielding such a gneiss are known, and a black schist which may be altered Sweetsburg outcrops a few feet away.

Sweetsburg slate.

The characteristic Sweetsburg slate is a black or very dark grey slate with interbeds of white or light grey siliceous material spaced about an inch apart and commonly one or two mm. in width.

In Warwick map-area, however, parts of the formation are made up of alternating bands of light and dark grey slate about an inch or so

in width, with the characteristic white beds entirely lacking; in other places some narrow dolomitic beds were found in it. In Arthabaska map-area still larger parts of the formation exhibit these characteristics. Considerable amounts of the interbedded dark and light grey slate are present, and in places narrow dolomitic beds are quite numerous, particularly in the northeastern part of the map-area. One such place is in Inverness, range III, lot 18, where the dolomite beds are about an inch wide and reasonably numerous. One dolomite bed three or four inches wide was noted.

A change of grain also seems to appear near the north side of Arthabaska map-area, and makes the texture of some slate beds approach that of coarse silt.

The Sweetsburg underlies some of the larger areas of these intensely folded rocks and is therefore probably reasonably thick. T.H. Clark hazards the opinion that the thickness must be at least two or three hundreds of feet, and the writer would be inclined to suggest about the same amount.

Melbourne limestone

The Melbourne limestone, in most places, is a very schistose, black, graphitic, crystalline limestone that blackens the fingers when handled. It is found, however, on close examination, that the graphite forms very thin films around the grains of rock material, so that the total content of graphite, even where the rock appears to contain much of it, is less than 1%. Where the rock is not sheared it is dark grey to black, but does not blacken the fingers; some beds are lighter in colour and in places beds of ordinary grey limestone form part of the formation. The relations suggest that the shearing has caused the development of the

graphite. In many highly graphitic parts, rounded nodules of pyrite about half an inch in diameter are fairly numerous.

The shearing, recrystallization and flowage have obliterated the bedding in most places, though differences in the way various samples react with cold dilute acid indicate differences of composition. Some beds about half an inch thick were seen, however, in the canyon of Nicolet river at Victoriaville.

The Melbourne limestone was probably originally a few hundreds of feet thick. The Bulstrode river runs over an almost continuous section of it in its course through the flat between the upland and the fault through Princeville; other outcrops are numerous enough to suggest that it underlies most of this flat, an area of more than 75 square miles.

CAMBRIAN ?

Granby Group

The Granby group is supposed, from a few scattered outcrops, to underlie the unconsolidated deposits of the Champlain sea in the northwestern third of Arthabaska map-area, and to cross the east half of Lyster map-area in a band about nine miles wide on the west side, and some twelve miles wide on the east side. This inference is based, however, on the presence of a very few widely spaced outcrops projecting through the drift cover, or exposed in creek bottoms. The only places where outcrops are reasonably numerous are from Princeville northeast to the north side of Arthabaska map-area and about a mile farther; and, in Lyster map-area, in the bed of Becancour river.

In the northern outskirts of Princeville some large outcrops are

characteristic of those seen elsewhere. They include greenish impure quartzites and dark red slates. The quartzites are mostly fine to medium in grain. Quartz grains constitute 75% of them or somewhat more, grains of fairly fresh albite-oligoclase about 10%, and the remainder secondary chlorite, mica, and zoisite. These rocks are greenish on fresh surfaces and weather to rather warm brown tints. With them are interbedded some much coarser beds containing quartz pebbles up to a quarter-inch in diameter. Many pebbles are quite angular, suggesting rapid deposition and little wear.

With the quartzites more or less slate is commonly associated. The wider bands of slate are mainly dark red in colour, the red tint much brighter than the reddish tints of the West Sutton slate. Thinner slate beds interstratified with quartzites are usually grey in colour, though red slates have also been observed.

These rocks have yielded very little information as to structure, hence no determinations of succession or thickness have been made. Lithologically they are identical with the rocks of the Granby group near Granby.

Along the highway, about a mile and a half northeast of Ste. Julie station, some medium-grained, pure white quartzite outcrops. A thin section shows about 99% quartz in grains 0.4 to 0.5 mm. in diameter, with a little carbonate in intergrain spaces. Although entirely unlike most of the quartzite of the Granby group, it has been mapped as Granby for lack of other information.

Caldwell Group

The Caldwell group occupies the southeastern quarter of Arthabaska

map-area. Most of it lies southeast of the band of Tibbit Hill lava, but some isolated patches also lie northwest of that band. The rocks include both sedimentary and volcanic types.

The sedimentary rocks display wide variations in composition. In Chester, range II, south end of lots 14 and 15, fairly pure quartzites in beds several feet thick are interbedded with less pure quartzite and greywacke now sheared to mica-chlorite schist. In Halifax, range III, lot 14, fairly pure quartzites form beds one or two inches thick, separated by beds of greenish-grey greywacke of about the same thickness.

In many parts of the area, but particularly southeast of Ste. Helène de Chester, the common rocks are rather dark grey, fine-grained mudrocks or silt-rocks, with hardnesses about $3 \frac{1}{2}$ to 4. Most of them have a directed texture, but some do not. Several specimens examined by Dr. F.F. Osborne were reported by him to be all very similar. "They consist of albite, quartz, sericite (with paragonite ?), chlorite, and chloritoid. The chloritoid is very abundant and has its normal habit. Perhaps a little rutile. These are beautiful rocks and are formed from shales high in alumina and low in magnesia and lime. I cannot find rocks with precisely similar texture described".

In more metamorphosed parts of the Caldwell, rather silvery schists thickly spotted with small black crystals are common. These were determined by F.F. Osborne to be chloritoid, in a matrix consisting largely of white mica with a little quartz and albite. In some specimens about 35% of the rock is chloritoid.

Black slaty schists or phyllites have been mapped as part of the Caldwell group southeast of St. Ferdinand, and also for about a mile southeast of Avon corner, because such slates overlies without break a Caldwell

lava exposed in a road cut at the west end of St. Ferdinand. It is possible, however, that some bodies of similar phyllite are badly metamorphosed Sweetsburg slate.

