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WEEDON AREA AND ITS VICINITY

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on
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XIV
XX

GEOLOGY OF THE WEEDON LAKE AREA AND ITS VICINITY

WOLFE AND COMPTON COUNTIES

QUEBEC

by

Gilles Duquette

ABSTRACT

The map-area, nearly 100 square miles in all, belongs physiographically to the Appalachian Highlands characterized in Southern Quebec by three parallel series of ridges. The area described in this thesis is located on the central ridge known, at the latitude of Weedon, as the Stoke Mountain ridge.

Weedon Centre, on highway No 1, just west of Weedon lake, is 100 miles south of Quebec City and 140 east of Montreal.

The greater part of the area is characterized by a rolling upland, reflecting accurately the distribution of sedimentary rocks. The map-area is also traversed diagonally by a series of hills made up of granite stocks and metavolcanics. A maximum relief of 1000 feet is on a granite stock south of Elgin lake.

Bedrock is generally well exposed except along the St. Francis valley.

The drainage pattern is controlled by the regional structure and by the glacial destructive and constructive effects which are widespread in the map-area. The ice movement followed a S. 60° E. direction.

All the consolidated sedimentary rocks of the region are believed to be Paleozoic and are assigned to 5 major rock units. Each unit contains characteristic assemblages of rocks. They are from west to east, the Disraeli slates, the Lake Aylmer limestone, the Weedon schists or metavolcanics, the St. Francis-St. Juste limestone and the St. Francis-St. Juste slate and sandstone.

Early workers were able to recognize 4 out of those 5 proposed units. Except for the Lake Aylmer limestone, different ages have been assigned to the same unit by various authors. Cooke in 1947 was able to recognize the fifth unit, but he failed to give an acceptable interpretation of the stratigraphy and structure of the area.

St. Francis-St. Juste group: Compton-Seboomook fmt.
(Marleau's thesis area).

Middle St. Francis-St. Juste fmt.
(slate and sandstone)

Lower St. Francis-St. Juste fmt.
and Lake Aylmer fmt.
(limestone).

Quebec group: Weedon Schists fmt.
(metavolcanics)

Disraeli fmt.
(slate)

The terms Precambrian, Cambrian system, Beauceville series, Gagne Brook series and Sherbrooke group are not retained in this study. The serial names, Disraeli, St. Francis, St. Juste, Lake Aylmer, and the name Quebec group are retained but modified in the light of new observations. Group and formation are used instead of series.

The stratigraphic sequence proposed by the writer is in a large part a complete modification of those proposed by Burton, Clark, and Cooke, and, to a large extent, it is a reversion to Logan's and Selwyn's views.

The oldest rocks of the area belong to the Quebec group. In the map-area this group includes a slate sequence, called Disraeli, cropping out in the northwestern corner of the Lake Aylmer sheet and a volcanic assemblage here referred to as the Weedon schists. Those schists are exposed south of the Lake Aylmer limestone. From field evidence gathered near Sherbrooke City (Hawley 1945) it is inferred that these metavolcanics are an integral part of the Disraeli formation. On long range correlation the Disraeli formation has been assigned to the Precambrian by Selwyn, Ells, Dresser, and Bancroft. Cooke considered them as a part of the Sherbrooke group of Silurian age, an interpretation which is, according to the writer, unacceptable.

After the Taconic orogeny the sea came back into the area and deposited unconformably above the highly deformed pre-Silurian rocks, sediments of the Gaspé group. In the map-area this group is represented by the Lake Aylmer limestone, west of the Weedon schists and by the St. Francis-St. Juste sediments to the east of them.

On account of their similar lithology and similar structural relationships to the basement rocks, the Lake Aylmer limestone or Lake Aylmer formation is correlated with the limestone or Lower formation of the St. Francis-St. Juste group.

Fossils from the Lake Aylmer limestone indicate a Middle Silurian to Lower Devonian age.

The Lower St. Francis-St. Juste formation is overlain on the east conformably by a formation which is represented by a tightly folded sequence of slates interbedded with fine-grained sandstones and siltstones. The youngest sediments exposed within the map-area belong to that formation.

The Lower St. Francis-St. Juste and Middle St. Francis-St. Juste formations are equivalent to the St. Juste sequence near St. Juste (Béland 1957) which is similar to the Temiscouata formation, the Fortin series of Gaspé, and the Waits River-Gile Mountain sequence of northeastern Vermont. The basal beds of the Lake Aylmer and Lower St. Francis-St. Juste formations are correlative of the Shaw Mountain formation of Central Vermont (Cady 1956).

Two small granite bodies intrude the Weedon schists in the northern part of the Gould sheet. The granite is made up largely of quartz and albite. This granite is definitely pre-Silurian and was probably intruded about the time of the Taconic orogeny. Granophyre pebbles are abundant in the basal beds of the Lake Aylmer limestone. This material comes from pseudo-pebbles enclosed in a crush conglomerate unit of the Weedon schists. This granophyric material is also believed to be related to the Taconic orogeny. Abundant sill-like bodies of porphyry cut everywhere the Weedon metavolcanics and are believed to be also of pre-Silurian age.

An oligoclase-biotite-muscovite granite cuts the whole sequence east of Weedon lake. The Weedon ore body, the old Stratford pyrite deposit, and the Solbec Copper Mine ore body are all believed

to be genetically related to this intrusive. Along the eastern margin of the Stratford sheet, the edge of a body of oligoclase-biotite-augite granite is exposed. This granite intrudes the St. Francis-St. Juste sediments. Both intrusives are inferred to be related to the Acadian orogeny.

An important result of the present work has been the discovery that the St. Francis-St. Juste sediments rest with angular unconformity upon the Weedon metavolcanics. Instead of being Ordovician in age as proposed by Clark, Burton, Cooke, et al, the the St. Francis-St. Juste group must be assigned to the Gaspé group of Silurian and Devonian age and belongs for that reason to the "Gaspé-Connecticut River Synclinorium". The Lake Aylmer limestone is also a part of the Gaspé group and is here considered a correlative of the calcareous facies of the St. Francis-St. Juste group. At the latitude of Weedon, the Gaspé-Connecticut River synclinorium has a minimum breadth of 65 miles. As suggested by its name, the synclinorium is continuous from the village of Gaspé down to and along the Connecticut river.

INTRODUCTION

General Statement

This work gives the results of a study of the geology of the Weedon lake area and its vicinity. Detailed mapping of this part of the province was carried out by the author during the field seasons of 1958, 1959, and 1960 on behalf of the Mines Branch of the Quebec Department of Mines. During mapping special attention was paid to the structure, petrography, and economic possibilities of the area. It has been demonstrated that the St. Francis-St. Juste group lies unconformably above the metavolcanics of the Quebec group. Instead of being Ordovician in age, as proposed by Clark, Cooke, Burton, et al, the St. Francis-St. Juste group must be assigned to the Gaspé group of Silurian and Devonian age and belongs for that reason to the "Gaspé-Connecticut River Synclinorium".

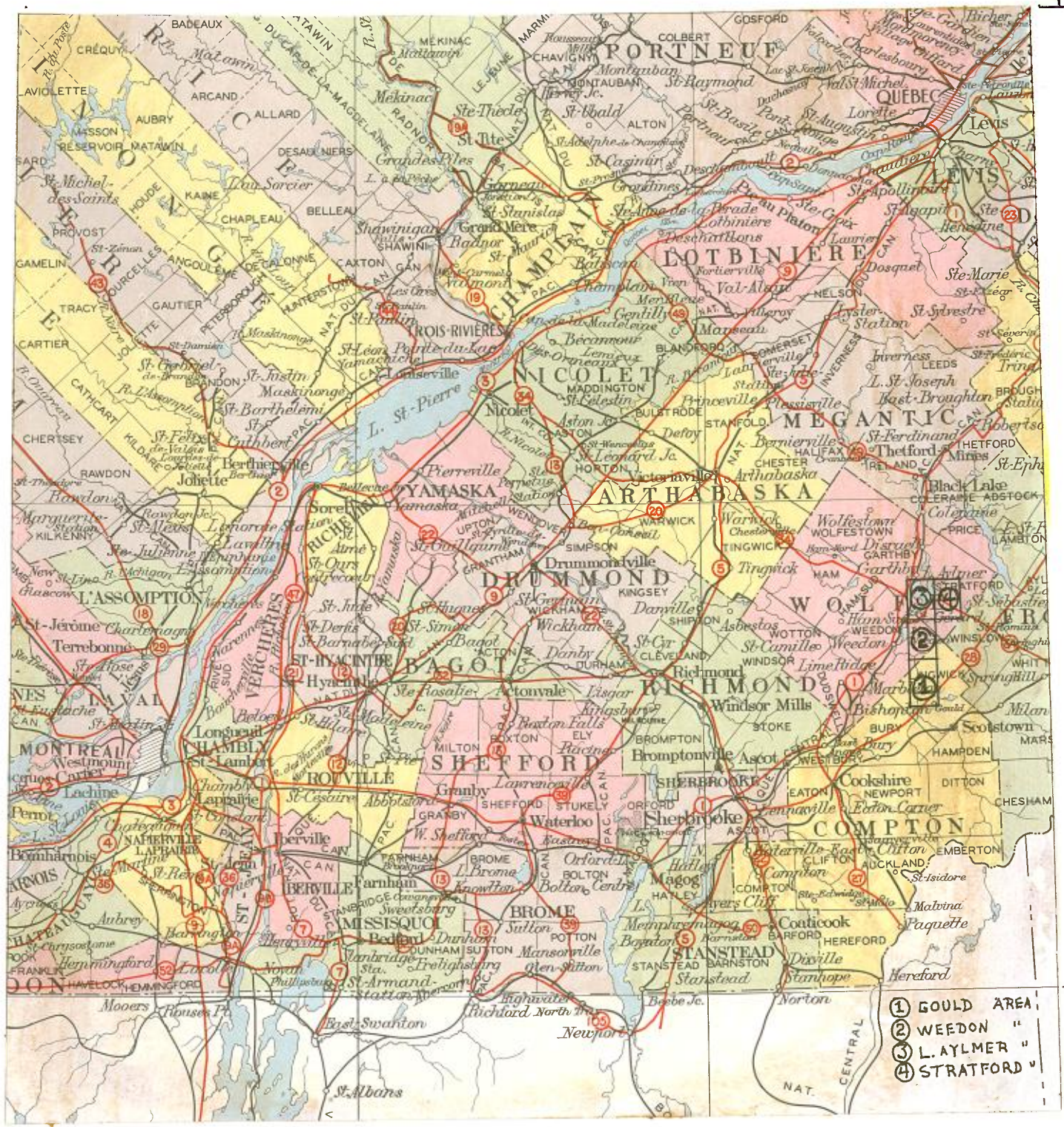
Two preliminary reports (No. 416 and No. 432) have been published so far and one more is yet to appear.

Location and Means of Access

The area mapped by the writer and discussed in this report includes the following sheets: Gould, Weedon, lake Aylmer, and Stratford (cf. page 1A). The four sheets have an area of nearly 100 square miles. They include part of Lingwick township in the electoral district of Compton and parts of Weedon, Garthby and Stratford townships of the electoral district of Wolfe. The inverted

- LOCATION MAP -

47°



74°

0 20 miles

71°

45°

L-shaped map-area (1) is bounded to the north by latitude $45^{\circ}50'$ and to the south by latitude $45^{\circ}35'$. Longitude $71^{\circ}30'$ west represents the western limit of the map-area.

Following the Quebec highway No 1, a Quebec Central Railway line passes through the village of Weedon Centre, located two miles west of the Weedon lake sheet, and also through the villages of St. Gérard Magella and Garthby. Weedon Centre is about 100 miles south of Quebec City and 140 east of Montreal. A good network of secondary and private roads render all parts of the map-area easily accessible.

Resources

Lumbering, mining, and farming are the three main industries of the district.

Most of the area has been logged at least once, but cutting is now done according to a cyclical system. Spruce and fir-trees are the principal conifers. Small tamarack trees are found here and there in swamps. Cedar occurs also in swampy areas and along the margins of lakes. Birch, maple, wild cherry-tree, and poplar are the commonest deciduous trees. Alders grow densely along streams, rivers, and lakeshores but they are usually not of large size. Hardwood and softwood lumber is produced both for export and local consumption. Most of the wood is cut for pulp and is floated down

(1) The term "map-area" indicates the four areas, Gould, Weedon lake, Aylmer lake, and Stratford.

the St. Francis river to East Angus, where the St. Lawrence Co. has its mills.

The Weedon Mining Corporation was until early in the spring of 1960 the only metal producer of the Eastern Townships. Rate of mining was close to 400 tons a day. This copper and pyrite deposit is one mile north of Fontainebleau, a small village located in the south central part of the Weedon lake sheet.

A new copper-zinc orebody was found in the winter of 1958 just north of the village of Stratford. Shaft sinking is under way and should be completed by April or May 1961. The Solbec Copper Mines plans a 1000 tons daily operation. Since this discovery active prospecting is being carried out in the Stratford area and in general over the whole belt of metavolcanics. A major new copper-zinc discovery has already been made by Solbec Copper Mines, south of Stratford village, 13000 feet south of and in strike with the Solbec orebody.

Quarrying is done just north of Moose pond, one mile south of Elgin lake. Huge blocks of granite are transported by trucks to the village of St. Gérard Magella where they are cut for building purposes. The quarry and the plant belong to la Compagnie de Granite Plamondon Ltée.

Asphalt is made at Stratford village where good sand and gravel deposits are available.

Farming is also an important industry. The country is moderately settled and most of the arable land is cleared. Large areas are left in pasture or have been abandoned because sand, gravel,

and erratics are abundant. Some maple syrup and maple sugar are produced and supplement the farm income.

The principal villages are Gould, Fontainebleau, St. Gérard Magella, Garthby, and Stratford.

Previous Works

The earliest geological observation in the region was made before 1842 and was mentioned by Logan (1843) in his first report for the geological survey of the Province of Canada. He suggested the extension the Gaspé limestone, described by Captain R.N. Bayfield in the Gaspé Peninsula, to the Vermont state. His suggestion was based on the recognition of fossiliferous limestone cropping out at the Rivière de Famine and along the St. Francis river between lake Aylmer and Sherbrooke city. (Logan 1845, p. 18-19). In 1847, Logan gave a description of the section between Memphremagog lake and the Vermont - New Hampshire boundary. He added that the sequence would accord with that displayed in the great Appalachian trough. For the southward extension of the limestone, he referred to professor Adams, the State Geologist of Vermont, who traced the rocks along the eastern flank of the Green Mountains, to the southern boundary of the State. The crystalline schists of Weedon were considered as correlatives of what Logan later called Quebec group.

Hunt (1850) commented on the report made by Logan (1847) and discussed of the three now classic fossil localities; those on Famine river, at Dudswell, and at lake Memphremagog.

Hunt (1854) in a paper on some of the crystalline limesto-

ne of North America, restated the conclusions expressed earlier by Logan and Adams. Siluro-Devonian rocks extend from Gaspé to lake Memphremagog and into Massachussets. He (Hunt 1861, p.93) believed the limestones to rest unconformably on the altered strata of the Quebec group.

Selwyn (1877) was first to assign to the Precambrian, part of Logan's Quebec group. For that reason he regarded the Weedon schists as Precambrian. On his map of 1884, Selwyn correlated, in the present map-area, the Devonian Gaspé sandstone of Logan with the sandstone and slate sequence running south of St. Francis river. The lithologically similar sequence of rocks exposed north of lake Aylmer was assigned, however, to the Cambrian.

Ells (1886) was, after Logan, one of the few Canadian geologists who worked extensively in the Eastern Townships. On his published geological map, the Precambrian belts of rocks of the Eastern Townships are in every respect similar to those proposed by Selwyn. He considered the grits and the large pebble conglomerates exposed near lake Aylmer as being Cambrian in age. The two bands of slate and sandstone found respectively to the north of this Cambrian unit and to the south of his Precambrian belt of rocks, are correlated and inferred to be of Cambro-Silurian (Ordovician) age. This correlation had already been proposed by Logan and the two rock units correspond to the Upper-Silurian Gaspé limestone of Logan. Ells calls Silurian the Devonian Gaspé sandstone of Logan exposed at lake Aylmer.

In a report on the copper deposits of the Eastern Townships, Dresser (1902 p.25) showed that what has been so far considered as

Precambrian sediments are for the most part highly deformed volcanics. He tentatively correlated those volcanics with the Precambrian meta-volcanics of Pennsylvania. As to the Paleozoic rocks he refers to Ell's view and gives no additional information.

Bancroft (1916) like Dresser, made a report on the Copper Deposits of the Eastern Townships. His report is extensive and gives a detailed account of the history, production and general geology of all copper occurrences known at that time. Bancroft, following Dresser's idea, believed that most of the Precambrian rocks were derived from volcanic of which he gave, however, a more exact account of their distribution.

The first detailed and systematic mapping, dealing with the local geology, was done by Burton (1930 and 1933) in the Lake Aylmer area and its vicinity. Burton introduced the serial names Gagné Brook, Weedon, Disraeli, and Lake Aylmer to designate from west to east successively younger rock units, all Ordovician in age except the Lake Aylmer series which he classed as Lower Devonian. He reported that a major southeasterly dipping thrust-fault which he named Weedon thrust-fault runs along the contact line of the Lake Aylmer and Gagné Brook series. He also gave evidence for correlating units of his series on each side of that fault.

Cooke in 1932 (1937 p. 33) claimed he was able to trace the Beauceville group named by MacKay (1921) from the type locality on Chaudière river down to the American border line.

In 1935 Clark (Cooke (1937) undertook the study of the

fossiliferous Ordovician and Devonian rocks of the Disraeli map-area previously examined by Burton. Clark accepted Cooke's contention that the Ordovician Beauceville group extends to Disraeli and accordingly dropped Burton's serial name Disraeli. Although Clark retained the name and age of the Lake Aylmer series of Burton, he proposed to use the name St. Francis series to designate the assemblage of rocks included in Burton's Gagné Brook and Disraeli series south of the Weedon thrust. The volcanics of the Gagné Brook series were considered as the basal member of the St. Francis series.

Cooke (1950) mapped an adjoining area to the southwest and surprisingly enough, he concluded that the Weedon schists belong to a hitherto unrecognized group which he named Sherbrooke and considered it to be Silurian in age. He excluded from the Ordovician St. Francis series of Clark the volcanic member and considered this newly defined St. Francis series as an older rock unit thrust westwardly over his younger Sherbrooke group. Similarly, accepting Burton's Weedon thrust he believed that his Sherbrooke group had been thrust westwardly over Burton's Devonian Lake Aylmer series. The latter series was described as resting unconformably above the Beauceville group.

During the next decade Cooke's work remained the standard of reference for this part of southern Quebec.

Method of Study

During the summers 1958-1959 and 1960, the writer spent a total of 13 months in the field. Furthermore 345 thin sections were

studied under the microscope.