Bands of basic lava are interbedded with the sedimentary rocks. Though now completely altered to chloritic schists, they appear to have been of andesitic or basaltic composition. In many places amygdaloidal textures have been preserved, and the epidote nodules characteristic of basic lavas are reasonably numerous. The bands of lava vary considerably in width. One only eight feet wide was found, but most of them have outcrop widths of a few hundred feet. They contain little magnetite, and hence show much less prominently than the Tibbit Hill lava on the aeromagnetic map of the district. Most of them strike N 15° - 20° E, distinctly more northerly than the Tibbit Hill band.

An unusual band runs northerly from lot 3, range line V-VI, Wolfestown township, into lot 1, range II, Halifax township, a distance of 2 1/2 miles. Its further possible extension both north and south is hidden by drift. At the south end this rock looks like a coarse gabbro or hornblendite; thin sections show it made up of lath-like hornblende crystals with a pronounced linear arrangement, and a small amount of interstitial matrix that is mainly quartz with some feldspar. At the north end, however, only the west side is thus metamorphosed. The eastern part is fine-grained, and contains both amygdules and epidote nodules, so that its identity as a lava is fairly certain.

It has been impossible to determine tops of beds in this part of the Caldwell group except in rare instances, or to establish any definite succession. Therefore no statement can be made regarding the structure, succession or thickness.

ORDOVICIAN?

Plessisville Group

The Plessisville group of rocks has not hitherto been recognized in the Eastern Townships, so far as the writer is aware. The main body begins at Plessisville and underlies the ridge to the northeast, widening rapidly to a width of about 2 1/2 miles. With varying width it crosses the southern side of the east half of Lyster map-area in a direction somewhat north of east; and the band passes across the east side of that map-area with a width of about three miles. The band is completely bounded by faults. One great fault separates it on the south and southeast from the Oak Hill rocks; another, on the north and northwest, from the Granby group. Near Plessisville these faults approach closely or coalesce, but to the southwest they separate again sufficiently to expose Plessisville rocks in three places. The largest exposure, about a mile and a half long and half a mile wide, underlies the town of Princeville. Much smaller bodies, represented by one or two outcrops, were found in Stanford, range VIII, lot 4, about half way between Plessisville and Princeville; and again near the west boundary of Arthabaska map-area, Stanford, range X, lot 25, four miles north of Victoriaville.

The principal rock of the group is a black argillite, commonly quite hard and therefore presumably containing more or less silica. Hardnesses of 4 to 6 in the Mohs' scale have been found, though more usually the hardness is not more than 3 to 3 1/2. In Lyster map-area this argillite contains, in places, numerous white beds up to a quarter-inch wide, that make it strongly resemble Sweetsburg slate. It is readily distinguished from the Sweetsburg, in mapping, however, as it is not associated with

other members of the Oak Hill succession.

Bands of andesitic lava, most of them very amygdaloidal, are associated with the black argillite. The largest is a band 50 or 60 feet wide that near Plessisville follows the north side of the band of Plessisville rocks for more than a mile. About a hundred yards above the northernmost bridge across Bourbon creek, in the town of Plessisville, this band displays excellent pillow structure. The pillows are almost spherical, very amygdaloidal, and average about a foot in diameter.

Similar lavas are found near the Somerset-Inverness line, in Somerset just northwest of range I, Inverness tp.; and in Lyster map-area, Inverness, range II, northeast of Rectory Hill on the north side of Becancour river. Road cuts or other large outcrops may show small bands a foot or two in diameter, interbedded with the shales. Dr. F.F. Osborne, of Laval University, who studied thin sections and specimens of the lavas and sedimentary rocks, has suggested that these thinner bands may be sills, but their highly amygdaloidal nature is opposed to that interpretation, in the writer's view.

The lavas are mostly altered to secondary minerals, but in a few places appear moderately fresh and hard. Thin sections cut from these show small phenocrysts of albite-oligoclase; Dr. Osborne also found some phenocrysts of microcline in one section. The matrix contains much albite-oligoclase in small laths. Parts that may have been glass display rather numerous small spherulites. Former mafic minerals are now rather completely replaced by chlorite, carbonate, etc.

A large outcrop about three quarters of a mile northeast of Plessisville, on the northwest side of the highway and some 300 feet from it, (Somerset, range VIII, lot 25) is a chert breccia. It is a rather dark

grey rock, weathering white, and made up of angular fragments of all sizes, but most of them less than an inch in diameter. Two thin sections of this rock were examined by Dr. Osborne who reports that they are about 70% quartz, the remainder a much altered mineral that was probably albite. "One thin section shows angular grains, the result of a brecciated structure. The fragments are quartz in a dactylic fabric with some other mineral. Some quartz is in spherulites with the Brewster's cross about 20 degrees to the Nicols. This is probably lutecite. Other masses consist of a granular mosaic of quartz". The rock, Osborne considers, is probably a silicified volcanic, possibly a low-quartz soda rhyolite. The spherulites are probably the result of alteration.

The sedimentary rocks of the Plessisville group include, in addition to the prevailing black argillite already mentioned, a variety of minor types. Here and there, as for instance below the falls on Bourbon creek where crossed by highway #5, on the west bank of the stream, is a bed some 15 to 20 feet thick of coarse agglomerate, made up of amygdaloidal fragments of lava like the pillow lava farther downstream. The fragments are angular, and up to six inches in diameter. Similar though less coarse agglomerates were seen elsewhere, as at the road corner, Somerset, range X, lot 17.

Along the crest of the ridge in Somerset, range IX, lots 20-24, the prevailing rock is rather hard black argillite in beds about an inch thick, which alternate with brownish-grey, thicker beds of much softer silt rock. Osborne considers them to be normal sedimentary types. Interbedded with them are beds of brown-weathering dolomite. Those observed range up to a foot or two in width, but some very large boulders near the creek in Somerset, range VIII, lot 24, indicate that much wider beds are

present in places beneath the drift. In Lyster map-area bands of dark limestone are found in addition. Most of them are only a few inches wide, but in the bed of Becancour river, near the east side of Lyster map-area, one bed about 25 feet wide is present.