Except for the surface and underground geology of the Weedon Mining Corp. Ltd and the Solbec Copper Mines properties which were mapped at a scale of 100 feet equal to one inch, the whole area was studied on a scale of 500 feet equal to one inch. Roads, lakes, and major watercourses were examined, and pace and compass traverses were run at intervals of 500 feet, in a general northwest-southeast direction. All traverses were tied to surveyed pickets spaced at every 200 feet along roads, cut lines or blazed lines. Many bush trails in the northeastern part of the Weedon lake area were surveyed by using plane table. The geology was plotted on a base-map compiled by A.E. Simpson Ltd of Montreal from their own aerial photographs taken in May 1959 on a scale of 2500 feet to one inch. During the summer of 1958, the author used a base-map compiled by the Quebec Department of Mines from enlarged topographical maps furnished by the Topographical Survey of Ottawa. The Quebec Department of Lands and Forest provided many maps which were of a great help in the preparation of this manuscript and its accompanying maps. The Simpson aerial photographs were used for the location of rock exposures but more particularly for the planning of the field work. During the summer of 1958 a similar use was done of the Royal Canadian Air Force aerial photographs.

Acknowledgments

The field work was carried under the auspices of the Mines Branch of the Quebec Department of Mines.

Efficient service was rendered in 1958 by senior assistant Ron Buckley and junior assistants Ron Doig, A.D. Ouellet, and Yves Moore and during the summer of 1959 by senior assistant Hubert Brosseau and junior assistants Tony Acer, Carl Johnson, and Gilbert Grisé. In 1960, senior assistant, Jean Lacasse and junior assistants Allen Petryk, Jean-Paul Bolduc, Pierre Gadbois, and Robert Beaudette gave valuable help.

PHYSIOGRAPHY

Regional

The map-area belongs to the physiographic province commonly called the "Appalachian Highlands", characterized in Southern Quebec by three parallel series of ridges, trending in a general northeastern direction.

The western chain of hills, known as the Sutton range, is the northeastern extension of the Green Mountains of Vermont.

Approximately 25 miles east of the Sutton range, a central ridge, rise above the plateau which Fenneman (1917) has termed the New England Upland. This chain of hills loses its identity in the vicinity of lake St. Francis. The northern extremity of that central ridge is the object of the present investigation.

The easternmost range which was originally known as the Boundary Line Hill was named, at the turn of the twentieth century, the Lake Megantic range by Dresser (1909). This chain of hills and the adjoining Blue Mountains of Maine are a continuation of the White Mountains of New Hampshire.

Local

Topography

The map-area is part of the Stoke or Ascot mountain ridge. Because the series of hills found near Weedon are slightly to the south of the northeastern extension of the Stoke Mountain range and also because there is gap of 8 mile between the Weedon hills and those belonging to the Stoke Mountain ridge, it is proposed to call the series of hills found near Weedon, the Weedon Mountain ridge.

For a matter of convenience, the map-area can be subdivided into three topographical units oriented in a northeasterly direction parallel to the local trend of the formations.

West of Elgin lake, there is the St. Francis valley, un-

derlain by limestones and characterized by the presence of the lakes Aylmer and Weedon, and the St. Francis river (Plate I).

Next to the southeast, is a series of hills made up of metavolcanics and younger granite stocks. A maximum relief of more than 1000 feet is reached at one place northeast of Fontainebleau.

South of Red river in the Gould area, a third unit is represented by a gently rolling topography. Here, the underlying rocks are metasediments of the St. Francis-St. Juste group.

Lakes

Hook-shaped lake Aylmer covers nearly half of the lake Aylmer map-area even though only two thirds of the total lake surface is within the map-area. Approximately 11 miles long and varying in width from $\frac{1}{2}$ a mile to 3 miles, the lake Aylmer is drained to St. Lawrence river by way of St. Francis river. Its north-south direction, across the structural trend of the rock formations, suggests a scooping out of the lake basin by ice.

Weedon lake, which is a mere widening of the St. Francis river, was formerly called Louisa lake. At that time, the lake was only half as wide as it is now. To-day the lake is two miles long and one mile wide. Although never reported as such it is reasonable to think that the lake is only a few hundred years old. This lake is extremely shallow except along the St. Francis river channel. The lake basin is everywhere sand covered. No doubt the shape of the lake has been controlled by river erosion of glacial drift.

Elgin lake, which is drained northward to the lake Aylmer by

way of Maskinongé river, is assigned to the class of rock-basin lakes. It is triangular in shape. The lake is 2 miles long in an east-west direction and has a maximum width of one mile. It is reported that its waters are locally more than 100 feet deep. The east-west orientation of the lake, the resistant nature of the surrounding rocks, and the straightness of its shoreline in an area of rather rugged topography strongly indicate that some structural control must be invoked to explain its shape and its location. So far, however, evidence for a fault is lacking. Also glaciers have very likely enlarged this lake basin.

Trout lake, Moose pond and lac l'Equerre are characteristically rock basin lakes. Moose pond is drained northward to Elgin lake, whereas Trout lake is drained to Salmon river and lac l'Equerre to lake St. Francis. The water surfaces of those three ponds are respectively 268,305 and 398 feet above the surface of lake Weedon. Weedon lake itself is 798 feet above sea-level. Lake Aylmer and lake Elgin are respectively 813 feet and 890 feet above sea-level.

Rivers and Streams

The greater part of the map-area is well drained, but swamps and muskegs are found north of Fisher Hill and at the head of Red river where beaver dams have caused some flooding.

The St. Francis river valley is controlled by structure of the bedrock. This river flows within the map-area for a distance of only 2 miles, connecting lake Aylmer to lake Weedon.

Red river and St. Francis river are subsequent streams that flow southwestward.

Rat river is a subsequent stream in its upper course only. In its lower course it flows westward into St. Francis river.

Salmon river, a major tributary of St. Francis river, is only in part a subsequent stream. Flowing from south to north the river turns left one mile south of Fontainebleau and meets St. Francis river one mile south of Weedon Centre.

Westwardly flowing Moffat brook meets Salmon river at Gould village. That brook is very poorly adapted to the local structure. The same may be said about Maskinongé river, draining lake Elgin to lake Aylmer, as well as Bernier river and Coulombe river both of which flow into lake Aylmer.

Except for the St. Francis and Salmon rivers, the valleys occupied by all the above streams are miles up or down stream, strewn with glacial boulders of all sizes. Alluvial sand deposits representing reworked glacial drift particularly well exposed along Salmon river and where secondary streams meet larger ones. A delta is being built at the head of lake Weedon.

GENERAL GEOLOGY

Regional Geology and Rock Magnetism

In southeastern Quebec all the rocks are believed to be Paleozoic and may be subdivided into pre and post-Taconic rocks assigned respectively to the Quebec and Gaspé groups. The rocks of the Gaspé group have been established to be Silurian and Devonian in age

whereas those of the Quebec group are inferred to be Cambrian and Ordovician. Fossils of Ordovician age have locally been found in that sequence.

Between the Stoke or Weedon range and the western limit of the Arnold River formation (Marleau 1958) exposed near the Quebec-Maine boundary, the rocks consist of tightly folded strata belonging to the Gaspé group and have been shown to be a part of the "Gaspé-Connecticut River Synclinorium" (Duquette 1959 p. 243; Marleau 1959 p. 129).

Unconformably beneath and west of that synclinorium, a wide band of metavolcanics and metasediments of the Quebec group is exposed.

Resting unconformably above those pre-Taconic rocks, a narrow belt of Silurian and possibly Devonian limestone can be traced from lake St. Francis down to lake Memphremagog near the Quebec-Vermont boundary. This limestone is assigned to the Gaspé group and is for that reason correlative of the rocks of the "Gaspé-Connecticut River Synclinorium". This correlation is based on fossils and it is strongly substantiated by a nearly continuous series of lithologically similar rock exposures connecting those two belts of rocks south of Marbleton.

In general pre as well as post-Taconic rocks trend north-east with comparatively straight contacts between them.

When comparing geological maps with aeromagnetic maps published by the Geological Survey of Canada (Maps 162G, 163G, 156G, 157G), it is striking to see how closely the trend of the formations follows the elongation of magnetic highs and lows expressed by magnetic contours.

As a rule the Quebec group metavolcanics are characterized by closely spaced highs oriented parallel to the local trend of the rock formations, and the sedimentary rocks of both Quebec and Gaspé groups are represented by irregularly distributed magnetic lows.

Within the map-area, a maximum magnetic intensity of 2700 gammas is reached over the Weedon schists cropping out in the northeastern part of the Stratford sheet. Here the schists have been derived from basic lava flows interbedded with tuffs and a few horizons of cherty iron formation. The lowest magnetic value which is equal to 1690 gammas is found west and adjacent to the high mentioned above. A maximum magnetic difference of 1010 gammas is thus present within the map-area. It is interesting to note that the Solbee Copper Mine orebody is located over that magnetic high.

It is also worth mentioning that the unconformity known to exist between the rocks of the Quebec and Gaspé groups, is well indicated near Marbleton and Bishopton where an axis of high magnetic intensities caused by the Stoke schists and oriented in a northeasterly direction continues for nearly 4 miles east of the line of contact of the two groups.

At the same locality the irregular line of contact of the two groups is in strong contrast with the local trend of the magnetic highs and this is taken as additional proof of an unconformity between the two groups.

Local Geology

General Statement

Near Weedon the sedimentary rocks can be subdivided into 5 major units, each one containing characteristic assemblage of rocks. They are from west to east, the Disraeli slate, the Lake Aylmer limestone, the Weedon schists or metavolcanics, and the lower and middle formations of the St. Francis-St. Juste group represented respectively by limestone and siltstone interbedded with slate.

The author retains the use in its original meaning of the terms Quebec group and Gaspé group as proposed and defined by Logan.

The five units can be grouped as followed:

<u>St. Francis-St. Juste Group</u> (part of Logan's Gaspé Group)	<u>Upper formation=</u> (Compton formation) not exposed.
	<u>Middle formation=</u> (interbedded slate and siltstone)
	<u>Lower formation</u> (limestone) correlated with the Lake Aylmer limestone.
<u>Quebec Group</u>	<u>Weedon Schists formation</u> (metavolcanics)
	<u>Disraeli formation</u> (slate)

Abundant small intrusives hitherto undetected, are seen cutting the Weedon schists and are believed to be related to the Taconic orogeny.

Stratigraphic Sequence

The oldest rocks of the area belong to the Quebec group of inferred pre-Silurian age. West of the Lake Aylmer limestone the Quebec group is represented by the Disraeli formation characterized by a sequence rich in black slate with minor acidic tuffs and grits. East of the limestone the rocks of the Quebec group are confined to a belt of schistone metavolcanics and related intrusives called the Weedon schists.

The Lake Aylmer limestone of Upper Silurian to Lower

Devonian age rests unconformably above the Disraeli slates and the Weedon schists. Farther south the St. Francis-St. Juste group lies unconformably above the Weedon schists. The lower part of this group consists of a calcareous sequence in all respects similar to the Lake Aylmer limestone. Because of the similarity of them as far as lithology and structural relationship to the Weedon metovolcanics go, a correlation of those two limestone formations is here proposed.

Conformably and above the St. Francis-St. Juste limestone, a sequence of siliceous siltstone interbedded with black slate crops out abundantly in the southeastern part of the Stratford and Gould sheet-areas. This sequence represents the Middle formation of the St. Francis-St. Juste group.

Because the St. Francis-St. Juste limestone is here correlated with the Lake Aylmer limestone, the St. Francis-St. Juste group must be assigned to the Gaspé group of Silurian and Devonian age and belongs, for that reason, to the "Gaspé-Connecticut River Synclinorium", a major structural unit that will be discussed later.

The eastern part of the Weedon sheet is underlain by a post-Lower Devonian stock of granite. This biotite-oligoclase-granite is seen to cut the whole stratigraphic sequence including a coarse-grained meta-gabbro sill found east of Trout Lake.

Another oligoclase granite stock of post-Lower Devonian age crops out along the eastern boundary of the Stratford map-area.

A thick blanket of unconsolidated materials covers the lower parts of the region and the flanks of hills. The Pleistocene deposits are of variable thicknesses and consist of glacial till, erratic blocks, and kame terraces. Alluvial deposits are also abundant and consist mainly of silt, sand and gravel.

Age	Formation	Lithology
Pleistocene and Recent		Stream deposits
		Moraines and kame terraces

Angular unconformity

	Intrusive rocks related to Acadian orogeny	Feldspar porphyry dykes Granite Diorite Gabbro
--	--	---

Siluro- Devonian	Gaspere Group	St. F Upper Formation (Compton-Seboomook formation)	Black and grey slates, fine-grained sandstone. (not exposed within the map-area)
		St. I Middle Formation	Siliceous siltstone interbedded with black slate.
		St. J Lower Formation and Lake Aylmer Formation	Silty limestone and calcareous siltstone (some rhyolite porphyries and blotchy lavas in Lake Aylmer formation alone) Conglomeratic lenses interbedded with slate, greywacke, grit and dolomite.

Unconformity

		Intrusive rocks related to Taconic orogeny	Sill-like bodies of albite rhyolite porphyry Albite granite plugs Light grey granophyre.
Pre- Silurian	Quebec Group	Weedon Schists Formation	Sericitic crystal tuff, agglomerate, and a few meta-basic flows.
			Augen schist and crush conglomerate
			Greenstone, dark green tuff, agglomerate, blotchy lava, and red cherty bed.
	P	Disraeli Formation	Sericitic crystal tuff and agglomerate.
			Black slate, some tuffs, grits, and greenstone.

STRATIGRAPHYLOWER PALEOZOIC (PRE-TACONIC)QUEBEC GROUPDisraeli formationName and History of the Name

The northwestern corner of the lake Aylmer map-area is underlain by slates that represent the southern half part of the Disraeli formation.

The name "Disraeli series" was introduced by Burton in 1930 and redefined three years later in a doctoral thesis dealing with the geology of the lake Aylmer area and its vicinity. On poor lithological evidence and because of a presumed major thrust fault running along the eastern contact of the Lake Aylmer limestone, Burton concluded that the slates lying west of the fault are repeated east of it, that is, south of the Weedon metovolcanics in the Stratford map-area.

In 1932, Cooke reports that he was able to trace the westerly band of Burton's Disraeli series east to Chaudière river. He thus believed it to be continuous with what MacKay (1921) had previously termed the Beauceville series. Accordingly the name Beauceville was extended by Cooke to the area here treated.

The writer suggests that the name Disraeli proposed by Burton be retained, but it is recommended that it be termed a formation rather than a series. Also Disraeli formation as used in this work includes only that part of the Disraeli series that lies west of Burton's Weedon thrust fault.

Distribution

The rocks of the Disraeli formation are exposed in the northwest corner of the Lake Aylmer map-area and represent a complete section of only the southern half of the whole formation. The Disraeli formation is bounded on the west by rocks of the Caldwell group (Cooke, 1937) and to the east by rocks of the Lake Aylmer formation, which will be

The total breadth of the Disraeli formation is approximately four and a half miles near Garthby and about six miles near lake St. Francis. The exact strike extension of the formation is still unknown.

According to original work of Burton, the Disraeli formation would, however, extend from lake St. Francis down to latitude of Weedon lake, a total distance of 18 miles. This, of course, must be taken strictly as a minimum value.

Lithology

The rocks seen in the southern half part of the Disraeli formation can be grouped into four lithological units. The sequence followed for the description of the rock is only a matter of convenience.

Striped Slate - Evenly and thinly laminated dark grey to black slates underly approximately four fifths of the area covered by this half section. Bedding and cross-bedding is usually reflected by interlamination of black slates with thin but usually rusty siltstone or sandstone layers. Slate beds are a fraction of an inch to a few inches thick. The rock is fissile along two subparallel planes of schistosity and breaks down, for that reason, into minute chips and spindle-shaped fragments, smaller than one inch across. The chips have characteristically a shiny luster. In places, innumerable tiny pyrite cubes are crowded in the sandier interbeds, the intervening argillaceous beds being comparatively free of pyrite.

Excellent exposures of striped slates showing small scale cross-bedding can be examined on a road cut in range I.N. a few feet south of range Central. Similar exposures are to be found on lots 45, 46 and 47 in range I.N.

At one or two localities a four inch thick limestone bed has been mapped. The black limestone shows a coarse crystalline texture

and has been broken under deformation into lens-shaped fragments that are locally a foot a part.

The few thin sections of black slate examined under microscope, show that the rock consists of quartz grains (.03mm across) set in a nearly or completely recrystallized clayey material now converted into hydro-muscovite. Several samples of slate have been chemically analyzed for Na_2O , K_2O , SiO_2 as well as for trace elements in order to compare them with the slates of the St. Francis-St. Juste group. The results are given in table 4.

Siltstone, Sandstone, and Grit - Apart from the micro-interbeds of siltstone, the slate beds are commonly interlaminated with thick siltstone, sandstone, and grit layers. There is complete gradation from siltstone to sandstone and grit. The rock weathers creamy white showing minute stains of limonite. On its fresh surface it is light grey to greenish grey.

Commonly the deeply weathered zone is separated from the fresh rock by a semi-weathered layer, dark brown in color and approximately an inch thick. In thin section, the sandy siltstone consists essentially of quartz grains (0.25-0.5 mm) that are enclosed by a quartz and sericite rich matrix. Coarse grains of plagioclase have occasionally been observed.

One band of siltstone and sandstone is 500 feet thick and carries minor interbeds of black slate and grit. The band crops out just west of Garthby. A bed of grit, two feet thick, has been found at its western contact with the slate, 400 feet south of highway No 34 on lot-line 53-54.

The coarser fragments of the rock are quartzite, siltstone, and plagioclase crystals. Some of the fragments are as much as 10 mm across. Well rounded quartz grains of 2-4 mm in diameter are also abundant. Matrix of the grit is essentially made up of quartz and sericite in a ratio 4 to 1. The rock shows very poor sorting and is rather massive when compared to the siltstone and sandstone beds. The siltstone fragments are readily seen on a fresh surface because of their deep limonitic stain (Plate II).

Three other similar but rather thin bands of interbedded siltstone and sandstone were mapped west of the above one. None of them is thicker than 40 feet. Quartz and sericite are the most abundant minerals. Slate and tuff are locally interbedded with the siltstone and sandstone beds.

Acidic Tuff - The second most abundant rock type of the Disraeli formation in the section covered by the lake Aylmer sheet is tuff. It weathers characteristically white but it is dark grey on its fresh surface. Because of its homogeneity and its very fine-grained texture the tuff tends to be exposed as ledges.

A minimum of six tuff layers were mapped by the writer and they vary in width from 10 to 300 feet. The best exposures are on lots 48 and 49 in range I.S. and along lot line 4-5 in range Central, 500 feet north of the lake Aylmer sheet, in Garthby township.

Under the microscope and with one nicol, numerous curved shards (0.25-0.5 mm) of crescentic and spicule-like shape are seen welded together. Under crossed nicols however, only a very fine-grained (0.01 mm) crystalloblastic texture is detected, the lack of optical continuity between the grains being quite characteristic. Also present

in the rock are small crystals (0.3-0.5mm across) of feldspar and quartz and nodular agglomerations (0.2-0.6 mm) of interlocked crystals of quartz and albite. In general the rock is slightly peppered with minute stains of pseudomorphic limonite after carbonates. Almost 90 per cent of the rock volume is accounted by quartz and feldspar grains, the remaining part being taken by sericite.

Greenstone - Two bands of greenstone, 400 feet apart and traversed by some calcite and epidote veins, were examined on a road cut on highway No 34, 1000 feet west of its junction with highway No 1. Each band is approximately 2 feet thick and lies parallel to the nearby slate beds.

The rock shows, under microscope, a blastoporphyritic texture, chlorite and actinolite needles having almost completely replaced the original pyroxene or amphibole phenocrysts. Relic phenocrysts are $\frac{1}{5}$ to $\frac{1}{2}$ mm across. The feldspar grains are much altered into clinozoisite. Actinolite (75% - 80%), chlorite (10% - 15%), albite (2% - 3%) and clinozoisite (1% - 2%) are the main rock constituents.

Those two greenstone bands may represent one single band repeated by folding.

Metamorphism

The whole formation has been moderately metamorphosed by dynamic action. Mica has been recrystallized or developed from clayey material and the flakes have tended to take up a parallel orientation. Part of the quartz has recrystallized, and most feldspar grains are more or less converted into sericite and clinozoisite. Mafic minerals

are most commonly replaced by chlorite and actinolite.

On a regional scale, the formation is of low metamorphic grade corresponding essentially to the greenschist facies.

Structure

By determining tops from graded bedding and cross-bedding in the slates 12 fold axes have been recorded in the southern half part of the Disraeli formation. Eleven out of 12 have been recorded in a band of rock less than 3200 feet thick. It is inferred that a similar situation prevails throughout the whole formation. Fold axes trend parallel to the strike of the more northerly local schistosity that is N. 40° E. and plunge from 0° to 30° north or south. Cleavages in the slate dips steeply east or west. Bedding strikes parallel to the more northerly schistosity except around nose of folds and dips everywhere steeply to the east or west. Overturning is not common in the slate.

On a road cut along highway No 34, 2500 feet west of its junction with highway No 1, and 200 feet south of range Central, an anticline is well exposed in the Disraeli slate (Plate III). Adjacent syncline gives a maximum spacing of 50 feet between the two fold axes. Similar values have been found elsewhere and it is taken as a fairly representative figure for the rocks of the Disraeli formation. As a rule, folds are asymmetrical and tight but at two localities they were respectively overturned and vertical isoclinal.

Following Burton's contention (1933 p. 102), the writer believes that the Disraeli formation looked at broadly is part of the west limb of a major syncline, probably closing to the south. The

axial plane of this major fold is N. 42°E. and stands vertical or dips steeply east or west. Because of cross folding, the crest of the fold may pitch at angles up to 30° in either direction but the northeast pitch is the more common.

The view that the formation is in the main a monoclinial succession is based largely on the fact that distinctive beds of tuffs and grits are apparently not repeated as one crosses the strike of the formation.

There has been general agreement since Logan time that the sequence of sedimentary and volcanic rocks found next to the west of the Disraeli formation is older than the rocks of the Disraeli formation. Good evidence has been put forward to prove an unconformity between the two formations but just as strong arguments have been recently offered for the alternative hypothesis. There seems to be however general agreement on considering the Disraeli formation as resting above and being younger than the Caldwell volcanics.

Adjacent and east of the Disraeli formation, there is a band of conglomerate which is followed to the east by limestones of the Lake Aylmer formation. There is little doubt considering variety, size and abundance of pebbles that this conglomerate is the basal conglomerate of the Lake Aylmer formation. Therefore the Lake Aylmer formation must be lying unconformably above the Disraeli formation. Although Ellis considered this conglomerate as Cambrian and older than the here-called Disraeli slates, found to the west, the writer fully subscribes to the view expressed by Logan, Burton, Cooke, and Clark who all agreed on considering the conglomerate as the basal unit of

the Lake Aylmer formation, dated, since Logan time, as Siluro-Devonian from fossils data.

Thickness

In a belt of very tightly folded rocks having no horizon marker, it is a most difficult task for a field geologist to give a fair estimate of the true thickness of a formation. The Disraeli formation falls into that category but in order to find a reasonable answer a short study of the problem has been made by the writer in a doctoral thesis (1961) dealing with the geology of the Weedon area and its vicinity.

As the Disraeli formation represents a very tightly folded sequence of rocks, curve A of graph 5 shown on page 36 of the writer's thesis (1961) may be used. Because the writer considers the Disraeli formation as being a monocline and more exactly as the western limb of a synclinatorium (or the overturned western limb of an anticlinorium which is highly improbable), the angle " σ " which corresponds to the angle of dip of the limbs of this synclinatorium, is assumed to be equal to 75° . This 75° degree value is suggested in part by the general dip of the formations close to the Sutton axis and also by the very likely similar values of dip for both the Disraeli monocline and the eastern limb of the Sutton anticlinorium. Those 2 units are adjacent and appear to be structurally conformable with one another. From the above assumptions, by using curve A of graph 5, a ratio "r" equal to 0.475 is found. As the outcrop width of the Disraeli formation is close to 23,000 feet near Garthby, its true thickness would there-

fore be approximately 11,000 feet.

Correlation

Previous Correlation - Logan (1863) made, what he called, a doubtful correlation of the Disraeli formation with the lower part of his Gaspe limestone. He inferred that the slates were lying unconformably above the volcanics cropping out to the west and assigned to his Quebec group.

From field work done during the summers of 1884 and 1885, Ellis concluded that the sequence of rocks here called Disraeli is part of his Cambro-Silurian series.

Burton in 1930 makes a correlation between the St. Francis-St. Juste slate and the Disraeli slate because of their similar lithology and metamorphism.

Cooke on a long range correlation identified in 1932 the Disraeli formation with MacKay's Beauceville group, the type section of which is exposed on Chaudière River west of St. Georges. He reports that he has been able to trace the band eastward to Chaudière River, a distance of approximately 22 miles.

Clark apparently accepted in 1935 the correlation suggested by Cooke.

Present Correlation - Because of a good strike alignment, a similar lithology and metamorphism, it is here proposed to correlate the slates found east of lake Memphremagog and named Magog forma-

tion by Ami in 1900 with the slates of the Disraeli formation and with those of MacKay's Beauceville series cropping out on Chaudière river. As the distance between lake Memphremagog and Chaudière river is nearly 100 miles, facies changes may be invoked for variations of lithology along strike.

This view has already been presented by Cooke in his memoir 211 and 257. (G.S.C.) It must be stressed however, that instead of considering this correlation as a fact the author sees it only as a highly tentative correlation that must be used as a working hypothesis.

On a much larger scale the writer accepts Cooke's correlation of the slates east and west of lake St. Francis, north of the Narrows. (map 417 A, G.S.C.) Leaving the shore of lake St. Francis and going northeastward along strike, Cooke indicates on his map a sudden decrease in the total breadth of his Beauceville group. Although the western limit of the group appears to be correct, the writer feels that the eastern boundary should be pushed eastward down to a line passing by Lambton lake and lac aux Grelôts to the northeast. The rocks in this added portion are in every respect similar to those that lie to the west.

Age

No fossils are found in the rocks of the Disraeli formation. It is believed, however, that the Disraeli formation underlies with unconformity the Lake Aylmer formation, the fossils of which indicate

its age as Middle Silurian, upper Silurian or Lower Devonian. As it is generally accepted that the Taconic revolution ended in late Ordovician time, the rocks on which the lake Aylmer sediments were laid down must have been pre-Silurian in age.

Another line of evidence for considering pre-Silurian the rocks of the Disraeli formation is found by correlating the formation with rocks cropping out in the Castle Brook area and its vicinity where graptolites are found in extraordinary profusion in thin-bedded graphitic slates. In fall 1960, eight collections of these graptolite-bearing slates collected on lots 19 and 21, range XIV, Orford Twp. by Pierre St. Julien of the Quebec Department of Mines were sent to B.N. Berry of the Museum of Paleontology of Berkely, California who reported (personal letter to Osborne, 1960) as follows: "most can be confidently assigned to a zone and the majority are from the Climacograptus bicornis zone. This is a correlative of the Black River stage. I have assigned two collections to my (1960) zone of Orthograptus Truncatus var. intermedius. This zone overlies that of C. bicornis and is a correlative of the Trenton stage. These are the same two zones that I recognized in the Magog material from Castle Brook; and also, the major part of the Normanskill formation falls within the C. bicornis zone, but the upper most part of it is within the next younger zone".

Thus if the rocks of the Disraeli formation proved to be correlative of the slates of the Castle Brook area and its vicinity, part, at east, of the Disraeli formation should be Middle Ordovician.

A similar age is also indicated for the rocks of the Disraeli formation if the latter rocks are correlated with those of the Beauceville series, near Chaudière river. Burton (1956, p. 62) who found graptolites in slates exposed 4 miles north of lake Etchemin and in strike with the slates of MacKay's Beauceville series, to the south, reports that. "Within the Beauceville group, as exposed in the St. Justine map-area, there is a fossil locality on lot 10, range VI of Ware township, where graptolites are found in black slates. All these graptolites appear to be biserial. Lasiograptus bimucronatus appears to be present and is suggestive of Normanskill type. Although the identification is not positive it appears that these fossils are of Ordovician, and probably of Middle Ordovician age".

Pending further work on the correlation of the Disraeli formation, this formation is tentatively assigned by the writer to Middle Ordovician.

Weedon Schists Formation

Name and History of the Name

Logan in 1860 noticed the presence of very schistose rocks cropping out east of lake Aylmer. He described them as very similar to the volcanics of his Quebec group.

Burton in 1933 proposes to call Weedon schists, the volcanic assemblage that crops out between the Lake Aylmer formation to the west and the St. Francis-St. Juste group to the east (named Disraeli by Burton). He classed the Weedon schists in his Gagné Brooks series which he considered to be of lower Paleozoic age.

The Weedon schists had previously been assigned by Selwyn (1877), Ells (1886 p. 31), Dresser (1907, p. 25-26) and Bancroft to the Precambrian.

Clark in 1935 reexamined Burton's Weedon schists and Disraeli series east of the lake Aylmer and concluded that they were conformable to each other, the schists being at the base of what he called the St. Francis series of inferred Ordovician age.

From field evidence gathered in september 1947 in Orford township, Cooke (1950) reports he has discovered a new group of rocks of Silurian age and he named it Sherbrooke group. According to Cooke the Weedon schists are petrographically similar to the lava sequence exposed near Sherbrooke City and proposed that: "until evidence of the contrary is obtained, the two must be classified together in the Sherbrooke group".

Distribution

The Weedon schists form a northeasterly trending belt, about 23 miles long and 3 miles wide at its maximum breadth (south of Trout lake). The formation has a much flattened S-shaped outline and gradually pinches out when going towards its extremities. It is bounded to the north by lake St. Francis, south of the Narrows, and to the south by latitude $45^{\circ} 37'$ (cf. geological maps).

This belt of rocks extends diagonally across the Stratford and Weedon map-areas and underlies the southeastern corner of the lake Aylmer sheet and the northwestern corner of the Gould map-area.

In all, the formation covers an area of approximately 29 square miles.

Lithology

The order followed in the description of the Weedon schists is only a matter of convenience and without implication of relative age.

Four main units have been recognized. Going from west to east there are:

- 1-) Sericitic crystal tuff and agglomerate.
- 2-) Greenstone, dark green tuff, agglomerate blotchy lava, and red cherty bed.
- 3-) Augen schist and crush conglomerate.
- 4-) Sericitic crystal tuff, agglomerate, and a few metabasic flows.

Sericitic Crystal Tuff and Agglomerate - Starting on lot 18, Rg II, Weedon tp, a series of quartz sericite schists and quartz albite sericite schists runs in a northeasterly direction right up to and beyond the northern extremity of the Stratford map-area. This band of tuffs is limited to the west by the Lake Aylmer formation and to the east by a sequence of meta-basic flows and pyroclastics. From its southern extremity, the band gradually increases in width and reaches a maximum breadth of 2 miles near lake Elgin. Further north the width of this series of tuffs narrows down fairly rapidly and is only 1100 feet wide where the band crosses the northern boundary of the Stratford sheet. Along its eastern contact, this unit is commonly interfingered with meta-basic flows which will be described later.

The sericite content of the schists varies from one place to another, but it is particularly abundant south of Elgin lake near

Fontainebleau. Here the schists are usually silvery white and have a greasy feel when rubbed between fingers. Good examples of this are found on lot 20, range II, Weedon Township. When examined under microscope it is seen to be made up essentially of quartz, sericite, and feldspar. The coarser fragments ($\frac{1}{2}$ mm) are mostly bipyramidal corroded quartz and albite crystals. Graphitic tuffs are abundant.

On lot 21, range II, west of the road of Fontainebleau, a 30 foot thick lens of volcanic agglomerate is exposed (Plate IV). Approaching the Weedon granite plug, part of the sericite has been converted to biotite, and the schists are dark brownish grey.

West and north of Elgin lake, the quartz sericite schists commonly carry albite crystals and small rock particles made up of albite and of a mixture of quartz with albite, the two being intimately intergrown.

In this part, the schists represent therefore the altered equivalents of rhyolite crystal tuffs interlayered with ashy tuffs and minor agglomerate.

The following description of cores coming from a hole (H7, Sullivan 1959) drilled on lot 14 in range VI S.W. of Stratford Township, will serve to illustrate the above statement.

Examination of cores coming from holes drilled at a latitude north of Elgin lake, across the whole band of sericite schists, has led to results similar to those found from hole H7.

Seen under microscope the crystal tuff shows a variable amount (20-70%) of quartz and albite crystals, and small rock particles (< 2 mm) made up of albite phenocrysts surrounded by an

Hole 7

Thickness	Depth	Description
100'	0' - 100'	Yellowish to light yellowish green sericitic tuffs in part carbonatized and very thinly laminated; the schistosity plane is characteristically planar and uniform.
60'	100' - 160'	Medium grey sericitic crystal tuffs. Sericite is less abundant than above. The rock has a more massive appearance and does not cleave as easily. Quartz and feldspar phenocrysts make small protuberances on the schistosity plane.
64'	160' - 224'	Sericitic tuffs as 0'-100'
52'	224' - 276'	Sericitic crystal tuffs as 100' - 160'
65'	276' - 346'	Sericitic tuffs as 0' - 100'
29'	346' - 475'	Bluish acidic intrusive (albite rhyolite porphyry)
	475'	end of hole

intergrowth of quartz with feldspar. The quartz crystals are normally irregular in shape having numerous smooth embayments, and are traversed by curved cracks (Plates V, VI). The albite crystals show albite and pericline twinning. Carlsbad twinning is rare. The rock as a whole has a noticeable absence of potash feldspar. The rock particles made up of quartz and albite, exhibit as a rule a rounded outline. The groundmass is very fine-grained (1/20 - 1/100 mm) and consists of a mixture of quartz, feldspar, and sericite with a minor amount of magnetite and biotite, the latter replacing any of the original minerals. The groundmass as well as the coarser portion of the rock show a marked degree of heterogeneity and a wide variation in grain size. Pro-

bably because the crystal tuffs were not formed far from a volcanic center, some crystals of quartz and feldspars, perfect or broken, often show a characteristic arrangement, standing with their long axis vertical or roughly perpendicular to the lamination of the matrix, as if dropped into their place from above. The great abundance of crystals and rock particles in some of the tuffs may be explained by their proximity to the volcanic center. It is, indeed, a generally accepted view that the ejecta of a volcanic eruption will normally be richer in crystals and rock particles near the source than at greater distances.

In summary, this first unit of the Weedon Schists formation represents a schistose and fine-grained pyroclastic assemblage made up essentially of completely devitrified rhyolitic tuffs that carry a variable amount of quartz and albite crystals and small rock particles.

Greenstone, Dark Green Tuff, Agglomerate and Blotchy Lava -

The second unit of the Weedon Schists formation is east of and apparently conformable on to the first one. The unit is made up essentially of greenstones and minor pyroclastics. The Mount Aylmer granite cuts in two roughly equal segments this band of rocks. Although there is a gap of 3 and a half miles between the two segments it is reasonable to assume that they were at one time forming one single band. Each segment will be described separately in order to facilitate the description of their petrological characteristics.

Southern Segment - The southern segment starts on lot 23 in Range III, Weedon tp, runs due south to lot 19 of range III of the same township where it swings into a southwesterly direction and

keeps on this direction to its southern tip. This segment near Fontainebleau, is 500 to 1500 feet wide south of the road to Trout lake, but the band width increases rapidly going south. Where it crosses the western limit of the Gould sheet, the segment is approximately 7500 feet thick. The total length of this southern segment is 8.5 miles. The last three miles of this belt lies south of the map-area and were not studied by the writer.

The greenstone represents by far the most widespread rock type exposed along this belt. The rock is derived from massive and pillowed lavas, originally ranging in composition from about andesite to basalt. They are now represented by chlorite schists. Metamorphism has destroyed most of the original flow structure, but pillows are still quite prominent. The latter are, however, considerably elongated by deformation. They are locally quite porous due to the weathering out of the fillings of amygdules. Amygdaloidal structure is most commonly confined to the pillows. Chlorite is the dominant mineral determinable megascopically, with a minor amount of quartz. Epidote is present in places in considerable amount, especially around the remains of pillows. Thin veinlets of quartz and calcite are common in this sequence. The average mineral composition of a greenschist based on the estimated modes of 6 representative specimens studied under microscope is as follows: plagioclase (45%), chlorite (30%), epidote (5%), actinolite (5%), quartz (4%), calcite (3%), magnetite, pyrrhotite, and pyrite (2-3% combined), sericite and muscovite (2%) and traces of zircon, sphene, and leucosene (Plate VII).

Here is the details of those analyses:

TABLE I

Estimated Modes of Greenstones (Southern Segment) - (Weedon Schists formation).

No. of Specimen	S199*	b 269	S 111	b 122	S 90	S 75	Average
Plagioclase (An o-5)	45	35	35	40	70	45	45
Chlorite	25	55	25	10	25	30	30
Quartz	4	5	tr	10	3	4	4
Sericite & Muscovite	5	-	-	5	-	-	2
Epidote	-	-	-	20	-	10	5
Actinolite	-	-	25	-	-	-	5
Calcite	10	-	3	20	1	-	3
Fe ores	2	2	1	1	-	10	2-3
Zircon & sphene & leucoxene.	tr	tr	tr	tr	tr	tr	tr

*: The number represents specimen and thin section number. (held by Q.D.M.1960)

Epidote and calcite occurs both in large aggregates and disseminated throughout the section. Quartz is found in amygdales and quartz epidote calcite veinlets. Magnetite is usually well crystallized, the crystals measuring up to 0.3 mm. in diameter. Epidote, quartz, calcite, magnetite, and pyrite are all secondary minerals. Biotite has been altered to chlorite and albite shows incipient sericitization.