There is no definite evidence as yet to indicate the structure and succession of the Plessisville beds. In Somerset, range IX, lot 27, about 250 feet northwest of range line IX-X, the beds in a road cut strike northwest and dip northeast at a low angle. This strike, at right angles to the regional strike, is obviously the crest of a fold, though whether of a regional syncline or of a drag fold is unknown. Individual beds yield no information; neither gradations in grain nor cleavage-bedding relations were found. The appearance of lava on the southeast side as well as on the northwest does suggest, however, that the mass as a whole is either synclinal or anticlinal, more probably the former in view of the evidence first cited.

In 1955 some poor fossils were found by T.H.Clark in the limestone bed in the Becancour river valley. Clark considered them as probably Ordovician, but a definite determination is deferred until they can be examined in detail.

ORDOVICIAN

Joly Series

The Joly series appears to underlie much of the northern part of the east half of Lyster map-area. It has been found in the bed of Henry river for more than five miles from the west border of the map-area, and also in the bed of the creek passing through Val Alain. Thus at the west side of the map-area the band of Joly series has a minimum width of four miles.

The principal rocks are brownish limy shales that strike northeast

and mostly dip southeast at low angles. The low-dipping beds swing suddenly over anticlinal crests, and the other short limbs have steep or near-vertical dips. Thus the beds lie in a succession of anticlines with axial planes that dip about 60° southeast.

Interbedded with the limy shales are a few beds of limestone conglomerate mostly less than a foot thick, and a few narrower beds of what look like quartzites. Thin sections of these, and of the finer-grained conglomerates, show that nearly all the fragments are carbonate like the surrounding limestone, though a very few grains of quartz are also present.

These beds were examined in August, 1955, by T.H.Clark, and were found to contain numerous fossils, chiefly graptolites. Clark's preliminary examination suggested that the beds are of Utica age.

SILURIAN OR DEVONIAN

Inverness series

The Inverness series is found in a small band about a mile and a half long and a quarter of a mile wide. Its south end is in Arthabaska map-area, in the northeast end of lot 25, range II, Inverness township, and from there it runs northeast into lot 23, range IV. In addition, several small outliers have been found over distances of some two miles from the main body.

The rocks of the series are mainly arenaceous limestones and limy sandstones in beds two to four inches thick, with occasional beds up to a foot or more. In a few places, near the contact with the Oak Hill, thick beds of hard quartzite containing little calcium carbonate have been found. Some beds near the middle of the band are limestone with little or no sand in them. In the main, however, a sand content of 25 to 50 per cent is

present. One thin section shows the sand grains to be all quartz, most of them about 0.5 mm. in diameter, and of various shapes, rounded, irregular, or with one or more sharp angles.

The south end of the band is found near the narrows in a small lake in lot 25, range II, Inverness township. West Sutton slate outcrops abundantly along the east side of the southern expansion of this lake, and at its south end. The West Sutton is flanked on both sides by the Gilman formation, so that the structure of the Oak Hill in this neighborhood is anticlinal.

The axis of the anticline strikes northeast and the cleavage, presumably parallel to the axial plane, dips vertically or steeply southeast. At the narrows of the lake the Inverness series appears, striking N 80° E and dipping 58° N. The beds are one to three inches thick and display neither contortion nor cleavage. A short distance farther northeast, just west of the north end of the lake, further outcrops of the limy quartzite strike N 62° E and dip 40° SE. Thus the structure of the south end of the Inverness band is that of a syncline plunging northeast, whereas that of the Oak Hill beds just to the southwest is anticlinal. Excluding faulting, of which there is no evidence, the only way of explaining these relations is to conclude that the Oak Hill beds were laid down, folded, and eroded to a surface of low relief before the Inverness beds were laid down on them.

It therefore seems indubitable that the Inverness beds overlie the folded Oak Hill rocks with great structural and erosional unconformity. Singularly, though, no trace of a basal conglomerate has been found at contacts. Since the Inverness was deposited, some gentle folding has taken place, so that the beds now lie in a succession of rather narrow

folds with dips on the limbs about 45°.

Search for fossils yielded only a few small crinoid stems. However, the great structural break seems to place the series above the Taconic orogeny, hence it has been indicated as Silurian or younger.

DEVONIAN ?

In the southwestern outskirts of Inverness village, and half a mile farther southwest, on the west side of the road, two outcrops of limestone breccia or conglomerate have been found. The first set of outcrops extends southwest about 150 feet, and is perhaps 50 feet wide. The second is much smaller, some 20 feet long and five or six feet wide. No local name has been given to these rocks, as much larger, identical masses are found in St. Sylvestre map-area to the east, and others have been described still farther east, and there found to contain lower Devonian fossils.

The rocks are composed mainly of fragments of blue-grey limestone, with grains and an occasional pebble of quartz, a few pebbles of brown-weathering dolomite, and one or two of slate. The limestone fragments or pebbles, which constitute 95% of the fragments and more than half of the rock, are most of them less than an inch in diameter, though a few attain two and a half inches. They have most irregular shapes; three fourths of them have one or more sharp angles and possibly 40% have two or more. Neither the fragments nor the rock as a whole displays any sign of squeezing, or has any directed texture.

The matrix of the fragments is mostly weathered to a rusty mass, and hence is probably dolomitic in composition.

This rock, which shows no sign whatever of deformation, lies only a few feet from outcrops of Sweetsburg slate and Gilman formation which

have not only developed a good slaty cleavage, but in which the beds are on edge and intensely drag folded. It is clear, therefore, that the limestone conglomerates cannot have been affected by the pressures which effected the deformation of the Oak Hill rocks. Obviously the conglomerate must overlie the Oak Hill beds with great structural unconformity. This conclusion, and the entire lack of deformation of the conglomerate, suggest that it is probably of Devonian age.

PLEISTOCENE

In an area of this structural complexity it is obvious that the geologist, in two brief field seasons, could give little study to the unconsolidated deposits. Only the following scattered observations were therefore obtained.

The upland part of the map-areas is covered, as usual, with stony ground moraine which, as outcrops are fairly numerous, appears to have no great thickness. No terminal moraines were noted.

In the lowland areas the moraine deposits are mostly covered by sands and muds deposited in the Champlain estuary. Marine clays and silts overlie most of the lowland area between the upland and the Princeville fault. They do not appear to have a thickness of more than about ten feet, as Bulstrode river cuts completely through them to run on a rock bed in most of its course.

Between Arthabaska and Norbertville a series of oval knobs of bedded gravel apparently overlies the marine silts and rises some 25 feet above them. An average size for these knobs is about half a mile long and a quarter-mile wide, with the long axis striking northeast. A more detailed study of these features is desirable.

Northwest of the Princeville fault the overburden rather abruptly becomes sand, poor agriculturally and now largely covered with scrubby second-growth forest and swamp. Possibly recent movement on the fault caused uplift of the part southeast of it, thereby shoaling the water of the Champlain estuary so that wave and current action could remove most of the sand.

Much of the sand northwest of the fault is coarse and obviously waterlaid, but other parts are windblown sands, fine grained and uniform. The depth of the unconsolidated deposits appears to be much greater than southeast of the fault line. Outcrops are very few there; in Lyster map-area Becancour river has cut fifty feet through the cover to encounter rock; and where the same stream crosses the northwest corner of Arthabaska map-area in a valley of about the same depth it exposes no rock whatever.

Ice Movement

A number of observations on the direction of glacial movement, as shown by moutonnée structures and the strike of glacial striae, were made in Arthabaska map-area. Practically all were found on the upland. Though many record the ordinary late movement from northwest to southeast, other movements are also indicated. Striae with directions of E-W or thereabout may have been made in the closing stages of glaciation when the ice was becoming thin and more influenced by local topography. Some of the observations are more puzzling, as they have northeasterly strikes and some of them seem to indicate movement from northeast to southwest, others a movement exactly opposite.

Locality	Direction	Movement	Remarks
Arthabaska, VIII, 3	N 20° E	None determined	
Arthabaska, XI, 3	N 45° W N 20° - 30° W N 25° - 30° E	NW to SE NW to SE NE to SW	Large grooves " " Small grooves cross floors of large
Halifax, I, 10-11		SE to NW	Moutonnée.
Halifax, I, 25	N 20° & 40° E	Undetermined	
Halifax, IV, 2-3	N 30° - 50° E N 10° E	SW to NE (?) N to S	Separate locality
Halifax, VI, 25	N 10° E	S to N	
Halifax, VIII, 28	N 30° W	NW to SE	
Halifax, IX, 19	E - W N 45° E	W to E SW to NE	Earlier movement Later movement
Halifax, XI, 16		NW to SE SW to NE	Moutonnée "
Chester, I, 12	N 85° W N 60° E	W to E NE to SW	Earlier movement Later movement
Chester, II, 21	N 75° W	W to E	
Chester, II-III, 6	N 5° - 15° E	S to N	
Chester, III-IV, 28	N 80° W	W to E	
Somerset, IX, 18	N 80° W N 45° E	Undetermined "	
Somerset XI, 24		NW to SE	Moutonnée
Somerset XI, 25		SE to NW	"
Inverness, II, 20	N 55° E	SW to NE	
Inverness, IV, 16	N 40° E N 30° E	Undetermined NE to SW	Separate locality
Inverness, IV, 17	N 65° E N 45° E	NE to SW NE to SW	Earlier movement Later movement
Inverness, IV, 20	N 60° E	SW to NE	

Intrusive Rocks

No intrusive rocks have been found in the areas under discussion, except one possible occurrence in range VIII, Inverness township, slightly more than 3 1/2 miles due northwest of Inverness village. This rock forms a low knob projecting through the drift, and in mapping has been included with the Plessisville group. It is almost black in colour, coarse grained, and is not in contact with, or close to, any other rock. A thin section has a grain of 1 to 1.5 mm., and is rather suggestive of some intrusives of the Essexite group. Large crystals of brown hornblende constitute perhaps 20% of the section, and somewhat smaller grains of pyroxene with good crystal outlines another 10%. More or less altered plagioclase approximately An₅₀ in composition, forms about one quarter of the section. Much chlorite and sericite or paragonite are present, and apatite, titanite, and black iron oxide, probably ilmenite, are accessory.

STRUCTURAL GEOLOGY

Faulting

The big structural features of the map-areas are the great faults separating the formations described, and which cut the ground into strips of differing age and lithology. Four such faults are found in the area under discussion. From southeast to northwest these are (1) the Caldwell fault, a great overthrust bringing the Caldwell rocks northwest over the Oak Hill beds. In Warwick map-area it was proved that the overthrust was at least thirteen miles. (2) The Inverness underthrust which separates the Oak Hill from the Plessisville beds. Southwest of Plessisville this

fault approaches closely the Princeville fault, and the two may unite to constitute the Oak Hill fault farther southwest. (3) The Princeville under-thrust, separating the Plessisville group from the Granby group. (4) The Chêne River thrust, which separates the Granby group from the Joly series. It may be a part of Logan's line. All these faults strike about northeast in the southern part of the area, but swing more to the east in the northern part.