Interbedded with those greenstones we find blotchy meta-basic lavas on lot line 1-2 in range E of Lingwick township, 1500 feet north of range line E-D. The exposures of this type of rock suggest a lens-

shaped body elongated sub-parallel to the local schistosity, having a maximum breadth of 250 feet and exposed for a minimum distance of 450 feet. The rock has a blastoporphyritic texture given by relic crystals or clots of feldspar reaching commonly half an inch in diameter. Because of their whitish color on the weathered surface, the feldspars stand out in strong contrast to the dark green matrix. Under microscope the rock is seen to consist essentially of chlorite (60 - 65%), zoisite and clinozoisite (30% combined), sphene (strongly altered to leucoxene) (3 - 4%), and traces of calcite, quartz, pyrite, and remnants of plagioclase. The relic phenocrysts, making up more than 40 per cent of the total rock volume, still exhibit (001) and (010) cleavages but they have been almost completely replaced by minute scales of chlorite and grains of clinozoisite. The groundmass is now a fine aggregate of chlorite, zoisite and minute laths of albite (probably secondary).

This blotchy and massive looking igneous rock could be interpreted as intrusive. But its field association with lavas as well as a complete absence of evidence for a cutting relationship with the latter, have led the writer to believe that it represents an effusive rock. It may be the central and coarse-grained portion of a thick flow but evidence for such a contention is still needed.

In the north central part of the Gould map-area a wedge-shaped band of greenstone, crops out, 1000 feet north of Salmon river, and 2000 feet east of the Wolfe-Compton county line. The wedge is 800 feet wide at its base and apparently terminates before tra-

versing the northern limit of the Gould sheet. (a distance of 5000 feet). The writer believes that southwestwardly, beneath the cover of the younger sedimentary rocks of the St. Francis-St. Juste group, the band joins the main greenstone belt to the west. A line of evidence for such a correlation is given by the presence in that wedge-shaped band of lavas of two 40 foot thick bands of blotchy lavas, identical to the blotchy lavas previously described. The two bands are 50 feet apart and are exposed for a distance of 50 feet along strike, cropping out on lot 3 of range F, 1000 feet north of Salmon river.

Three feet long inclusions of red chert were found embedded in a greenstone exposure located also on lot 3 of range F, but at 1500 feet to the north of Salmon river. Those fragments of chert must have been picked up or torn off by the movement of the lava. Bands of a similar chert are seen interbedded with greenstones of the northern segment.

Northern Segment - The northern segment is about 12 miles long, limited to the north by lake St. Francis and to the south by mount Aylmer. Only the southern half part of this northern segment crops out within the limits of the area under study and it is included in the Stratford map-area. The band traverses the sheet in a northeasterly direction starting at mount Aylmer where it is 3800 feet wide. At the latitude of the village of Stratford, it is 7400 feet wide. The interfingering of this unit with the unit to west explains this sudden increase in width. Where the band of greenstones leaves the Stratford sheet to the north a width of 3500 feet is observed.

As in the segment south of Elgin lake, the most abundant rock type is greenstone.

Instead of having bands of blotchy lavas interbedded with the greenstone, the greenstones of the northern segment are partly interbedded with dark green tuffs, agglomerates, and red cherty beds.

The greenstone exposed in the northern segment has a mineralogical composition quite similar to that of the southern segment. A comparison of the average modal analysis given on page 49 with those given below, clearly illustrates the above sentence.

TABLE 2

Estimated modes of greenstone (Northern Segment) - Weedon Schists formation

Specimen No.	17	19	20	64	74	147	196	197	L64	P75	P152	Average
Plagioclase	30	50	50	15	65	35	30	70	85	55	45	50
Chlorite	40	5	5	35	15	5	40	15	10	15	tr	18
Actinolite	30	40	40	-	15	2	2	-	1	15	35	15
Epidote	-	-	-	10	3	55	-	-	1	10	tr	5
Calcite	-	-	-	30	-	-	20	3	-	-	-	5
Sericite	-	-	-	15	-	-	-	-	-	1	-	2
Quartz	-	1	tr	tr	tr	-	4	5	3	-	15	2
Fe ores	-	3	-	-	-	-	4	4	-	2	-	1
& Zircon sphene	-	-	-	-	tr	1	-	-	-	11	-	1
Biotite	-	-	tr	-	tr	tr	-	-	-	-	-	tr

It is interesting to note that the actinolite content is three times higher than the one found for greenstones of the southern segment.

What is more representative is the fact that here nine out of eleven specimens do carry actinolite whereas in the southern segment only one specimen had any actinolite. This indicates that the greenstones of the northern segment have undergone a slightly higher degree of metamorphism. It may be due in part to the presence of two granite stocks in the very close vicinity.

Amygdaloidal flows are more widespread than in the segment south of Elgin lake. The filling material of the amygdules is either quartz, calcite, epidote, chlorite or a combination of them. Some of them have a core made up of calcite, epidote, and biotite which is surrounded by granular pyrite. Some others have a chlorite-rich core rimmed by clinozoisite. The average diameter of the amygdules is 1mm.

Pillows are abundant and often have a rim of quartz and epidote. South of the old Stratford Pyrite Mine, close to mount Aylmer, some of the pillows have been almost completely replaced by epidote (Plate VIII).

Small basic sills of uralitized gabbro are fairly common throughout this lava sequence but it is not possible to trace them for more than 100 feet. They very likely represent channels along which lava has circulated and they are considered to be penecontemporaneous with the enclosing lavas. The rock is medium green and shows a fine-to medium-grained texture. A good example of this can be examined on lot 35, range 1 N.E. in Stratford township, 1200 feet north of range line 1 N.E. - 1 S.W. The gabbro has been found to ha-

ve under microscope the following mineralogical composition: actinolite (40%), oligoclase (An 30) (30%), chlorite (20%), pigeonite (18%), and epidote (2%). Traces of magnetite and sphene are also present. Actinolite and chlorite replace at its periphery the pigeonite crystals.

The second most common type of rock found in this greenstone band, is the dark green tuff. The beds of tuff can readily be recognized in the field by their distinctive planar schistosity that makes the rock split into plates less than 1/10 of an inch thick. This splitting property of the rock is conferred by a repetition of successively rich in feldspar and chlorite bands. If examined under microscope, the rock shows (45%) albite, (20%) biotite, (20%) chlorite, (15%) quartz, (2%) calcite, (2%) clinozoisite and a minor amount of magnetite and pyrite. Large crystals of albite (3mm across) are distributed at random in the rock making up 10% of the total rock volume. Biotite which replaces chlorite is held responsible for the very dark color of the rock. Those intermediate to basic tuffs are well exposed in the northern half-lots 31 and 32 of range II N.E. and lots 43 and 44 in range III S.W.

Interbedded with the greenstone, there are black and more commonly red cherty horizons that vary in thickness from a fraction of an inch up to 8 inches. The beds are everywhere strongly magnetic and carry above 90 per cent of granoblastic quartz. Up to 10 per cent of magnetite or hematite is present in the rock. Under shearing stress the cherty beds have been broken into phacoidal fragments instead of becoming schistose or folded. Exception to this rule however,

is found on the northern face of an agglomerate outcrop located on lot 33 in range II S.W., 700 feet north of the road going to Stratford. (Plate IX). Here a 8 inch thick cherty bed has been dragfolded quite surprisingly. It may be that folding took place before complete lithification of the cherty bed. Because of their lateral continuity, their widespread occurrence and their thickness which is often more than 6 inches, it is believed that the cherty beds represent sedimentary deposits closely connected with the volcanic activity that was going on at the time the Weedon lavas were being outpoured.

Also associated with the greenstones, the basic tuffs, and the cherty iron beds, we find rather irregularly distributed throughout this northern segment, thick lenses of volcanic agglomerate that are locally many tens of feet thick. Characteristically the matrix is rich in feldspar and chlorite. Large crystals of albite, single or agglomerated, are set at random in the matrix. By order of abundance the essential minerals of the matrix are albite (75%), chlorite (15%), quartz (5%), calcite (3%), and magnetite (1-2%); the bombs are normally four inches across and represent up 80 per cent of the rock by volume.

Some of the bombs are dark grey, aphanitic, and poorly to strongly magnetic. Some other are green, porphyritic to glomeroporphyritic and non-magnetic. The dark grey bombs carry quartz and calcite amygdules whereas the green ones have mixed chlorite albite epidote amygdules. The amygdules (3-4 mm across) are flattened parallel to the elongation of the bombs. The only mafic minerals in the bombs are chlorite, actinolite, and magnetite but they nowhere exceed per

cent of the total rock composition. The groundmass in the bombs is composed of an intimate mixture of quartz and plagioclase. An excellent exposure of this is seen on lot 33 range II S.W. 700 feet north of the road going to Stratford (Plate X).

The second unit of the Weedon Schists formation is thus characterized by a volcanic assemblage of rocks which is altogether intermediate to basic in composition.

Augen Schist and Crush Conglomerate -

Distribution and Description - The next unit of the Weedon Schists formation runs parallel and east of the greenstone band (Southern segment only). This third unit starts at Salmon river in the northern part of the Gould map-area and ends to the north abruptly against the Weedon granite stock, west of Trout lake. The distance between those two end points is 3 miles and a half. The width of this band gradually increases from 2400 feet to 5400 feet when passing from its northern extremity to the southern boundary of the Weedon sheet. South of this line, the band lenses out beneath the cover of the St. Francis-St. Juste sedimentary rocks.

The expression augen schist first used and defined by Lapworth (1885) refers to a cataclastic rock intermediate between a mylonite and a crystalline schist. The augen are porphyroclasts or mineral aggregates and they preserve evidence of cataclastic texture but the surrounding groundmass has been recrystallized. Megascopically, the augen schists resemble ordinary schists or phyllites but with a hand lens one can see eye-shaped mineral aggregates or porphyro-

clasts which have survived the complete pulverization of the groundmass, and which reminds one, on a miniature scale, of the augen in a typical augen gneiss.

Under microscope, the fine-grained crystal aggregates wander irregularly in swirls between the larger crystals and yet are oriented into streaks which give the rock a definite foliation. The larger grains, usually, consisting of quartz, feldspar or fragments of granophyre, occur either as individual crystal or in group, more or less isolated in the very fine-grained matrix made up of comminuted crystal tuff and pulverized granophyric material. In the latter case, 30 to 40 per cent of the groundmass consists of potash feldspar. Sericite, in the matrix, normally represents more than 10% of the total rock composition. The porphyroclasts and microfragments of granophyre show obvious evidence of rather intense cataclasis (Plate XI, XII). They are bent, cracked and deformed. They show wavy extinction, an abundance of microfaults and their edges are commonly surrounded by angular fragments rubbed off by mechanical movement. The foliation of those rocks is swirled to an extreme degree, its pattern in places resemble eddies in a turbulent stream.

Pseudo pebbles, cobbles and boulders of granophyre with a few fragments of milky quartz are found throughout the sequence of augen schists. Because there is a complete gradation from augen schist to crush conglomerate, (Plate XIII) the rocks of this unit may be called augen schists or crush conglomerates. The subrounded fragments of granophyre weather characteristically white and they stand out so ni-

cely above the outcrop surface that they can easily be mistaken for true pebbles. The quartz phenocrysts of the granophyre fragments are everywhere prominent on the weathered surface. Rod-shaped fragments of granophyre and milky quartz (Plate XIV), are also abundant in this sequence. The rods are a fraction of an inch to more than 6 inches in diameter. Where the rods of granophyre are split along their long axis, it is seen that the crystals of quartz, and feldspar are elongated parallel to the long axis of the rod (Plate XV). This elongation of minerals is probably the result of some recrystallization during deformation.

In the Gould map-area only a few pseudo cobbles and pebbles were seen in this unit. In the Weedon area, in strike and north of the latter outcrops, more pseudo pebbles, cobbles or boulders are found as going to the north. Pseudo boulders of one and two feet in diameter have been recorded by the writer, northwest of Trout lake. North of the outlet of Trout lake, only crush conglomerates are found (Plates XVI, XVII, XVIII).

The granophyre of Weedon is essentially a combination of quartz (25% - 45%) potash feldspar (30%- 40%) and albite (An 0-5) (15%- 35%). Leucoxene, sericite, pyrite, zircon, and epidote amount to less than 5%. The phenocrysts are everywhere quartz and albite, present in a nearly equal amount and making up together 30 to 80 per cent of the rock volume. Phenocrysts are on the average 5 millimeters across. The groundmass is made up exclusively of an intergrowth of quartz and potash feldspar that exhibits several types of implication texture. (A more detailed analysis of the granophyre is

found under the heading of granophyre in the chapter dealing with intrusives).

Age and Mode of Formation - As the Lake Aylmer conglomerate carries abundant pebbles of granophyre, this igneous material must have been injected into the Weedon pyroclastics before deposition of the Lake Aylmer conglomerate. But then at what time did the crush conglomerate and augen schist form? It may have formed during the Acadian orogeny or during a pre-Acadian orogeny. After a careful examination of excellent exposures of augen schist and crush conglomerate, particularly the outcrops found on lot 20 of range II, east of Fontainebleau, it became clear to the writer that the long axis of the rods and pseudo-pebbles of granophyre represent a "b" type of lineation and not a "a" type as one might suggest. It is believed that all the fragments of quartz and granophyre present in the augen schist and crush-conglomerate unit were formerly part of very competent, continuous and presumably thin igneous bodies such as dikes and sills that were injected into acidic pyroclastics. The granophyre bodies were then broken up phacoidally into fragments of all sizes under shearing stress. Under prolonged deformation a great many fragments were rounded by mechanical movement and eventually became isolated masses of granophyre surrounded by a very finely crushed material.

As the "b" lineation given by the long axis of the rods and pseudo-pebbles has a trend and a plunge nearly at right angles to the

"b" lineation present in the rocks that have been deformed by the Acadian orogeny uniquely,, the writer is inclined to think that the "b" lineation given by the rod axis must be related to a pre-Acadian period of deformation. Because the Taconic orogeny is known to have taken place in many parts of the Northern Appalachians (Schuchert 1885, Eardly King 1951) the same orogeny is called for the formation of those pseudo-conglomerates. The Taconic disturbance culminated at the close of the Ordovician period.

Sericitic Crystal Tuff, Agglomerate and a few Metabasic Flows -

The fourth unit is lying east and apparently conformable to the augen schist and crush conglomerate unit. The band is limited to the north by the Weedon granite and to south and east by rocks of the St. Francis-St. Juste group. This fourth unit of the Weedon Schists formation extends strikewise for nearly 5 miles and has a maximum width of 7000 feet.

This unit is made up almost exclusively of pyroclastics that pass from fine-to coarse-grained as going eastward across strike. The rocks adjacent to the augen schists are mostly tuffs and crystal tuffs whereas the rocks in the eastern half part are mostly agglomerates. Everywhere the rock is schistose and rich in sericite (Plate XIX).

The crystal tuffs were called in the field quartz feldspar sericite schists. They weather white but they are light green on a fresh surface. The combined percentage of quartz with albite is close to 90 per cent of the rock volume. Sericite accounts for the remaining 10 per cent. In the western half part of the band, the tuffs, as a rule, carry only 1 or 2 per cent of large crystals of albite and quartz. But in the eastern part the tuffs carry up to 50 per cent

of such phenocrysts (1 mm). Where such crystals are abundant the rock on its schistosity plane is light greenish grey and under microscope it is quite similar to the tuff that belongs to the first unit of the Weedon Schist formation. Locally the fine-grained pyroclastic beds show an intricate pattern of folding suggestive of a period of deformation prior to their complete lithification (Plate XX). Approaching the Weedon granite the tuffs get tougher. The writer has also observed that close to the granite, the same rock is fractured along two sets of planes that intersect each other at a small angle. The wedge-shaped fragments, thus formed, show however very little or no visible relative displacement.

As mentioned above, the agglomerates are more abundant farther to the east. They are best displayed on lot 6 of range F, Lingwick township, on both sides of the road that runs parallel to Salmon river (Plates XXI, XXII, XIII). Here subrounded and porphyritic masses of all sizes and made up almost exclusively of quartz and feldspar are set in an apple green and sericite rich matrix. The bombs as well as the matrix weather powdery white but they are light grey on a fresh surface. Under microscope the bomb is seen to have approximately 5 per cent combined quartz and albite phenocrysts (2-3 mms across) surrounded by a felted groundmass consisting of crowded microphenocrysts of feldspar disposed in a sub-parallel manner and of minute quartz crystals (about 30 per cent). As the quartz appears to be primary the bombs are rhyolitic in composition. The bombs are of all sizes and shapes. Some of them are tear-drop-sha-

ped some other are circular in cross section. They are everywhere elongated parallel to the local schistosity but as the foliation of the rock swirls to an extreme degree around the larger fragments, the smaller ones appear to be haphazardly distributed. A close examination of the rock, however, disproves this first impression.

A few greenstone bands are seen intercalated with the above pyroclastics close to the contact with the St. Francis-St. Juste group of rocks. Megascopically the rock is dark green and very fine-grained. Pillows are rare and as a rule they are highly deformed (Plate XXIV). In this section the mineralogical composition is about the same as that of other bands, previously described, and they all fall in the chlorite-epidote facies. Exception to this rule is found in a band of greenstone that has been traced for 2000 feet, 500 feet west of the Weedon granite stock and runs across lots 28 and 29 of range X, Lingwick township. The greenstone of this band belongs to the chlorite-epidote-amphibole facies. The presence of actinolite is obviously related to the nearby granite. Also related to this granite intrusion is the presence, on the weathered surface of the rock, of a series of closely spaced ridges oriented parallel to the local schistosity. This kind of differential weathering is explained by a slight silicification of the rock along thin and closely spaced layers (1/8" of an inch thick). Silicified greenstones found near mount Aylmer show a very similar pattern on the surface of weathering (Plate XXV).

Metamorphism

Regional Metamorphism - The Weedon volcanics have been subject to a regional metamorphism but to a much higher grade than that of any other formations mentioned in this thesis. The rocks are now schists of low metamorphic grade, corresponding to the greenschist and the albite-epidote-amphibolite facies. The most characteristic mineral assemblages of the pyroclastic rocks are quartz, albite, hydro-muscovite, and chlorite. The regional metamorphism has been mostly dynamic and this is in strong evidence where augen schists and crush conglomerates are found.

The derivatives of basic lavas have chlorite, actinolite, epidote, and feldspar with calcite and quartz as secondary constituents. The greenstones, as described earlier belong to two sub-facies, the albite-epidote-chlorite facies for the greenstones of the southern segment (i.e. south of Elgin lake) and the albite-epidote-chlorite-actinolite facies for those of the northern segment.

The regional metamorphism of gabbroic sills is apparently that of the basic lavas.

Contact Metamorphism -

Biotite - In addition to a regional metamorphism, the Weedon metavolcanics have been subject to a contact metamorphism along their contact with the two granite stocks. The isograd line of biotite runs roughly parallel to the line of contact of the granites with the invaded rocks. Within that line, biotite crystalloblasts have developed in any type of rocks whether acid or basic. In the southern and middle part of Weedon map-area, this isograd line is nowhere more than 2500 feet from the granite contact. From a point located

approximately one mile south of Elgin lake, the northern extension of this isograd line is not plotted with as much accuracy as to the south because of a lack of outcrops. In the Stratford map-area, close to mount Aylmer, the line has been traced with a reasonable degree of precision. As shown on the geological map of Stratford area, the isograd line of biotite is, in this part, everywhere within 1500 feet from the granite contact. North of mount Aylmer, the line apparently swings slightly to the north until it hits the base of the middle formation of the St. Francis-St. Juste group with which it seemingly coincides right up to the north of Stratford map-area.