Caldwell Fault

The western edge of the Caldwell fault runs northeast through Arthabaska map-area, following in a general way the southeast side of the band of Tibbit Hill lava. At the northeast end, where the fault passes out of the map-area, it is marked by a deep valley which continues for some miles into Thetford map-area, but throughout most of Arthabaska area its trace is most irregular, suggesting that the fault plane is nearly horizontal. South of Ste. Helène de Chester the trace of the fault swings abruptly west, carrying the Caldwell rocks two miles or more in that direction. To the northeast, patches of Caldwell are found on the northwest side of the Tibbit Hill band in several places. Near Henderson Vale a mass of Caldwell rocks a mile and a half long and three quarters of a mile wide is separated from the main body of the Caldwell by half a mile of Oak Hill beds. Northwest of Woodside a somewhat smaller body of Caldwell schist is separated from the main body by a mile of Oak Hill. About a mile and a half west of Pidgeon a small remnant of Caldwell rocks is nearly six miles from the main body.

Near Black Lake the Caldwell rocks are massive, with little or no directed texture. From Black Lake westward they become progressively more intensely sheared till near the contact with the Oak Hill they are

intensely crumpled and highly schistose. The schists display numerous drag folds in the cleavage, with axial planes dipping southeast, and thus attest overthrust from that direction. The schists also dip southeast as far as the anticlinal axis in the schists, which lies on a line running north-northeast through the west end of Trout lake.

Evidence is lacking in Arthabaska map-area as to the maximum amount of overthrust, but the presence of the outlier six miles east of the present main body of Caldwell rocks indicates that they must once have extended much farther northwest than now. At one time possibly the Caldwell rocks may have extended well across the Oak Hill, but if so there must have been much erosion before the next movement took place, because the one erosion remnant of the Plossisville rocks rests directly on the Oak Hill. The latter, it is true, is only 1 1/4 miles from the main Plossisville boundary.

The Caldwell overthrust is the oldest of the great thrusts. The Caldwell rocks, along with the Oak Hill, are deformed by the next fault, the Inverness underthrust. The western edge of the Caldwell mass, with an outcrop width of four to six miles, has been deformed by that great overthrust, so that the schists now dip to the northwest and display drag folds with axial planes that also dip northwest. This holds true as far as the anticlinal axis in the schists, which, as already stated, runs north-northeast through the west end of Trout lake.

Inverness Underthrust.

The Inverness underthrust forms the boundary between the Oak Hill and the Plossisville rocks. Southwest of Plossisville it approaches the next, or Princeville fault, quite closely, and perhaps coalesces with it;

but near Plessisville it separates to follow the southeast boundary of the Plessisville rocks. In Lyster map-area it swings from its hitherto northeast strike to almost due east, to cross that map-area and pass out of the east side only two miles from the southeast corner.

Drag folds in the Oak Hill beds with the axial planes dipping northwest, and a general dip of much of the cleavage in the same direction, indicate that the movement of the Plessisville was an overthrust to the southeast over the Oak Hill. However, as the thrust movements appear to have come from the east or southeast, driving the rocks from that direction against the immovable block farther northwest, it is concluded that the apparent overthrust was due to the rocks being underthrust from the southeast into and beneath those to the northwest. Either movement would produce the observed effects.

The drag folds with northwesterly dips are found as far southeast as the anticlinal axis previously mentioned in the schists, a distance of about sixteen miles from the present trace of the Inverness fault. It seems reasonable to conclude, therefore, that the underthrust amounted to some such amount.

In view of this conclusion, it might be expected that here and there some erosion remnants of the once overlying sheet of Plessisville rocks might be found within the Oak Hill. Actually, only two such occurrences have been found. Near the south end of lot 21, range IV, Inverness township, a mass of what appears to be Plessisville lava lies on the Sweetsburg slates, and a second small body was seen in the same lot about a quarter mile from the road. The second occurrence is in the southwest corner of lot 23, range I, Inverness, where a very small body, probably of Plessisville lava, about 15 feet in diameter, is completely surrounded by beds of the Gilman formation, and appears to overlie them.

As the Caldwell rocks at their west side also show cleavages and drag folds with axial planes dipping west, the Inverness thrust must be later than the Caldwell thrust.

Princeville Underthrust

The Princeville underthrust separates the rocks of the Plessisville group from those of the Granby group. In Arthabaska map-area it has a northeast strike, but in Lyster map-area it swings more to the east and passes out of the east side about six miles from the southeast corner.

A number of direct proofs of faulting and of underthrust were obtained. In Arthabaska map-area the northwestern side of the Plessisville mass is intensely brecciated; so much so that near highway #5, in Somerset, range VIII, lot 21, the breccia has been quarried like gravel. In the Granby group two bands of red slate were carefully traced, and it was found that the fault bevels them at a small angle, about fifteen degrees. In Somerset township, range VIII, lot 24, highway #5 crosses a small creek where it has cut a little canyon some fifteen feet deep. The highway crosses the creek exactly on the contact between the Granby and Plessisville groups so that the contact is concealed by the cement work of the bridge. Upstream the Plessisville rocks are intensely contorted, and some 300 feet above the bridge a large block of Granby quartzite occupies the northeast wall of the canyon. The block is some 50 feet long and about 8 feet high; its upper end and part of its lower side, where it rests on Plessisville rocks, are visible. The Plessisville rocks both beneath it and at the upper end are crushed into small fragments and converted into a sort of slaty gouge, over widths of several inches. Obviously this block has been carried into its present position by being thrust over the Plessisville

for some 300 feet.

At the corner of highway #5, approximately a mile and a half southeast of Laurierville, a gravel road continues southeast past a large cross at the top of the hill, about a quarter mile farther southeast. Under this cross, and near it, are small masses of massive quartzite surrounded by schistose and much crushed rock of the Plessisville group. A thin section of the quartzite is identical with thin sections of the Granby quartzite; and this, coupled with the fact that no coarse quartzite has yet been found in the Plessisville group, causes the writer to consider it Granby quartzite brought into its present position by faulting.

Chêne River Thrust

This fault is assumed to be the boundary between the Granby group in the east half of Lyster map-area and the Joly series. It is entirely concealed beneath the unconsolidated deposits of the Champlain sea. Its position so far north suggests that it may be a section of Logan's line, the great fault extending from Lake Champlain to Quebec.

The fault enters the east half of Lyster map-area, probably, about a mile north of the middle of the west side, and crosses the map-area in a direction somewhat east of northeast. The fact that the folds on the Joly series have axial planes dipping southeast about 60 degrees suggests that the fault, in this section, is an overthrust.

Minor Faults

The displacement of such great blocks of the earth's crust for distances measured in miles must have been accompanied by much minor fracturing. The probable faulting along the west side of the Tibbit Hill lava

band has already been mentioned; and at Mailhot, in the creek valley south of the corner, a fault is visible which has brought Sweetsburg slate into contact with West Sutton slate on the southeast, a movement of the order of one to two hundred feet. Such displacements are probably numerous, but are concealed by drift and by the fact that most of them are parallel to the general strike of the rocks.

In a few places, clean glaciated surfaces show that the rocks have been rather closely sliced, with displacements of a few inches along the planes of slicing. The aggregate amount of such small movements must have been great, but cannot be observed on ordinary rough, eroded surfaces.

Folding.

Oak Hill series.

The Oak Hill rocks, in structure, form somewhat more than half an anticline. The axis of the partial anticline is exposed; it is the band of Tibbit Hill lava that begins half a mile north of Ste. Helène de Chester and runs northeast to cross the east F.B boundary of the map-area four miles from the northeast corner. At the south end the band plunges abruptly southward and disappears beneath younger rocks.

Northwest of the Tibbit Hill band all the overlying formations of the series appear in turn, thus indicating a general dip to the northwest. This general dip must be very low, because, though the formations are thin, they outcrop over a distance of about nine miles. At the bottom of the syncline the Holbourne limestone appears, and the series breaks off at the Inverness fault.

On the southeast side of the Tibbit Hill band only scraps of the

Oak Hill rocks are found; most of the series is broken off by the Caldwell thrust, or is covered by rocks of the Caldwell group which have been thrust over them. The general dip may also be steeper, for the width of West Sutton slate, seen in Halifax, range VI, is only half a mile, whereas on the northwest side it is nearly three miles.

The low general dip inferred from rock distribution cannot be seen in the field. There steep dips, even overturned, are the rule, and narrow canoe-shaped anticlines and synclines are numerous. Obviously the nearly flat-lying formations are closely crumpled, implying much shortening. For such shortening to take place either the formation must have been strip-thrust over its original base, or the base must have been folded with the same intricacy.

Both the Caldwell and the Inverness thrusts have affected the structure of the Oak Hill, but the effect of the latter has been much the greater. Large sections of the Oak Hill have been given a well developed cleavage that strikes N 40° - 50° E, and dips northwest at angles of 50° to 60°. Almost invariably, also, the cleavage displays drag folds indicating upward and southeastward movement of overlying beds. These structures are entirely independent of the local folds. Thus in Inverness, range line III-IV, lot 19, drag folds show upward movement of the northwest side, whereas the top of the beds indicated by the succession is to the southeast.

In a few places it was possible to observe folds small enough for the position of the axial plane to be seen. Thus in Halifax, range I, lot line 23-24 approximately, the axial plane of a small syncline dips 65° NW. Though such occasions are rare, the fact that both bedding and cleavage generally dip northwest indicates that axial planes must also dip in that direction.

The Caldwell overthrust, if it covered much of the Oak Hill, would of course have produced effects precisely the opposite of the Inverness underthrust; and though most of them would probably have been obliterated by the later thrust, some should be preserved. In two places effects perhaps due to the Caldwell overthrust were noted. At Ste. Sophie de Megantic a bridge crosses the stream on the road going north, and beside it a syncline of Sweetsburg slates in Gilman formation some ten to fifteen feet in amplitude is beautifully exposed. The axial plane of this syncline dips southeast, as if an overlying bed has passed northwest over it; while the cleavage, obviously formed after the fold had formed, dips about 40° northwest.

Less than half a mile northeast, well-bedded Sweetsburg slates strike northeast with a fairly steep dip. Looking northeast at a well-bedded cross section, one sees the beds are bent as if dragged westward by the movement of overlying strata.

In the northern part of Arthabaska map-area the map shows a number of places where cleavage dips southeast instead of northwest. It is not improbable that such cleavages were impressed by the Caldwell overthrust.

Caldwell Group.

Bedding in the Caldwell rocks is not commonly observable as it has been obliterated by shearing in most places, and no beds, except the lava flows, are sufficiently distinctive to be traced. The flows strike, roughly, about N 20° E, and have straight or gently curving courses. Thus they appear to indicate that the Caldwell in its larger structure has not been too greatly deformed by its overthrust into its present position.

Though this conclusion appears difficult to question, it is directly opposed by observations made on the sedimentary rocks. Unfortunately, it is admitted, the places where good bedding has been found are close to contacts with the Oak Hill, and these outcrops, where friction was undoubtedly intense, might be expected to exhibit unusual amounts of deformation. Be that as it may, the actual observations show the harder sedimentary beds intensely contorted, and thrown into recumbent and near-recumbent folds. Thus the remnants of quartzite in Halifax, range III, lots 14 to 15, show quartzite interstratified with greenish-grey greywacke in beds an inch or two in thickness. For perhaps eight or ten feet these beds strike N 75° E and dip vertically; they then swing abruptly to strike N 45° E and dip 30° - 40° NW for about the same length. These changes are repeated again and again, giving a general east-northeast strike.

As already stated, an anticlinal axis in the Caldwell schists runs north-northwest through the west end of Trout lake. On each side the schists strike N 40° to 55° E, but dip in opposite directions. In the axial zone itself the cleavage dips north-northeast at low angles.

Granby Group.

Little can be said of the structure of the Granby group, as outcrops are so scattered. The strikes are mainly northeast, following the regional trend, and the dips range from near-horizontal to vertical. Deformation has not been extreme. The quartzite members are massive, with little or no directed texture. Though the slate members have a good slaty cleavage, they do not seem far removed from shales. Their cleavage surfaces in most places are plane, not drag-folded as in the Oak Hill and Caldwell groups.