Garnet - A discontinuous garnet isograd line was observed in the southeastern corner of the Weedon sheet (Plates XXVI, XXVII). No attempt was made, however, to extend the line north or south.

Cordierite-Anthophyllite - Crystals of cordierite (4mms across) that show locally polysynthetic twinning and a strong yellow pleochroism are present in pyroclastic beds in contact with the Weedon granite in range X of Weedon township. The porphyroclasts are elongated parallel to the schistosity and are partly altered into quartz and biotite. Small needles of anthophyllite are everywhere found associated with cordierite (Plate XXVIII).

In the Stratford map-area, close to the granite of mount Aylmer, a great many bands of greenstone carry porphyroblasts of cordierite. The crystals stand above the weathered surface as grey grains about $\frac{3}{4}$ inch long and $\frac{1}{2}$ inch wide. Some of them are nearly square in cross section (Plate XXIX). Seen under microscope the rock consists of cordierite (35%), and a matrix composed of anthophyllite (25%), plagioclase (25%), and chlorite (15%). Chlorite is concentrated at the periphery of the cordierite crystals,

around which it forms a layer less than 4mm thick. This chlorite zone is even visible with the naked eye. Needles of anthophyllite are distributed at random as inclusions in the cordierite crystals (Plate XXX).

Cordierite with anthophyllite are also a characteristic assemblage of minerals found in zones of alterations of the Weedon ore deposit and the old Stratford Pyrite ore body. A thorough description of these occurrences will be given later.

Tourmaline - A greenstone band, 1000 feet east the hanging wall of the Solbec ore body in the Stratford area is filled with black tourmaline crystals over a 4 inch thick zone.

A microscopic examination of this rock has revealed that the tourmaline crystals (about 1 inch long) are of the schorlite variety showing a strong concentric zoning reflected by a marked change in absorption when passing from one zone to another (Plate XXXI). The matrix, surrounding the tourmaline crystals is made solely of penninite. The ratio of tourmaline to penninite is approximately 1 to 2.

Rosettes of tourmaline of $\frac{1}{4}$ inch in diameter are seen in a 6 inch thick vein that cuts a greenstone band, 1200 feet northeast of the above locality. The vein carries in order of abundance, oligoclase, clinozoisite, calcite, chlorite, and quartz crystals.

Structure

Schistosity - Schistosity can be seen in most exposures of the Weedon Schists formation. In the Gould area the schistosity

strikes northeast then swings towards true north in the Weedon area and resumes its northeasterly direction in the lake Aylmer and Stratford sheet-areas. Schistosity dips steeply to the southeast but it is in many places close to vertical.

Bedding - Measurements of bedding have been made where good lithological contrast is present. Thus, observations depend on finding pyroclastic-lava contacts which are very common in the Weedon schists. It has been found that bedding is everywhere parallel to the foliation of the rock.

Lineation - Two general lineations are present in the Weedon metavolcanic rocks. The stronger and apparently the older one is given by the axis of dragfolds and crinkles and also by the axis of rods of quartz and granophyre and lastly by the long axis of the pseudo pebbles found in the augen schist and crush conglomerate unit. This lineation trends S. 45° E. to S. 70° E. plunging 45° to 85° to the south. For reasons given on page 61 this lineation is believed to be connected with the Taconic orogeny.

The other and younger lineation is indicated by another set of drag folds and crinkles in the schists. The trend of this lineation is everywhere subparallel to the strike of the local schistosity and plunges from 15° to south to 75° to the north when going from the Gould area to the Stratford area.

The Weedon Thrust Fault - Burton (1930) was first to recognize, in the lake Aylmer map-area, the presence of a thrust fault at the contact of the Weedon Schists formation and the Lake Aylmer

formation. Later Cooke (1950) extended it many miles to the south. In the area covered by this thesis, there is no doubt that such a fault does exist. The writer has been able to trace the fault across the four map-areas except perhaps for the northern third of the Stratford sheet. Within the map-area the fault separates the Weedon Schists formation from the Lake Aylmer formation and dips steeply to the east.

In the northwest corner of the Gould sheet the Weedon thrust is accompanied by 4 secondary sheared zones each one being less than 600 feet long and running parallel to the Weedon fault. South of Salmon river, the Weedon thrust fault which is running at the contact of the Lake Aylmer conglomerate and the greenstone band of range II, as well as the 4 adjacent sheared zones, a few feet to the east, are actually zones of brecciation in which abundant fragments of albite rhyolite porphyry are set in a quartz sericite and limonite rich matrix. The fragments of porphyry are usually smaller than one inch across. The abundance of limonitic dust in the matrix confers to the rock a deep orange color which is in strong contrast with the grey color of the porphyry fragments (Plate XXXII). The greenstones, adjacent and south of the Weedon fault, are, from the northwest corner of the Gould sheet up to the latitude of Fontainebleau in the Weedon area almost completely dolomitized over a width varying from 50 to 1500 feet.

Another evidence of the Weedon fault is found in the southern half part of the Weedon map-area where the fault apparently cuts diagonally across the basal beds of the Lake Aylmer formation.

North of lot 17 in range III of Weedon township, the

Lake Aylmer limestone is found in contact with the Weedon schists. Close to the fault the limestone is characteristically dolomitized, fractured, and cut by abundant quartz-calcite veins that form a honeycomb-like structure on the surface of the rock. Dolomitization progressively weakens as going away from the fault. Where dolomitization is partial, only the original lime rich beds have been replaced by dolomite. As the dolomite weathers orange and the unaltered limestone is grey some bands of limestone have become markedly striped close to the fault. A good example of this is displayed on lot 27 of Range III S.W. in the Stratford area (Plate XXXIII). Along the fault the Weedon schists are extremely fissile and soft. They also are locally dolomitized. The actual contact of the two formations was seen at only one place that is on lot 28 of range III S.W. 500 feet west of the road going to the Solbec Copper Mines property (Plate XXXIV). Here the fault plane is quite regular in strike (N. 33° E.) and dips 67° to the east.

Examination of cores coming from a 190 foot deep hole (Bg) drilled on lot 27 of range I N.E. in the Stratford area, has brought unsuspected field evidence against a continuation of the fault north of the range line I N.E. - I S.W. in Stratford area. The first 70 feet intersected by drilling were schistose and carbonatized pyroclastics that belong to the Weedon Schists formation. The last 120 feet of core were graphitic slate interbedded with black quartzite and conglomerate lenses that are obviously part of the Lake Aylmer formation. As conglomerate beds are here found in contact with the Weedon schists, the writer considers that the contact may be conformable.

It is admitted, however, that the presence of conglomerate lenses does not exclude the possibility that the fault may still extend north of range line I N.E. - I S.W. This possibility is in part suggested by the fact that south of Salmon river, the Lake Aylmer conglomerate is, as mentioned previously, separated from the Weeden schists by the Weeden thrust fault.

Similar fault relationship would prevail along the eastern contact of the two limestone slices found a few hundred feet east of the Weeden fault in the Stratford area. In order to explain the presence of some Weeden schists west the Weeden thrust fault the writer thinks that two other small faults must be present. Here again the faults would run along the eastern contact of the limestone.

The figure on the next page shows in a vertical cross-section the relationship of the Lake Aylmer formation with the Weeden Schists formation before and after the Acadian orogeny. The section is drawn across the Weeden thrust fault, west of Stratford village.

The general northeasterly dip of the shearing planes in the Weeden thrust, the direct evidence thus quoted, and the fact that the fault has brought older rocks on the southeast into contact with younger rocks on the northwest, all combine to indicate that the fault is a thrust.

The age of the Weeden thrust is obviously post Middle Silurian as it cuts rocks of the Lake Aylmer formation. Probably, therefore, it was formed during the Acadian orogeny of Middle Devonian time, though movement on it may have been renewed later.

General Structure -- Previous workers have considered the Weedon volcanics as an anticline or more recently, as a monocline. The writer fully subscribes to the latter view. The best evidence that can be brought forward in favor of the monocline hypothesis is the fact that everywhere, tops are facing to the east. It is true that only 5 top determinations were made in the whole Weedon belt but because they are distributed across the whole section, they are believed to be most significant. Here is a list of them and the criteria by which each top was determined.

Lot 7, range F, Lingwick township, 2000 feet north of Salmon river; pillows in a greenstone band (Plate XXXV).

Lot II range VI, S.W., Stratford township, 700 east of a gravel road; pillows in a greenstone band.

Lots 4 and 5, range VI S.W., Stratford township (drill cores); graded bedding in agglomerate beds.

Lot 33, range II S.W., Stratford township; graded bedding in agglomerate beds.

Lot 29, range I S.W., Stratford township, 500 feet north of a paved road; pillows in a greenstone band.

The next evidence in favor of this hypothesis is the apparent lack of repetition of any lithological units. This may be taken as a negative argument but it is nevertheless strongly suggestive.

Lastly, it is a well known fact that in a belt of strongly deformed sedimentary rocks, the folds become more open where rigid units are seen interbedded with. Such competent units are most often

sills or lava flows. It seems therefore, highly improbable that the Weedon schists sequence more than 2 miles thick and made up exclusively of igneous rocks, would have been isoclinally folded into a syncline or an anticline.

Thickness

Assuming that the Weedon schists belt represent a monoclinial sequence dipping 70° to the east and considering the maximum outcrop width of the formation, which is 2.6 miles (south of Trout lake) the maximum thickness of the Weedon schists formation is accordingly 2.4 miles or 12,800 feet. Evidence from mapping clearly shows that this volcanic sequence becomes thinner north and south but the ratio of basic flows to acidic pyroclastics remains approximately equal to one everywhere along the belt.

Age and Correlation

Logan (1847 - 63) correlated the Weedon schists with the Quebec group of pre-Taconic age. His correlation will be retained in this work but a more precise dating will be sought.

On extremely poor petrographical evidence, Selwyn (1882) correlated the Weedon schists with the Lake Superior series of Keeweenawan age. Similarly Ells (1886) has correlated them with the Huronian. Following the same line of evidence, Dresser (1906) and later Bancroft (1916) described the Weedon schists as being correlative with Precambrian rocks of Pennsylvania.

All those long range correlations are believed to be incorrect although conclusive evidence against a Precambrian age for the Weedon schists has not yet been found by the writer.

After a detailed study of the lake Aylmer area, Burton (1930) concluded that the Weedon schists must be correlated with the volcanics west of the lake Aylmer (later called Caldwell volcanics by Cooke). Those volcanics are found west and beneath the Disraeli formation of inferred Upper Middle Ordovician age (Burton p. 115). Assuming that Burton's correlation is valid, the Weedon volcanics would be pre Upper-Middle Ordovician.

Clark (1937) puts the Weedon schists at the base of his St. Francis series of Ordovician age.

According to Cooke (1950), the Stoke schists and the correlative Weedon schists belong to the Sherbrooke group. Cooke considers the Sherbrooke group to be of Silurian age.

Because the rocks of the Disraeli formation are believed to be Middle Ordovician and to lie beneath those of the Weedon Schists formation, the latter formation is tentatively assigned to the Upper Ordovician.

SILURO-DEVONIAN
GASPE GROUP

Late in Silurian time, the sea came back in the area and laid down sediments over the rocks of the Quebec group, sediments that are now represented by the rocks of the Lake Aylmer formation and those of St. Francis-St. Juste group, respectively found west

and east of the Weedon schists belt.

Lake Aylmer Formation

Name and History of the Name

The name "Lake Aylmer series" was given by Burton (1930) to a band of limestone that strikes southwesterly across the Lake Aylmer map-area. Burton assigned to it all the calcareous shales and limestones and (1933) also the conglomerate at the base of the formation.

Burton (1930, 1933) reports that he gave the serial name Lake Aylmer because the limestones are well exposed along the shore of lake Aylmer.

Distribution

The Lake Aylmer formation crops out as a band, about 2 miles wide at the northern extremity of the Stratford sheet and $5\frac{1}{2}$ miles wide south of Weedon Centre. The formation can be traced continuously from lake St. Francis southward to Dudswell, near Marbletown, a distance of 30 miles.

From this point the limestone band runs west of the Stoke

Mountains axis and extends apparently as far south as lake Magog.

(Cooke 1952).

East of the Weedon thrust-fault in the Stratford area two slices of limestone have been mapped as being part of the Lake Aylmer formation. The outcrops of the two slices are about 9000 feet long and respectively from west to east 250 and 350 feet wide.

Lithology

General Statement - The lower member of the Lake Aylmer formation is an extremely coarse and polycomponent conglomerate, which includes more or less interbedded greywacke, slate, quartzite, and impure dolomite. The upper member of the formation is a succession of calcareous siltstone and silty limestone interbedded with a few acidic and basic flows.

Lower Member - Along the western contact of the Lake Aylmer formation, thick conglomerate lenses have been traced continuously. (Burton, Cooke, Clark) for over 21 miles. The conglomerate is very resistant to erosion and stand out as high ridges above the less resistant rocks on either side.

Within the map-area, particularly good outcrops occur in lots 18 and 19 of ranges A and B in Garthby township, and on the east shore of Ward bay. The conglomerate lenses of ranges A and B form a band, more than 2000 feet wide, although no lens exceeds 170 feet. The conglomerate lenses are interbedded with greenish black greywacke and slate. East of Ward bay there appears to be only one lens of conglomerate and it is approximately 150 feet thick and surrounded

by beds of greywacke and slate.

In general, the conglomerate is very coarse, with rounded boulders as much as 3 feet in diameter, contained in a dark green greywacke matrix. In places, it is comparatively unstratified with boulders in random arrangement, elsewhere it contains beds of slate or greywacke. The writer has collected and examined more than 250 pebbles or cobbles from lenses of conglomerate exposed in lot 18 of range B in Garthby township. Also the seven most representative specimens were studied under microscope. By order of abundance the pebbles were found to be: greenish quartzite (42%), light green granite (30%), greenstone (22%), and granophyre (6%).

The quartzite pebbles carry up to 5 per cent chlorite and from 5 to 15 percent feldspar grains. The texture of the rock varies from very fine- to very coarse-grained. The plagioclase crystals in the granite pebbles are highly sericitized and for that reason it has been found impossible to determine the An. content. Quartz is interstitial and represents 25 to 30 per cent of the rock by volume. Because the granite carries no potassic feldspar it may be called albite or oligoclase granite. The only mafic mineral present in the rock is biotite which is partly replaced by chlorite. The granite is most commonly medium-grained but occasionally shows a porphyritic texture. The pebbles of greenstone are dark green, massive and spotted with minute specks of pyrite. The granophyre is identical to that of Weedon. Phenocrysts of albite and quartz are set in a matrix made up of intimately intergrown quartz and potash feldspar. Penninite pseudo-

morphous after biotite constitutes the sole mafic mineral of this rock. Each crystal of penninite carries exsolution needles of titaniferous magnetite oriented in such a way that they form concentric triangles. Chips of slate or sericite schist, quite thin and less than an inch long, are also abundant in some parts of the conglomerate. Obviously most pebbles have been derived from rocks of the Caldwell group. The granophyre pebbles, however, because of their marked similarity with the granophyre of Weedon, are believed to come from the weathering of the crush conglomerate such as exposed south of Fontainebleau. The validity of this assumption is in a large part supported by the fact that outcrops of such a rock has not been reported in the literature dealing with the geology of the area, west of lake Aylmer.

The matrix of the conglomerate is a coarse greywacke that carries fragments of slate, quartzite, quartz, feldspar, mica, and pyrite all contained in what appears to be a chloritized groundmass. The term greywacke is here used in the sense suggested by Pettijohn (1943) who writes in a bulletin (Vol. 54) of the Geological Society of America: "the word greywacke connotes a type of sandstone marked by large detrital quartz and feldspars (phenocrysts) set in a prominent to dominant clay matrix (and hence absence of infiltration or mineral cement) which may on low-grade metamorphism (diagenesis) be converted to chlorite and sericite and replaced by carbonate, a dark color, generally tough and well indurated, extreme angularity of the detrital components (microbreccia), presence in smaller or larger quantities of rock fragments, mainly chert, quartzite, slate or phyllite, and cer-

tain macroscopic structures (graded bedding, intraformational conglomerates of shale or slate chips, slip bedding, etc) and certain rock association".

Along the eastern contact of the Lake Aylmer formation, the lower member of the Lake Aylmer formation is cut, north of Salmon river, by the Weedon thrust fault. South of Salmon river, in range II of Weedon township more than 1500 feet of conglomerate is interbedded with slate. Here again the conglomerate is coarse and polycomponent. Sorting is very poor and interlamination of slate are quite rare. Some of the conglomerate lenses are more than 300 feet thick. Most of the pebbles are well rounded, crowded together, and of all sizes up to one foot in diameter (Plate XXXVI). The matrix is a coarse grit made up of grains of quartz, feldspar, granophyre, and rhyolite porphyry set in a sericite rich matrix (Plate XXXVII). Minute fragments (2mm.) of quartzite and slate are also present in the matrix. In general the groundmass of the conglomerate is much more schistose than that of Garthby and is commonly stained orange by a dust of limonite. From its composition and texture the matrix represents a typical greywacke (cf. Pettijohn's definition). The pebbles, cobbles and boulders are by decreasing order of abundance, light grey to green granophyre (60%), light grey albite rhyolite porphyry (30%) and greenstone (10%). All pebbles are clearly derived from the nearby Weedon schists and related intrusive rocks.

This thick conglomerate band stops abruptly, 800 feet south of Salmon river. In strike continuation of it, impure dolomite beds are seen. On a rock exposure located 800 feet south of Salmon river,

on lot 16 of range II in Weedon township, the conglomerate is interfingered with rusty beds of dolomite (Plate XXXVIII). The contact between those two types of rock is so sharp that it gives one the illusion that the coarse conglomerate has intruded the dolomite. A similar relationship was also found in nearby outcrops. This dolomite carries approximately 65% ferruginous dolomite, 20% sericite, 5 to 10% quartz, 5% epidote and 2% leucoxene (detrital grains).

North of lot line 17-18 of range II in Weedon township to range I N.E. - I S.W. of Stratford township, the basal member of the Lake Aylmer formation is completely cut out by the Weedon thrust fault and the Weedon schists lie directly against the limestone beds of the Lake Aylmer formation. However, on lots 24 and 25 of range III in Weedon township, a few beds of black shales are seen at the base of the limestone band.

As already mentioned in connection with the description of the Weedon fault, logging of cores from hole B_g drilled on lot 27 of range I.N. E. in Lingwick township has shown that north of range line I N.E. - I S.W., basal beds of the Lake Aylmer formation reappear.

There is a description of the cores from hole B_g, on the next page.