Plessisville Group.

This group resembles the Granby group in that little can be said of its general structure. Mention has already been made of the possibly synclinal structure, but this is hardly better than a guess based largely on the discovery of lavas on both edges of the band. In most places the bedding can be seen to be highly contorted; and no succession of formations has been found, as in the Oak Hill, to give a hint as to the general structure.

Joly Series.

The Joly series outcrops only in part of the bed of Henry river, and at Val Alain at the west boundary of the map-area. Wherever found it strikes near N 60° E and dips southeast at low angles, save for the sharp folds mentioned in the description of the rocks. As no other outcrops are available, its broad structure is unknown.

Inverness Series

This series underlies but a small part of the map-area. At the middle of the band the rocks lie in folds not more than 200 to 300 feet from one anticlinal crest to the next. Dips are low near the crests, and on the limbs average about 45°. No cleavage has developed.

Small remnants of these rocks have been found in places up to two miles, or even more, from the main body. It is likely, therefore, that it formerly extended, fairly flat, over a considerable area.

Limestone Conglomerate.

The small outcrops of limestone conglomerate near Inverness village display no bedding. Cleavage is entirely lacking also.

GENERAL DISCUSSION

The Palaeozoic rocks west and northwest of the region under consideration are not deformed; hence they, and the Precambrian rocks on which they lie, may be termed the buttress against which the deformed rocks of the Eastern Townships were thrust. So it is concluded that the thrusts came from the southeast or Atlantic side. There would appear to have been several such movements, spaced presumably at long intervals of time.

(1) The first movement of which there is record flexed the Lower Cambrian Oak Hill strata into northeast-striking folds. Quite possibly this movement took place soon after the Lower Cambrian was deposited. The Caldwell rocks are folded along parallel axes, suggesting that they may have been deformed by the same forces.

(2) The Caldwell beds, after folding, were bent into a great drag fold that made them strike almost east-west through the south end of Warwick map-area (8). Probably the same pressures thrust the Caldwell rocks westward over the Oak Hill. This movement appears to have taken place in late Cambrian or early Ordovician time (5).

(3) The Oak Hill rocks, reinforced by the overthrust Caldwell sheet, were again thrust northwest beneath the Granby and Plessisville formations. This movement could have taken place during either the Taconic or Acadian orogeny, but as the Inverness series and the limestone conglomerates near Inverness are but slightly deformed, the Taconic orogeny seems much more probable.

(4) The Inverness series has been thrown into gentle folds, and the limestone conglomerates (more extensively displayed in St. Sylvestre map-area) are folded to about the same extent. This comparatively slight movement seems to have been due to the Acadian disturbance.

(5) Finally, in late Pliocene time, the Oak Hill and Caldwell rocks were uplifted to form the upland area. This of course was a very gentle movement compared with the violent seismic storms of the early Palaeozoic.

As the evidence for the latter movement is largely physiographic, and the movement has not been more than a few hundred feet, it might scarcely be expected that the rocks would show much evidence of it. However, two small structural features were found that may be connected with it. At Victoriaville, where the bridge crosses Nicolet river, bedding in the Melbourne limestone strikes N 85° E and dips about 30° S, but the whole rock is shattered into plates about an inch thick and a foot long. The fracture planes strike about N 65° E and dip 65° SE, but display drag folds indicating uplift of the southeast side.

In Arthabaska township, range VIII, lot 3, is exposed a succession of rather thick-bedded dolomitic mud rocks identified as West Sutton. Toward the south end of the exposure the beds dip northwest and are bent into large drag folds showing uplift of the northwest side. However, both the beds and the near-vertical cleavage also display small drag folds that indicate some upward movement of the southeast side. Possibly this movement and the fracturing at Victoriaville may have been due to the Pliocene uplift of the upland.

ECONOMIC GEOLOGY.

Copper.

In Chester township, range line II-III, approximately on lot line 5-6, copper was discovered about 1904 on what was known as the Savole-Tessier prospect. Later, in 1912, the Canada Copper Company was organized to develop it, and in July of that year a shipment of 2758 pounds net weight

was sent by Albert Blanchette, Arthabaska, to the American Smelting and Refining Co., 165 Broadway, New York. According to their receipt, the shipment contained 32 per cent of copper. The copper minerals included bornite, chalcocite, and malachite.

Work then apparently ceased. The deposit would seem to have been no more than an isolated patch of ore. B.T. Denis, who examined the property in 1942 for the Quebec Department of Mines, and who had the pits dewatered for examination, reports that he could find almost no mineralization in them, and adds, "It was explained that all the ore had been hand cobbled in order to make the shipment of 2758 pounds".

When the writer saw the property in 1954, the pits, said to be about 15 feet deep, were full of water, and it was only after some search that a couple of grains of chalcocite, about the size of match heads, were found on the dump. The rock is a rather massive silt rock of the Caldwell group, dark grey in colour and very fine-grained. It has some directed texture, but is much more massive than most of the Caldwell rocks. The sides of the pit show a good deal of fracturing, with the fractures filled with barren-looking quartz.

In Halifax township, range VI, lot 8, about 1100 feet southwest of the road along range line VI-VII, some excavation was done many years ago in search of copper. According to our guide, a man more than 70 years of age, the "mine" was an old working when he was a boy, suggesting that the pits were originally dug when copper prices were high in the 1870's. The deepest pit is said to have been sunk for 70 feet, but to the writer the dumps appear small for such a depth.

The rock is rather intensely sheared mica schist of the Caldwell group. It appears to be mainly sheared quartzites of varying degrees of purity, together with some black slate. The schistosity strikes N 30° E, and dips southwest at very low angles averaging about 30 degrees. In some drag folds the schist is bent to have northwest strikes and southwest dips over distances of a few feet, suggesting northeast movement of the southeast side. Small quartz veins are numerous, and in general parallel the schistosity. Most of them are unmineralized.

Four pits have been sunk, approximately on the strike of the schist. The northernmost dump affords good specimens of carbonate, chalcopyrite, and pyrite, with some products of weathering such as malachite.

Some diamond drilling was done in 1951 on this property, without finding anything of value. The writer has no information as to where the holes were drilled.

In Inverness township, range I, southwest quarter of lot 8, two pits have been sunk near the boundary of lot 7. The small size of the dumps suggests that neither is more than twenty to thirty feet deep. The rock fragments in the dumps are mainly grey Caldwell silt rocks with moderately good cleavage and numerous small black crystals of chloritoid, together with reddish slates that look like typical West Sutton. It was concluded that the pits have been sunk almost directly on the overthrust fault that brought the Caldwell over the Oak Hill. Both strikes and dips in the neighborhood are intensely contorted.

The only copper mineral observed at this locality was malachite, small quantities of which fill joints or impregnate the schist.

Iron.

The presence of hematite in lot 12, range II, Chester township, has been recognized at least since 1895. In that year J. Obalski first briefly described the deposit in the Report of the Commissioner of Crown Lands for 1895. According to him, the first discoveries uncovered veins of hematite up to two feet wide, in a dolomitic limestone. Three analyses of the hematite gave its iron content as 56.83, 67.81, and 69.42 per cent respectively. Work in later years has indicated that the gross amount of hematite present is small, of the general order of 50 tons, and no work has been done on the property for some years. In May, 1954, Strategic Metals, Ltd. made a gravimetric survey of the district, but no further operations were attempted.

The hematite deposits are found within a bed of the White Brook dolomite, on the northwest side of the Tibbit Hill band, where sharp drag folds have bent the band. In the pits, which are not more than five or six feet deep, and twenty or thirty feet long, massive hematite forms veins of most irregular, serrated shape. The largest vein observed was about ten inches wide. Contacts between the massive hematite and dolomite are sharp. No evidence of replacement, such as gradational edges, scattered grains of hematite in the dolomite, or inclusions of dolomite in hematite, were observed. The dolomite band has an exposed width of only some fifteen or twenty feet, and as the hematite is confined to it, the body can be of no great size.

Clark has noted (2) the presence of hematite-rich rock in many places at the contact between White Brook dolomite and West Sutton slate; and states that "in some places the hematite is so pure and abundant that it has been worked as an iron ore". Perhaps the body of hematite under discussion

had a similar origin.

H.W.McGerrigle in 1941 made an examination of this property for the Quebec Department of Mines, and his report may be found in their files. The following quotations from his report may be of interest.

"Some loose blocks of hematite up to about 16" x 10" x 6" were seen (on lot 11) about 350 feet south of the fault contact on the hill. No other hematite occurrences, apart from thin seams, were noted on lot 11. An old pit, apparently exposing little or no hematite, was seen in lot 11 about 200 feet east of the line between lots 11 and 12. Immediately west of this line is another old pit 25 feet long, 8 feet wide, and 4 to 7 feet deep. The main band of hematite exposed in it is a lens thinning to north and south and 4 inches thick on the average ... A pocket associated with this lens is up to 10 inches thick. Another lens ... is 4 feet long and up to 8 inches thick. Besides these two lenses, small pockets and stringers of hematite were seen, particularly in the southwest corner of the pit, where six short veins, one inch or less thick, occur within a width of three feet of dolomite. No other occurrences of hematite were noted in this, the main band of dolomite here. Thus, in a length of about half a mile, there are only two places where hematite was seen.

"The second line of dolomite outcrops, in lot 13, west of the main band, has a total exposed length of about 800 feet. Hematite was noted in very small amount in an old pit 200 feet from the south end of the exposures. In another pit at their south end more hematite is exposed than at any other place in the area. This pit is 30 feet long in a N 43° E direction, 5 to 8 feet wide, and up to 10 feet deep. The best showings of hematite are at the south end, and in the west wall near the south end .. This section measures about 8 feet by 5 feet deep, or some 200 cubic feet.

"Judging from the amount exposed in the walls, the material removed from the pit would have yielded about fifteen cubic feet of hematite, or less than 5,000 pounds. From the quantity of hematite stacked by the pit, and the amount reported locally to have been taken out (15 tons), it is evident that the veins or lenses were wider in their upper parts, now removed, than as now exposed. This checks with Obalski's statement of veins up to two feet wide, apparently in surface exposures.

"A very little hematite in thin, short stringers was seen in the continuation of the dolomite band between the Range I road and Bulstrode river. The same may be said of the dolomite in its discontinuous exposures north of Bulstrode river. Some prospecting has been done among boulders of dolomite in the west bank of the brook between lots 12 and 13 of range I, Halifax tp., and a small quantity of very pure hematite has been found here. Blocks up to 8" x 6" x 4" in size were shown to the writer. These evidently came from dolomite exposed not far to the west of the locality where the loose material was found.

"All told, it may be seen that the total quantity of hematite in sight along this dolomite band amounts to 50 tons at the most. It must be stated, therefore, that further prospecting along this belt is not warranted."

Sand and Gravel.

Several large deposits of sand and gravel are found on the lowland near the edge of the upland. Most of them are found between the southern side of Arthabaska map-area and Bulstrode river, but there is also a large quarry in Lyster map-area two miles due southwest of Laurierville. On the remainder of the lowland gravel deposits are comparatively rare, although one pit has been opened near Bourbon creek about a mile and a half northwest of Plessisville. In Stanstead township, range VI, lot 2, and in range IV, lot 25, red Granby slates have been weathered to a loose gravelly rubble, and have been quarried and used as road material.

On the upland, deposits of gravel are mostly small pockets. Larger bodies, however, are found on the lower ground close to streams. At Chester North such a deposit close to Bulstrode river is being actively worked for road material, and other deposits, not yet quarried, were noted farther downstream. At Woodside there are several large deposits of good gravel that have been quarried to some extent; and others still untouched are found along the north side of Lake William.

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