The small pebble conglomerate contains detrital particles of fine-grained pyroclastic rocks which make up about 25 per cent of the conglomerate. Those fragments are surrounded by a sericite and carbonate rich matrix. The schistosity is bent to an extreme degree around the larger particles. A few rounded quartz grains are seen here and there in the matrix. The conglomerate beds are about three feet thick

Hole B_g:

Depth	Number of feet	Description
0-72	72'	carbonatized and sericitic crystal tuff.
WEEDON THRUST FAULT		
72-90	18'	yellowish impure sandstone, lenses of small pebble conglomerate, thin beds of calcareous siltstone.
90-187	97'	carbonatized small-pebble conglomerate grading into black slate. Some siliceous sandstone interbedded with thinly laminated black slate. Dragfolds are visible in the conglomerate.
187		end of hole.

and most commonly grade into black slate. The sandstone is siliceous but also carries abundant pea-sized grains of fine-grained pyroclastic rock. The matrix is similar to that of the conglomerate. Because the hole does not cut through the whole basal member of the Lake Aylmer formation and also because part of this lower member may have been cut off by the Weedon fault, it is impossible to tell how thick the lower member is at this locality. From the above drill data the latter member has a minimum thickness of 75 feet.

Those basal beds should continue to the north but on lot 22 of range VII in Weedon township, a distance of three miles from location of hole B_g, the limestone is again found in contact with the Weedon schists (hole C, Sullivan 1960).

Upper Member -

Limestone - Although the actual contact between the lower and the upper member of the Lake Aylmer formation has nowhere been seen within the map-area, it is assumed that the two members are conformable with one another. The upper member is characterized by a thick sequence of calcareous siltstone and silty limestone that carries a variable amount of sericite. Siltstone beds alternate with limestone beds at every inch or so. The siltstone weathers light buff or white but is everywhere very light grey on its fresh surface. The limestone weathers light grey or bluish grey but is light bluish grey to dark grey on its fresh surface.

Under microscope, the siltstone was found to contain approximately 50 per cent quartz, (1/30 mm), 40 per cent calcite, and 10 per cent sericite. The limestone has, on the average, the following mineralogical make up: calcite (90%), quartz (7%), sericite (3%), and a few grains of pyrite and iron ore.

An intraformational conglomerate exposure forms a small knoll on lot 17, range III in Weedon township, a few feet south of the road of Fontainebleau. The conglomerate is made up of a limestone matrix carrying limestone fragments. The matrix as well as the fragments are partly dolomitized. Crinoidal stems and other highly deformed fossils are distributed at random in the rock (Plates XXXIX, XL). A similar conglomerate band crops out on lot 21, range V S.W. in Stratford township, 100 feet east of the road of Stratford. Here again the rock is partly dolomitized. At both places, the conglomerate weathers light buff but is medium grey on its fresh surface.

A band of fairly pure limestone runs across lots 28 and 29 of range III S.W., lots 27 and 28 of range II S.W., and lots 26 and 27 of range I S.W. in Stratford township. The limestone is limited to the east by the Weedon thrust fault and because of this, it shows a marked degree of dolomitization over a width of approximately 150 feet. At a distance greater than that from the fault, the limestone has only been partially replaced by dolomite, and it eventually becomes normal at a distance exceeding 200 feet. In the zone where limestone shows partial replacement by dolomite, abundant crinoidal stems, corals and bryozoans have been found. The fragmental nature of the fossils suggests a possible reworking of those by the sea along the shore. Those fossiliferous limestone beds may represent basal beds of the Lake Aylmer formation. It is believed however that those beds more likely belong to the upper member of the Lake Aylmer formation the basal beds of which would have been locally cut off by the Weedon thrust fault.

Rhyolite Porphyry - Apparently interbedded with limestone of the Lake Aylmer formation a band of sheared albite rhyolite porphyry is exposed across a width of 1700 feet in range III of Weedon township. This band has been traced for $2\frac{1}{2}$ miles. Everywhere the rock is rusty on its weathered surface and light grey across fracture. Seen under microscope, the rock consists of albite and bipyramidal quartz phenocrysts (25 per cent combined) set in a crypto-crystalline groundmass made up of quartz and sodic plagioclase (Plate XLI). The quartz phenocrysts show a characteristic ring-like arrangement of inclusions along their border, a texture probably resulting from a secondary

growth of quartz around the original phenocrysts (Plate XLII). Where it is more schistose, the rhyolite was found to be traversed by abundant veinlets of chlorite, dolomite and pyrite ($\frac{1}{4}$ - Imm). The oligoclase phenocrysts are, as a rule, partly sericitized but some of them are completely replaced by dolomite. At a few places the rhyolite is black to dark grey. The staining is due to the presence of carbon which was probably brought along with the carbonates and the pyrite. Good example of this is found on rock exposures located on lots 17 and 18 of range III in Weedon township a few feet north and south of the road going to Fontainebleau. Where the porphyry is found in contact with the intraformational limestone conglomerate south of the road of Fontainebleau, the writer has noticed some brecciation in the rhyolite (Plate XLIII). This breccia is obviously not of the flow type but rather connected with some tectonic activity. The relative displacement between the individual fragment is in general very small and gives one the impression that the rock has cracked as a rigid unit would do under deformation.

The highly schistose nature of this porphyry and its proximity to the Weedon schists belt support the idea that this band of rhyolite could belong to the Weedon Schists formation. However the peculiar mineralogical composition and the perfect conformity of the rock with the adjacent limestone beds have led the writer to believe that it rather represents a rhyolitic flow interbedded with the Lake Aylmer limestone. A similar occurrence has been reported by Gorman (1954) in the St. Juste group of rocks, one mile east of St. Rose,

Dorchester County in Quebec where a Silurian or Devonian limestone is seen interbedded with rhyolite flows.

Blotchy Lava - North of Fontainebleau, on lots 21 of range III, Weedon township, good exposures of porphyritic basic flows can be examined. This band of lava is approximately 700 feet thick and has been traced for nearly one mile in a northeasterly direction. In the field, the most distinctive feature of the rock is its blotchy appearance which is given by feldspar forming clots that are up to 1 inch across (Plates XLIV, XLV). Within this band of lavas, a few interbeds of dolomitized limestone have been found. Contact of the limestone with the lava is everywhere conformable (Plate XLVI). On its weathered surface the lava surface is extremely porous and resembles for that reason to a scoraceous lava flow (Plate XLVII). The rock weathers light buff to green but it is quite rusty where carbonates have dissolved out. On its fresh surface the lava is light greyish green.

A microscopic examination has shown the rock to have the following mineralogical make up: ferruginous dolomite (from 5 to 40%) zoisite and clinozoisite (15% combined), chlorite (10%), actinolite (2 - 3%), leucoxene (1 - 2%) and a few grains of apatite, sericite and iron ore. Albite phenocrysts represent up to 55% of the rock volume. Dolomite and zoisite have partly replaced feldspar whereas the original pyroxene or amphibole is now wholly replaced by chlorite, clinozoisite and actinolite (Plate XLVIII).

This rock may represent an intrusive mass of Taconic age. In favor of this hypothesis there is the fact that the rock is macro-

scopically and microscopically similar to the possibly intrusive blotchy gabbro exposed near Salmon river in the Gould map-area and to the Taconic gabbro intrusive (southern part only) that crops out east of Trout lake. But as the blotchy gabbro of Fontainebleau nowhere cuts the limestone and as the latter rock shows no sign of recrystallization along its contact with the gabbro, the writer tentatively considers this gabbro as an extrusive rock that must accordingly be assigned to the upper member of the Lake Aylmer formation.

Metamorphism

Regional Metamorphism - The rocks of the Lake Aylmer formation are the least metamorphosed units of the whole map-area. Shale has been metamorphosed into slate that shows a fairly good cleavage superimposed upon the original bedding. The clay minerals found in the limestone beds have been everywhere converted into minute scales of sericite. Along the Weedon thrust fault, the rocks of the Lake Aylmer formation have been subjected to intense dynamic metamorphism and, as a result of this, the calcareous silstone has become extremely schistone and the silty limestone has completely recrystallized.

Contact Metamorphism - Shaly beds of the lower member, exposed on lots 24 and 25 in range III, Weedon township, have been metamorphosed to hornfels by the Devonian granite cropping out 700 feet to the east. Small prophyroblasts of grossularite (20%) and biotite (20%) are found embedded in a granoblastic groundmass made up essentially of quartz (30%), sericite (20%), and feldspar (5%). Characteristically, the garnet porphyroblasts (1/5 mm across) tend to be idiomorphic.

In lot 19 of range II Weedon township, the contact between a limestone band and a small Taconic gabbro plug is exposed on a road cut (east side of the road). Up to a distance of 8 inches from the line of contact with the gabbro, the limestone shows a coarser crystalline texture and has become lighter colored than the surrounding calcareous beds. Under microscope the grains of calcite (3 mm) enclose minute crystals of clinozoisite (1/15 mm across) which give the rock a faint greenish color.

Structure

During the Acadian orogeny, the rocks of the Lake Aylmer formation were compressed into a succession of tight folds, and cleavage developed in the more competent beds.

This cleavage approaches the flow type in regularity, but the character of the rock in the major part of the formation, composed of coarse conglomerate and highly calcareous rocks did not favor the development of a well defined cleavage. The cleavage strikes N. 25°E., the strike becoming more easterly to the northeast, thus conforming to the general structure. Along the eastern side of the band, the schistosity dips to the southeast (65° or less) whereas to the west it is about vertical.

Bedding most commonly strikes parallel to cleavage and dips steeply east on the western side of the formation, but on the eastern side it generally dips east or west at angles of 45° or more. Although very few top determinations have been made, overturning is believed to be common, particularly on the eastern side of the formation.

Axis of small folds strikes roughly parallel to the strike of the cleavage and plunges on the average 30 degrees south. Similar results were found from bedding-cleavage intersection. Asymmetrical closed folding seems to be prevalent. A good example of this is found on the cliff of a small hill bordering the road (east), 1200 feet south of the village of Fontainebleau. The fold is an overturned syncline, the eastern limb being overturned to the west. Fracture cleavage is given by a series of parallel and closely spaced veinlets of quartz and calcite. This cleavage is parallel to the axial plane of the fold. Axis of the fold trends S. 30°E. plunging 25 degrees south. Other examples of closed and asymmetrical folds are common along the shore of the lake Aylmer, near Long Point (Plates XLIX, L). Very likely because folding was very intense, the folds are at this locality often cut by small reverse strike faults (Plate LI).

Open folds are very rare. One of them was seen on lot 17 of range III, Weedon township, 1000 north of the road of Fontainebleau and a few feet west of the contact with the albite rhyolite porphyry band (Plate LII).

Looked at broadly, the Lake Aylmer formation forms a compound syncline slightly overturned to the northwest on the northwest side and slightly more so on the eastern side. The axial line of this syncline is parallel to that of the minor folds. The best evidence in favor of this synclinal hypothesis is given by the presence of thick basal conglomerate lenses which are found on both sides of the formation and which are definitely facing each other. Along the northern

border of the formation, the rocks lie unconformably above the slaty sequence of the Disraeli formation but to the south, they are cut by the Weedon thrust fault that has brought pre-Silurian metavolcanics besides them. This fault is inferred from a variety of evidence, that has already been given. It may be added that wherever found in contact with the fault the limestone is extremely schistose. Slickensides are common and indicate a reverse movement. Orientation of those lines of striation is S. 35°E. and, their angle of plunge is 65° to 70° to the southeast.

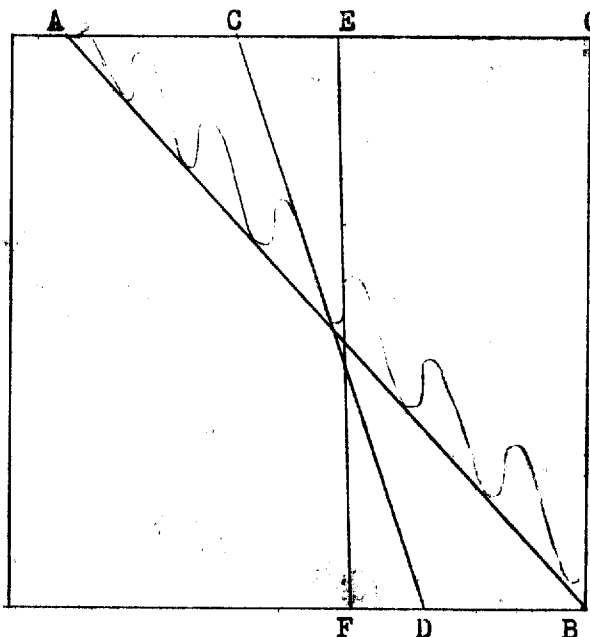
The compound Lake Aylmer syncline has a breadth of 5 miles at the latitude of Weedon and extends northward up to lake St. Francis where it apparently pinches out. Southwestward the syncline loses part of its identity by merging north of Marbleton with the Gaspé-Connecticut River Synclinorium represented at this point by limestones of the Lower St. Francis-St. Juste group. Farther south, the Lake Aylmer syncline can be followed west of the Stoke Mountain axis, down to Magog lake and Bunker Hill. Here the syncline is approximately 4 miles wide. Because the Glenbrooke group of limestone, found around lake Memphremagog, is structurally, lithologically and paleontologically similar to that of the Lake Aylmer formation and because the two groups of rocks are in rough strike alignment and separated from one another by a distance of only 8 miles, the writer proposes a correlation between those two limestone basins. The name "Lake Aylmer-Glenbrooke Synclinorium" is suggested to designate this structural and stratigraphic unit. This synclinorium would extend from lake St. Francis to Magoon Point, on lake Memphremagog,

a distance of about 85 miles. Near lake Memphremagog, the synclinorium is made up of two smaller synclinal structures that have been called by Cady (1960 p. 543) the "Memphremagog Synclines".

Thickness

Within the map-area the maximum outcrop width of the lower member of the Lake Aylmer formation is found near Garthby where a value of approximately 3800 feet is observed. The rocks stand vertically up and tops face everywhere to the east. The maximum thickness of the lower member is thus 3800 feet. The upper member (Limestone member) of the formation reaches a maximum breadth west of the Gould sheet area. At this latitude the limestone band has a width of 4.6 miles. It has been shown that this band forms a compound syncline and so, only one limb needs to be considered in order to determine the thickness of the whole member, assuming both limbs are dipping the same angle and have the same thickness. These two conditions are actually in fair agreement with field evidence gathered from detailed mapping. The problem is thus equivalent to that of determining the thickness of a band of isoclinally folded rocks that has a breadth of 2.3 miles and dips 65° . This value of 65° is inferred from the following considerations.

The upturned beds of the western limb of the Lake Aylmer syncline have a dip angle that varies from 70° to vertical. From graph(next page) 6 it is clear that the plane A-B tangent to all troughs of a folded bed dips at a smaller angle (angle BAO) than that of any upturned beds (angle DCO) and even more so of any overturned beds (angle FEO). As the

GRAPH I

smallest angle of dip of the upturned beds has been found to be 70° , a dip angle of 65° is therefore indicated for the western limb of the Lake Aylmer formation. Using curve A of graph 5 shown on page 36 of the writer's thesis (1961), a value of ^{"r"} (being the ratio of the horizontal breadth of a formation to its true thickness) equal to 0.225 is found for a σ angle of 65° and consequently the upper member becomes equal to 2,800 feet.

Thus the lake Aylmer formation is estimated to be 6,600 feet thick. This value, however, should only be considered as a maximum figure.

Age

General Statement - No fossils are found in the Lake Aylmer conglomerate but good collections have been made from several localities in the Lake Aylmer limestone. Some of the fossiliferous

localities are found within the map-area and its vicinity, and a group of others in the Dudswell or Marbleton area, 8 miles southwest of the map-area.

Evidence from the Map-Area and its Vicinity - In 1930 Burton collected fossils from an abandoned quarry on lot 22 in range VII of Weedon township and from lot 28 of range II in Stratford township. The fossils were later examined by Dr. T.H. Clark, of McGill University, who has furnished the following particulars (Cooke, 1937, p. 50 - 51).

1. Fossils from the old lime quarry, Weedon township, range VII, lot 22.

Corals:

Streptelasma sp. or Zaphrentis sp. The preservation is too poor to determine the genus with accuracy. Both occur in the Devonian, and as a rule the species are not highly diagnostic.

Favosites sp. probably F. Helderbergiae Hall.

Favosites sp. One of the ramose types which do not appear as a rule until the Onondaga.

Favosites sp. A species with very small corallites.

Halysites sp. probably H. catenulatus Linné. The writer has collected this coral from two other localities in Quebec, where, as at this one, it is associated with Devonian fossils. One of these localities is on the east shore of Memphremagog lake, the other is St. Joseph tp., range St. Thomas, into

Cranbourne tp., ranges IV and V. There can be no doubt as to its extension into the Devonian in southern Quebec.

Stromatocerium sp.

Brachiopods:

Leptaena rhomboidalis Wilckens; ranges from Ordovician to Carboniferous.

Meristella n. sp. Close to M. bella Hall from the Helderberg.

Meristella sp.

Pelecypods:

Conocardium sp. A dwarf species. The genus ranges from Ordovician to Permian.

Gasteropods:

Loxonema sp. Probably two species.

Diaphorostoma sp.

Cephalopods:

Orthoceras sp. Too poor to identify.

Trilobites:

Ceratocephala sp.

Ostracods:

Beyrichia sp. This genus ranges from the Ordovician to the Carboniferous, but is pre-eminently a Silurian genus. Only five species are at present recognized from the Devonian of North America, and of these but one from the Helderbergian.

Kloedenia manliensis Weller; Helderberg.

Kloedenia sp. Two or possibly three new species of this genus. All are very closely related to the species described by Ulrich from the Helderberg of New Brunswick.

Pachydomella sp. In North America this genus is restricted to the Devonian.

2. Fossils from the old lime quarry, Weedon tp., range VII, lot 26.

Favosites sp., probably F. helderbergiae.

Crinoids, columnals are common.

3. Fossils from outcrops at Stratford tp., range II S. lot 28.

Corals:

Favosites sp. Probably two species, one somewhat like Favosites cervicornis (de Blainville), but not co-specific with it. It is in all probability a new species, and most closely resembles other species of the Onondaga epoch.

4. Fossils from the brown-weathering calcareous shale east of Lambton lake, Lambton tp., ranges V, VI, lots 17 - 18.

Corals:

Zaphrentis sp.

Amplexus sp.

Favosites sp. Two or three species.

Heliolites sp.

Crinoids:

columnals abundant.

Brachiopods:

Strophonella geniculata (Hall); Helderberg.

S. punctulifera (Conrad); Helderberg.

Gypidula geleata (Hall); Helderberg.

Camarotoechis litchfieldensis (Schuchert); Helderberg.

Atrypa reticularis (Linné); Silurian-Devonian.

Atrypa imbricata (Hall); Helderberg.

5. Rolled fragments in the conglomerate south of Lambton lake.

Lambton tp., range IV, lot 20.

Corals:

One or two species of corals, too poorly preserved to identify."

Clark concluded that " the present list of fossils (from the 5 above localities) represents the result of considerable intensive collecting. Crystallization has unfortunately made identification of the species of the corals and stromatoporoids almost impossible. It can thus be seen that there are but two localities where fossils occur in a sufficiently well-preserved condition to be diagnostic. At both of these localities the evidence for the Helderberg age of the shale and limestone is incontrovertible".

Evidence from the Dudswell Area - The earliest published list of fossils from the Dudswell area appears in Logan's Geology of Canada, 1863, (p. 433), as follows: "At Dudswell, in addition to

encrinal columns and disks, there is a great abundance of corals; which occur chiefly in the light grey beds, and are readily distinguished by their whiter colour. The whole rock is highly crystalline; but the corals appear more evenly and finely grained than the enveloping matrix, and are free from mica. Their structure is often plainly discernible on the weathered surfaces, where deeply worn lines mark the divisions of the cells, columns, and concentric layers. Some of the species appear to be Favosites Gothlandica, F. cervicornis, F. Polymorpha, Halysites catenulatus, Heliolites Murchisonia, Syringopora compacta, a Diphyphyllum like D. arundinaceum, undetermined species of Zaphrentis and Heliophyllum, Stromatopora concentrica, and an undetermined Platyostoma".

Logan adds (p. 436) that recrystallization has rendered doubtful the determination of these fossils, but that they seem to indicate a Devonian age, with the exception of Halysites catenulatus and Syringopora compacta, which at that time were assigned to a lower level.

A.R.C. Selwyn (1880 pp. 1 - 2) later proposed the term Siluro-Devonian to designate these formations, which appear to present a composite of Silurian and Devonian.

In a report published in 1915, J.A. Bancroft (p. 66) gives a list of fossils collected from massive beds of grey limestone, on lot 17a, near Lime Ridge. These he submitted for determination to Professor Charles Schuchert, who commented as follows: "There is a small globular Favosites, ramose Favosites with slender branches; slender Cladopora; Halysites catenularia, Linné; large crinoid columns; an abundance of Trepostomata, very much altered, or, a ramose

Stromatoporoid. One can certainly say that they are of Middle Silurian age, and probably belong to about the time of the Rochester shale".

The Abbe J.W. Laverdière, who studied the Lake Aylmer formation near Dudswell and Marbleton (1935, p. 37 and 33), reports several other fossiliferous localities in range VI, VII and VIII of Dudswell township. After examination he declared: "The massive beds of limestone have yielded abundant fossils belonging to the following genera: Stromatopora, Favosites, Heliolites, and Diphyphyllum; also three specimens that were referred to Halysites catenularia. On lot 26, range VI, a large number of brachiopods were collected in a schistose limestone which weathers to a brown colour. Stratigraphically, these beds immediately overlies the massive limestone quarried at Lime Ridge. The species recognized are: Camarotoechia litchfieldensis, Schuchert, and Meristella belloides, Clark (ms). According to T.H. Clark (Personal communication), Meristella belloides resembles M. bella and M. Loevis, both of which occur in Lower Devonian beds elsewhere. Camarotoechia litchfieldensis also is a lower Devonian form".

Laverdière concludes:(p. 38) "The fauna collected are not sufficient basis for concluding definitely that Lower Devonian beds are present in the Dudswell basin. Therefore the Lake Aylmer limestone is either Silurian or Devonian".

More recently (1960) Boucot (personal communication to F.F. Osborne, Laval University) examined fossils from the Dudswell area and concluded that they apparently represent a fauna of Upper Silurian age (Lower Ludlow).

Conclusion - As various authors have successively assigned the Lake Aylmer limestone to Middle Silurian (Schuchert and Bancroft), Upper Silurian (Boucot), Lower Devonian (Logan, Burton and Clark) and Silurian or Devonian (Selwyn, Ellis and Laverdière) the writer can

only say that the Lake Aylmer formation is probably post-Lower Silurian but pre-Middle Devonian.

Correlation

Previous correlations - Logan (1863, p. 430) described the limestone and associated rocks around lake Aylmer and Ward bay as probably belonging to the Gaspé Series of Siluro-Devonian age. He recognized that the limestone is the youngest rock in the map-area and considered them to be correlative of his Gaspé Sandstone of Devonian age.

Ells mapped the lower member of the Lake Aylmer formation (basal beds and conglomerate lenses) as Cambrian and the whole upper member (limestone) except a narrow band as Silurian.

Schuchert (Bancroft 1916 p. 66) who determined fossils collected by Bancroft in limestone beds of the Lake Aylmer formation near Dudswell, states that:

"One can certainly say that they are of Middle Silurian age, and probably belong to about the time of the Rochester shale".

Burton in his doctoral thesis clearly suggests a correlation of a part of the Lake Aylmer limestone with McKay's (1921 p. 31) Devonian Famine series in which fossils of Onondaga age were obtained.

Following Logan and Schuchert, Burton expressed the view (1933, p. 139 - 140) that the Lake Aylmer formation is not only in part Devonian but is probably also in part Silurian.

Clark, after having established an Helderbergian age for part of the Lake Aylmer formation (1937, p. 50 - 51) made a comparative study of the rocks of the latter formation with those of other Helderbergian formations observed elsewhere in Eastern North America. Clark comes to the same view as that expressed earlier by Burton when he declares:

"In Northeastern North America beds of Helderberg age occur in New Jersey-Maryland-Pennsylvania, in New York, at Montreal, in Gaspe, in New-Brunswick, and in Maine. A tabulation of the species so far definitely identified (in the Lake Aylmer formation) with their occurrences elsewhere follows:

	Gaspe including Dalhousie formation	Montreal	New Jersey Maryland Pennsylvania.	New York Helderberg	New York Oriskany
B R A C H I O P O D S	<i>Leptoena rhomboidalis</i>	X	X	X	X
	<i>Strophonella geniculata</i>	X	---	X	---
	<i>S. punctulifera</i>	---	X	X	---
	<i>Gypidula galeata</i>	---	---	X	---
	<i>Camaratoechia litchfieldensis</i>	---	---	X	---
	<i>Atrypa reticularis</i>	X	X	X	---
	<i>Atrypa imbricata</i>	X	---	X	---
O S T R A C O D.	<i>Meristella bella</i> (cf. with <i>M. sp.</i>)	---	---	X	---
	<i>Kloedenia manliensis</i>	X	---	X	---

"A perusal use of this table leaves no doubt as to the validity of the correlation of the Lake Aylmer series with the Helderberg beds of Gaspe (St. Albans, Bon Ami, and Grande Grève formations), the Dalhousie formation and the Moose River formation to the northeast. Neither is there any doubt as to its equivalency with the Helderberg of New York, New Jersey, Maryland, and Pennsylvania to the southwest. Thus the existence of a seaway postulated by Clarke (1909 p. 153) stretching from Gaspe southwestward to New York and New Jersey receives substantial confirmation".

Clark made also specific correlations with the Famine and Cranbourne series north of Chaudière river and also with the Glenbrooke group of lake Memphremagog and with Billings' Littleton formation of Littleton N.H. Thus he concluded (1937 p. 52).

Present Correlations - As the Lake Aylmer formation is composed of a basal conglomerate overlain by a thick sequence of impure limestone of Siluro-Devonian age the writer proposes that the Lake Aylmer formation should be correlated with the lower formation of the St. Francis-St. Juste group since the latter formation is also made up of basal conglomerate lenses overlain by a thick sequence of impure limestone which will be shown to be also of Siluro-Devonian age. This correlation is also suggested by the fact that these two formations lie with a marked angular unconformity above the Weedon schists.

It is also suggested that the Lake Aylmer formation be correlated, northeastward, with the Famine series (MacKay, 1921), the Cranbourne series (Tolwan 1936), the St Luc group and the basal member of the St. Juste group (Gorman, 1956). Southwestward the basal member of the Lake Aylmer formation is correlated with the grits and

conglomerates of Cooke's Sherbrooke group, and the Peasly Pond conglomerate of the Glenbrooke group (Clark, 1950). The Lake Aylmer limestone, on the other hand, is considered to be southwestward correlative of the Glenbrooke limestone. South of the border, in northern Vermont, the Lake Aylmer conglomerate is correlated with Currier's and John's (1941, p. 1496) Shaw Mountain formation and the Lake Aylmer limestone with Doll's Barton River formation (1951 p. 25) and Murthy's (1957 p. 35) Waits River formation. (Correlation Map, Duquette 1961)

Lower Formation of the St. Francis-St. Juste Group

Name and History of the Name

The name St. Francis series was introduced by Clark (1937) for a sequence of rocks found east of the line drawn from lake Rocheux in Adstock township to Elgin lake in Stratford. In this series, Clark groups the Weedon schist (basal member) with the rocks now assigned to the lower and middle formations of the St. Francis-St. Juste group.

The next detailed geological map directly concerned to the Lower St. Francis-St. Juste group is the Scotstown sheet of Cooke (1943). Cooke excluded the Weedon schists from Clark's St. Francis series and subdivided the remaining sedimentary sequence into 3 lithological units which correspond closely to the writers lower, middle and upper formations of the St. Francis-St. Juste group.

The group name St. Francis-St. Juste is used instead of St. Francis alone because the latter will be shown to be correlative of Béland's St. Juste group of the St. Magloire area (1953 - 7).

Distribution

In Quebec the belt underlain by the Lower St. Francis-St. Juste group of rocks trends northeasterly between the Quebec-Vermont border and latitude $46^{\circ}30'N$. The area so occupied is about

150 miles long and varies in width from 10 miles at the southern extremity to only a few hundred feet north of lake St. Francis.

Within the Gould map-area exposures are found south of the Weedon metavolcanics between a greenstone band to the west and a line passing by Red river. On the road going from Gould to Weedon, the formation reaches a maximum breadth of about 10,000 feet.

In the Stratford sheet-area, the rocks of this formation are confined to a narrow band lying east and adjacent to the Weedon schists belt. The band starts north of mount Aylmer where it has a width of 2700 feet, runs northeasterly across the northeastern corner of the sheet where it is apparently less than 1500 feet wide. Only a few erosional remnants of this formation were seen in the Weedon and Lake Aylmer sheet-areas.

Lithology

As in the case of the Lake Aylmer formation, the rocks of the Lower St. Francis-St. Juste group can be subdivided into two members conformable with one another.

Lower Member - The lower member is made up of basal beds represented by lenses of conglomerate interbedded with slate, sandstone, quartzite, greywacke and dolomite.

In the Gould sheet-area, the best exposures are grouped on lots 4 and 5 on both side range line E-D, Lingwick township. A study under microscope of pebbles and cobbles found in a conglomerate lens, 35 feet thick and less than 500 feet long, and exposed on lot 5, ran-

ge D, has revealed them to be fragments (Plate LIII, LIV) of medium-grained albite (An0-5) granite or fragment of albite (An 5 - 10) rhyolite porphyry. The albite granite shows occasional irregular and micrographic intergrowth of quartz with albite. Those pebbles are clearly derived from intrusive bodies cutting the Weedon schists, a few hundred feet to the north. The matrix of that ill sorted conglomerate is characteristically white and highly schistose. It is made up essentially of quartz (65%), dolomite (15%), and sericite (15%). The adjacent basal beds of the same formation are dark grey dolomite that carry approximately 95% dolomite and 5% quartz and feldspar grains.

Subangular to subrounded pebbles and cobbles of milky quartz and greenstone (Plate LV) are the main constituents of a conglomerate lens that crops out 200 feet west of lot line 4 - 5 and 800 feet north of range line E - D. Here again the conglomerate lens is interbedded with dolomite (Plate LVI) and is separated from the previously described lens by smaller but lithologically similar lens-shaped conglomerate beds.

A conglomerate bed, definitely less than 20 feet thick and exposed across a true thickness of only 5 feet was found on the stream bed of Red river, 50 feet east of the gravel road, on lot 7 of range F. Most pebbles and cobbles are porphyritic albite (An 0 - 5) granite the mother rock of which is found 40 feet north of it. In the same conglomerate lens, a few pebbles of albite (An 5 - 10) rhyolite porphyry were identified. This porphyry is similar to the rhyolite porphyry intruding the Weedon schists. Some of the pebbles are angular

and show evidence of some brecciation. The bottom part of the exposed portion of this conglomerate bed has a dolomite rich matrix but the latter gets richer in clay particles to the top where eventually a phyllitic shale is observed. At this locality the lower member is less than 30 feet thick.

Basal beds of dolomite were seen on lot 2 of ranges E and F of Lingwick township.

Abundant exposures of the lower formation are also found in the Stratford map-area. From south to north, here is a list of the different outcrops mapped by the writer.

On lots 4 to 8 of range VII S.W., thinly bedded hornfels slates are well exposed on the northern slope of mount Aylmer.

On lot line 3 of the same range and 700 feet east of the gravel road, a 20 foot thick band of rusty and sericitic schists of the Weedon Schists formation is bounded to the west by a fine-grained orthoquartzite and to the east by a calcareous quartzite carrying nearly 30 per cent clinozoisite.

In strike with the former locality and one thousand feet farther north a 150 foot thick sequence of interbedded quartzite and partly dolomitized limestone is exposed. The whole sequence is intruded by a dark-grey feldspar porphyry dyke of Devonian age.

A smaller exposure of graphitic and sericitic schist was observed 700 feet south of range line II - III S.W.

Interbedded slate and silty limestone can be examined on lot 41 of range I S.W. and a section of approximately 300 feet of

slates, limestone, sandstone, and small pebble conglomerate is exposed on a stream bed that runs along range line I S.W. - I N.E., on lot 40. Two thirds of the exposed strata are black slates. Limy slate is the next most abundant rock type. Two beds of coarse-grained sandstone were recognized. Each bed is about $1\frac{1}{2}$ foot thick. Under microscope the sandstone was found to have the following mineralogical composition: quartz (60%), calcite (20%), feldspar (20%), plus traces of sericite and pyrite. The small pebble conglomerate beds are also $1\frac{1}{2}$ foot thick and were seen at three horizons. They all carry abundant clasts (4 mm) of quartz, albite, and albite rhyolite prophyry. The matrix is made up of quartz and sericite in approximately equal amount.

On range line VII - II N.E., across lot line 34 - 35 of range II N.E., limestone beds and metavolcanics have been intersected by diamond drilling. Core logging was done by the author and the following data have been gathered:

Hole C₁₄ (core angle approximately 90°) (Solbec Copper Mines Ltd, Summer 1960)

Footage	Apparent thickness	Description
0-23	23'	drift.
23-168	145'	Greenstone, dark grey to green crystal tuff, volcanic agglomerate intruded by occasional tongues of bluish albite rhyolite prophyry.
168-417	249'	Cryptocrystalline limestone carrying locally some biotite, sericite, chlorite, and quartz. The rock is white, light grey, light green, or dark grey.
417-500	83'	acidic to intermediate crystal tuff intruded by bluish albite rhyolite porphyry.
500		end of hole.

All the above metavolcanic and related intrusive rocks are obviously part of the Weedon Schists formation. The limestone band may also belong to the Weedon Schists formation or else, it may represent an infolded syncline or a faulted slice of post-Taconic rocks. The writer considers the latter hypothesis as being the more probable one. Indeed, limestone beds were nowhere seen in the whole Weedon schists belt whereas similar beds of limestone of the lower formation of the St. Francis- St. Juste group crop out abundantly 1000 feet farther east. Marmoratization of the limestone also points into this direction (fault).

Erosional Remnants - Lying unconformably above the Weedon schists, a great many erosional remnants are found in the Weedon and Stratford map-areas. They all represent basal beds of the lower St. Francis-St. Juste group.

A quartz anthophyllite cordierite chlorite biotite hornfels rock that shows a good banding crops out on lot 30 of range X and XI of Lingwick township. The rock is believed to be the altered equivalent of an impure sandstone. Each exposure is approximately 50 feet in diameter.

A narrow band of black argillaceous siltstone, made up of quartz (85%), sericite (12%), and graphite (3%) crops out on lot 19 of range I in Weedon township, 10 feet west of the Compton-Wolfe county line.

A 300 feet wide band of similar rock but showing a higher grade of thermal metamorphism was found in contact with the Devonian granite of Weedon on lots 21 and 22 of range I in Weedon township.

Another band, 500 feet wide, can be traced across the central part of lot 22 of range II in the same township.

A section of 200 feet of rock represented by schistose black slate interbedded with siltstone can be examined on the bed of a stream that connects Trout lake to Salmon river, 500 feet south of the Fontainebleau road.

Rusty quartzite and black hornfels shale are exposed across a width of 300 feet, along the line of contact of the crush conglomerate unit and the greenstone band of the Weedon Schists for-

mation. The band is discontinuous and crops out on lot lines 20 - 21 and 21 - 22 of range II. Under microscope the quartzite was seen to carry about 70 per cent quartz, 20 per cent dolomite, 5 per cent feldspar grains, 3 per cent sericite and 1 to 2 per cent granophyre (Weedon crush conglomerate) fragments (Plate LVII).

Two small exposures of staurolite-bearing sericite schist are found on lot 22 of range II, 700 feet southeast and also 500 feet north of the shafts of the former Weedon Mining Corporation. A microscopic examination has revealed that the rock carries 70 per cent quartz, 20 per cent combined chlorite and biotite, 5 per cent sericite, 4 per cent staurolite and about 1 per cent magnetite. Staurolite is highly altered into sericite at its periphery (Plate LVIII).

Only two erosional remnants were noticed in the Stratford sheet-area. Beds of bluish orthoquartzite were seen in a stream bed, 100 feet east of lot line 36 - 37 in range III S.W. and also on lot 32 of range I S.W. just south of range line I N.E. - I S.W. The first outcrop is approximately 25 feet wide and 125 feet long, whereas the second one is 25 feet across.

Upper Member - The rocks of the upper member of the Lower St. Francis-St. Juste group like those of the Lake Aylmer formation consist of a thick sequence of interbedded calcareous siltstone with silty limestone. The zone of transition between the upper and lower members is, where observed, represented by a thin (5 - 10 feet) band of calcareous shale. Within the map-area the upper member crops out only in the Gould and Stratford sheet-areas. Siltstone is everywhere

interbedded with limestone on a scale which is most commonly less than a fraction of an inch. Cross-bedding is rare and visible only on the weathered surface of the outcrop.

The calcareous siltstone is medium to light grey on its fresh surface but whitish or buff on its weathered surface. On the average the rock carries approximately 75 per cent quartz grains, 20 per cent calcite, and 5 per cent sericite. The calcite grains are often more than $1/3$ mm across. As the size of the surrounding quartz and sericite grains is about $1/30$ mm the calcite grains are believed to be porphyroblastic in origin (Plate LIX).

The silty limestone is usually massive and of uniform grain size ($1/20$ mm). Its average mineralogical composition is as follows: calcite (50 - 55%), quartz (40 - 45%), feldspar (1 - 2%), pyrite (cubes of 2 mm across) (1%), and sericite (less than 1%). The limestone often weathers to 2 inch thick gossan of chesnut brown material having the consistency of hard clay and which is the residue after the carbonates have dissolved out. In the absence of the gossan surface, the limestone weathers light grey but it is steel grey on its fresh surface.

From the above petrographic evidence, it is clear that the rocks of the upper member of Lower St. Francis-St. Juste group are much richer in quartz than those of the corresponding member of the Lake Aylmer formation. This conclusion is also substantiated by chemical analyses of limestones of the two formations given by M.F. Goudge in his report on the limestone quarries of Canada (1935 p. 241). The analyses of the Ayers Cliff and North Hatley quarry limestone repre-

sent the purer limestone of the Lower St. Francis-St. Juste group and the remaining 7 analyses, represent also the purer limestone of the Lake Aylmer formation (Dudswell and Weedon areas).

TABLE 3

Analyses of the purer limestone of the Lower St. Francis-St. Juste group and Lake Aylmer formation.

Lower St. Francis-St. Juste group			- Lake Aylmer formation -						
	Ayers Cliff	North Hatley	242	243	244	245	247	248	249
CaCO ₃	51.41	49.21	94.77	62.64	97.92	97.27	63.23	87.87	87.93
SiO ₂	40.36	43.06	1.92	23.50	0.45	1.14	29.92	6.08	8.30
MgCO ₃	3.70	3.01	2.05	4.20	0.51	1.21	3.60	3.30	1.60
Al ₂ O ₃	1.93	2.21	0.75	3.06	0.35	0.34	1.54	1.48	1.17
Fe ₂ O ₃	1.39	1.12	0.24	1.24	0.22	0.17	0.98	0.45	0.85
Ca ₃ (PO ₄) ₂	0.17	0.15	-	-	-	-	-	-	-
S	0.29	0.10	-	-	-	-	-	-	-

Analyst: C.L. O'Brian

242 - Dominion Station. Abandoned quarry, lot 13, rge VII, Dudswell tp.

243 - Lime Ridge. From road cut 1/3 mile south of village.

244 - " " Bottom Level, quarry of Dominion Lime Co.

245 - " " Outcrops 600 yards north of quarry, Dominion Lime Co.

247 - Marbleton. Outcrops lot 3, range VI, Weedon tp. on highway.

248 - St. Gérard. Abandoned quarry, lot 2, range VII, Weedon tp.

249 - St. Gérard. Abandoned quarry, lot 26, rge VII, Weedon tp.

Metamorphism

Regional Metamorphism - During the Acadian orogeny, the rocks of this formation have been mildly metamorphosed through folding. The shale has been converted into slate and phyllite, the sandstone into quartzite and the calcareous bed has been partly converted into crystalline limestone. The clay minerals are now represented by scaly muscovite.

Contact Metamorphism - Effects of contact metamorphism are obvious in practically all the rocks that are now found as erosional remnants or roof pendants. Thus the shale has been metamorphosed into black hornfels of a cherty aspect, the siltstone into quartz biotite sericite rock of very uniform texture, the sandstone into orthoquartzite of very massive appearance and the calcareous siltstone into a quartz calcite epidote (clinozoisite) rock. Garnets are found along certain horizons of metasiltstone and in most of the small inclusions of siltstone embedded in the Weedon granite, a few hundred feet south of Moose Pond.

The lower beds of the Lower St. Francis-St. Juste group, show also evident signs of thermal metamorphism. On the north flank of mount Aylmer, on lots 4 to 8 of range VII S.W., black hornfels shales and biotite rich siltstones crop out. Some of the metasiltstone beds, along lot line 4 - 5, 700 feet east of range line VI. S.W. - VII S.W., are filled with needles of pink andalusite (Plate LX). Under microscope each crystal of andalusite was seen to be bordered by a quartz rich and sericite and biotite poor rim, (Plates LXI, LXII)

a feature that very likely represents the result of a process of enrichment in clay minerals by the andalusite crystal at the time of its growth. This explanation is in agreement with Barth's belief that (1951, p. 319):

"The crystalloblasts outside the shear planes, grow by direct diffusion through the solid rock".

Structure

In the Gould map-area the beds of this lower formation strike everywhere N. 40°E. and dip from 45° to 85° to the east when going from south to north. As a rule the rocks show a distinct flow cleavage, subparallel to the bedding surface, and which dips steeply to the east.

Tight folding prevails in the rocks exposed in the Gould sheet-area, near Fisher hill and on strike continuation to the north. Folds are locally overturned to the northwest with axial lines plunging a few degrees to the south. Along Salmon and Red rivers the calcareous beds dip at an average angle of 50° to the east, and the tops are everywhere facing to the east.

In the Stratford map-area folding has been observed only in the uppermost beds of the upper member. On a rock exposure intersected by range line IHIII S.W. on lot 47, the calcareous strata are highly dragfolded. The axis of those minor folds strike S. 25°W. and plunge approximately 55° to the south. Crossbedding is well displayed in the southern part of this outcrop, and it indicates a top facing to the east. At the same locality, a few feet to the north,

fragments of granite up to one foot in diameter, are found embedded in this limestone band. It is believed that those fragments were formerly part of a granite dyke or sill injected through those limestone beds at a time preceding or contemporaneous with the Acadian period of folding. Examination of the granite under microscope has revealed that it has been subjected to intense dynamic metamorphism and has in part been replaced by carbonates and silica. The rock is made up of quartz (55 - 60%), plagioclase (30 - 35%), calcite (5%), and muscovite (1 - 2%). Traces of pyrite are also present. Some of the quartz grains, more than 4 mms across, have a very irregular outline. This texture is manifestly related to a period of secondary growth by quartz. Calcite and muscovite have preferentially replaced the plagioclase crystals.

West of lake L'Equerre, in the Stratford sheet area, two folds were observed by the writer. Each fold plunges 50 degrees to the south. Their axial planes are subparallel to the local schistosity. The fold lying to the west is a syncline and that found 125 feet farther east is an anticline. They are both slightly overturned to the northwest and have been traced for one mile across lots 37 and 38 of range II N.E. and lots 1 to 5 of range VII.

Slickensides are extremely common in the limestone of the Lower St. Francis-St. Juste group, along Salmon and Red rivers. Those lines of striation are everywhere visible on the bedding plane and are oriented parallel to the line of dip of the bedding surface (Plate LXIII). At a few places, small crenulations are seen at right angle to the slip direction (Plate LXIV). The slickensides indicate

everywhere a reversed movement and have very likely developed during the Acadian orogeny.

On a regional scale the lower formation of the St. Francis-St. Juste group represents the westernmost part of the Gaspé-Connecticut River Synclinorium, a major structural and stratigraphical unit that will be described in connection with the correlation of this formation.

At the latitude of Weedon there are, between the lake Aylmer-Glenbrooke Synclinorium to the west and the Gaspé-Connecticut River Synclinorium to the east, abundant islands of rocks of inferred post-Taconic age which are topographically higher than those of the two adjacent synclinoria. In view of the fact that their distribution is apparently the result of folding, they are believed to be part of a major anticlinal structure that the writer suggests it be called the "Weedon Anticline". This anticline axis would run from lake St. Francis down to the latitude of Marbleton. Approximately three to four miles west of this point, the Stoke Mountain axis dies off. For the same reasons given above, this mountain axis is also interpreted as an anticline axis and has already been named by Cady (1960, p. 543) the "Stoke Mountain Anticline". This axis extends as far south as the U.S. border line, in lake Memphremagog. The offset observed between the Weedon and Stoke Mountain anticlines near Marbleton coincides with a similar offset in the distribution of the ultrabasic rocks west of Marbleton. This feature is clearly indicated on the aeromagnetic map and may be due to cross-faulting or folding.

Thickness

Within the map-area, the lower member of the lower formation of the St. Francis-St. Juste group varies considerably in thickness. The maximum thickness of this lower member can be measured from rock exposures located on lots 4 and 5 of range VII S.W. in Stratford township. Here, the easterly dipping (55°) strata of the lower member are unfolded and have an outcrop width of 700 feet. Therefore the maximum thickness of the lower member is 570 feet.

Like the lower member, the upper member is variable in thickness but to a much smaller degree. In the Gould map-area, along Red river, the upper member has a width of about 2000 feet. The beds are unfolded and dip 55° to the east. Consequently the upper member is about 1900 feet thick. In the Stratford map-area, the thickness of the upper member passes from 1900 to 900 feet when going from mount Aylmer to the northern extremity of the sheet area. Obviously the value of 1900 feet is the maximum thickness reached by the upper member within the map-area.

Thus, the total maximum thickness of the lower formation of the St. Francis-St. Juste group is about 2470 feet.

Age and Correlation

Previous Views - The lower formation of the St. Francis-St. Juste group occupies a narrow zone of the belt considered to belong to the Gaspe limestone by Logan (1863).

Later, Ells (1886) postulated a Cambro-Silurian (Ordovician) age for the same belt of rocks.

In the Stratford area, the lower formation of the St. Francis-St. Juste group was mapped by Burton (1930 - 33) as the lower beds of the Disraeli series of inferred Ordovician age.

On the basis of the same fossils as given by Burton, Clark

(1937) assigned the St. Francis group of rocks to the Ordovician.

Present View - Although careful search was made of any beds that seemed to lack much deformation, the writer has been unable to find fossils in the rocks of the formation presently considered. Recrystallization and crushing would seem to have destroyed any fossils that may once have existed.

On very slender basis, the age of the St. Francis-St. Juste group had been inferred by Burton (1933 p. 115), Cooke and Clark (1937 p. 40) to be Ordovician in age. However since the mapping of the St. Magloire area by Béland in 1952, an alternative interpretation to the effect that many of the rocks, east of the Sutton axis and its northward extension, assigned to Ordovician or older formations are Silurian or Devonian has been developed. Béland's interpretation was extended by Gorman into the St. Justine (Gorman 1954) and St. Georges, St. Zacharie (Gorman, 1955) map-areas. In 1956 Marleau (1957) mapped the Woburn sheet and in 1957 (Marleau 1958) the East-Megantic and Armstrong areas, all of which border on Maine. He was able to demonstrate that the Magog anticline of Dresser (1906) involving the Frontenac volcanics (Mc.Gerrigle, 1934), (Lord, 1935) as well as many other formations is in reality a syncline. Furthermore slate of the Seboomook formation which has Silurian fossils in Maine was recognized beneath the Frontenac volcanics on the Canadian side by Marleau and on the American side of the border by A.L. Albee of the United States Geological Survey.

These workers were thus able to establish a belt of younger formations, conveniently referred to as the Gaspé group, more than 40 miles wide and as shown by extensive mapping by geologists

of the Quebec Department of Mines in the Temiscouata district and Gaspé, probably continuous to Gaspé.

While the changing interpretation of the stratigraphy in the region of Upper Chaudière river in Québec, a comparable modification was going on in Vermont. Cady (1956 and 1960) inferred that Waits River formation and Northfield slates of the Montpelier area, are correlatives of the Gaspé group rather than Ordovician and Dennis (1956) used St. Francis group for both Waits River and Gile Mountain formations.

At the latitude of Weedon, a northwest continuation of the Gaspé group from the western extremity of Marleau's area is apparently concealed by rocks of the St. Francis-St. Juste group which were assigned to the Ordovician by Cooke (1937) et al.

The position of the St. Francis-St. Juste group is therefore fundamental to the interpretation of the stratigraphy.

The St. Francis-St. Juste group is lithologically similar to the Gaspé group to the north and in strike continuation of it. Furthermore the discovery by the writer, during the summer 1959 in the Gould sheet-area, of basal conglomerate lenses enclosed in slate, dolomite, quartzite, and grit beds at the very base of the St. Francis-St. Juste group, lends support the assignment of the St. Francis-St. Juste sequence to the Gaspé group and to the presence of a synclinorium of rocks of Silurian and Devonian age extending from the tip of Gaspé to the Connecticut river. For convenience this is referred to as the Gaspé-Connecticut River Synclinorium. At the latitude of Weedon the synclinorium would exceed 65 miles in width and is therefore a major

structural and stratigraphic unit of the Northern Appalachians.

In Quebec alone, the synclinorium is 480 miles long and crosses the three divisions suggested by Osborne for the Quebec Appalachian region. These divisions, their lengths and their areas are shown in the following table.

<u>Segment</u>	<u>Square Miles</u>	<u>Length Miles</u>
Gaspe	10,240	148
Etchemin-Matapédia	9,350	204
Eastern Townships	10,070	128

On lithological and structural ground, the rocks of the lower formation of the St. Francis-St. Juste group are, as mentioned earlier, correlated with those of the Lake Aylmer-Glenbrooke synclinorium.

Therefore, the rocks of the Lower St. Francis-St. Juste group are probably post-Lower Silurian and pre-Middle Devonian.

For the correlation of the lower formation of the St. Francis-St. Juste group with rock units found outside the map-area, reference must be made to the chapter of this report dealing with the correlation of the Lake Aylmer formation and the middle formation of the St. Francis-St. Juste group (See also, Correlation Map. Index).

Middle Formation of the St. Francis-St. Juste Group.

Name and History of the Name

East and adjacent to the lower formation of the St. Francis-St. Juste group, there is a thick sequence of black and siliceous siltstone which will be referred to as the middle formation of the St. Francis-St. Juste group.

After a study of those rocks in the Disraeli and Scotstown areas, Clark (1937) concluded that this thick sequence of impure quartzites and greywackes represents the upper member of a new series which he called St. Francis, the lower member of which was considered to be represented by the Weedon schists band.

More recently Cooke (1950 - 1957) retained the serial name St. Francis but excluded from that sequence the Weedon schists.

For reasons given earlier, the group name St.-Francis-St. Juste will be used in this work instead of the term St. Francis series.

Distribution

In Quebec, the lower formation of the St. Francis-St. Juste group is confined to an area about 150 miles long and 15 miles wide. The beds form a northeasterly trending band that extends through the eastern parts of the Gould and Stratford sheet-areas. Only the westernmost part of the formation is exposed in the map-area and it represents only one fourth of the total width of the formation.

Southwestward this formation extends into Northern Vermont and northeastward into Maine, along St. John river.

Lithology

General Statement - In the map-area, the formation consists primarily of grey siliceous siltstone and black slate. Thin beds of calcareous siltstone are also present. There is everywhere a gradational contact between the lower formation (rich in limestone) and the middle formation (rich in slate and siltstone). Excellent exposures are seen just north of the village of Gould across a width of about two miles and east of the village of Stratford, across a width of about one mile.

Siltstone - The siliceous siltstone is grey to dark grey, medium to coarse-grained and locally calcareous. On its weathered surface the rock is commonly light steel grey. The recognizable minerals are quartz, sericite and biotite. Many exposures show slates with interbeds, two to five feet thick, of even-grained siltstone. In other cross-sections, the slates alternate with siltstone beds that are a fraction of an inch to a few inches thick. Gradation of grains can be observed in these laminae. The coarser, light colored phase passes upward into argillaceous siltstone then into slate; and this is succeeded along a sharp contact by the coarser-grained base of the next graded bed. This area underlain by the rocks of this formation is characterized by this monotonous repetition of silty and clayey material. In the map-area, the individual beds have been followed for at least 500 feet, that is on individual exposure. But if they can be extended from one exposure to the other, these beds would appear to have a great extent, perhaps of the order of miles.

In thin sections the siltstones are seen to be made up of quartz (75 to 80 per cent), sericite (5 to 10 per cent), feldspar (5 to 10 per cent), limonite (2 to 3 per cent), and a few grains of magnetite, ilmenite, zircon and epidote. The quartz grains are 0.03 to 0.1 mm in diameter. Very frequently the siltstone grades into fine-grained sandstone. Sorting and roundness vary from fair to poor. A good schistosity has been superimposed upon the original bedding. Specks of limonite (0.5 to 3 mm in diameter) are uniformly distributed throughout the siltstone and slate beds. In the siltstone, the limo-

nite is seen to be replacing only the sericitic matrix, forming subcircular clots filled with clastic grains identical to the grains outside the iron oxide aggregates. As the sections of those clots are nearly circular it is believed that this replacement texture is a post metamorphic effect (Plate LXV). Pyrite cubes, one eighth of an inch or more across, are also found in those rocks but are generally confined to certain horizons.

On lot 2 of range VI and lots 48, 49 and 51 of range I S.W. in Stratford township, numerous clayey nodules of concretionlike form, now highly metamorphosed and elongated, are contained in a band of siltstone, about 50 feet in width. The long axis of those nodules is approximately 3 inches and the small axis is one inch. The centers of those nodules are weathered out and they might be mistaken for the amygdules of a lava. A thin section was cut through one of those forms and examined under microscope. Both nodule and enclosing rock are quite fine-grained, but the former is appreciably the coarser. The country rock is composed of about 75 per cent quartz; 5 to 10 per cent clinozoisite; 5 per cent calcite; 2 to 3 per cent sericite and muscovite; 1 to 2 per cent hornblende; and minor amounts of titanite and limonite. The part of the nodule remaining contains about 60 per cent quartz (0.025 mm across); 40 per cent biotite; with a negligible amount of magnetite and limonite.

Apparently the rock records a period of aqueous deposition when the sediment was rather high in clay, and the nodules are due to accumulations of this clay. The exact process of accumulation is not

indicated but they may have resulted from dislodgment of mud from a bank or cliff, the dislodged pieces rolling along the floor of the basin of deposition and collecting small particles of argillaceous material during the movement, in the manner described by Twenhofel for clay galls (1926 p. 497) and Bell (1940, p. 1 - 31) for mud balls. Later the nodules were squeezed out and became elongated parallel to the local schistosity (Plate LXVI).

Slate -

Description - The slate is black and thinly laminated. The distance between two consecutive layers is of the order of 0.3 mm. This layering corresponds to a bedding cleavage in the rock. Megascopically the slates of the middle formation of the St. Francis-St. Juste group are similar to those of the Disraeli formation (called Beauceville by Cooke). They are soft and commonly grade into black phyllites. The few thin sections examined show that the rock consists of an argillaceous and sericitic matrix (75%), quartz grains (0.06 to 0.01 mm in diameter) (15 - 20%), limonite specs (4 - 5%), and traces of carbonaceous and chloritic material.

The beds vary from 0.1 inch to about one foot in thickness but they are on the average 6 inches thick. The graphite has probably been derived from carbonaceous material of organic origin which has been converted into graphite during the deformation and metamorphism of the rock. The graphite could also have been formed from hydrocarbons introduced into the rock during shearing and metamorphism of the region and derived from the surrounding carbon-bearing rocks.

Comparison with Slates of the Disraeli Formation - In order to compare the slates of those two formations, 5 representative specimens from each formation were chemically analysed for their SiO_2 , Na_2O and K_2O content and were also spectrographically analyzed for their trace element content. The specimens were collected at regular intervals across strike in the Disraeli formation and similarly from the part of the Middle St. Francis-St. Juste group that crops out in the Gould sheet-area. The spectrographic study of the minor elements was made to ascertain whether any group of elements are more concentrated in one formation than in another. The slates represent the finegrained portion deposited with the other sedimentary rocks of the Quebec and Gaspe groups and if condition of weathering, transportation, elevation of the land masses and source rocks remained constant, very little difference in the sediments would be expected but any variation in those factors may influence the composition of the sediments formed from time to time. The result of those analyses are tabulated on page 140, (Table 4).

Obviously the slates of the two formations have a similar trace element content. This gross similarity, however, may be more apparent than true because the analysis is only a semi-quantitative one.

The results concerning the SiO_2 , Na_2O , and K_2O content are, on the other hand, suggestive. The slates of the Disraeli formation are richer in SiO_2 but have a smaller K_2O content and a smaller $\text{K}_2\text{O}:\text{Na}_2\text{O}$ ratio than those of the middle formation of the St. Francis-

TABLE 4

Chemical (SiO₂, Na₂O, K₂O) and Semi-quantitative Spectrographic analyses (12 trace elements) of slates of the Disraeli and Middle St. Francis-St. Juste formations.

(Quebec Department of Mines Analyst: Henri Boileau)

Sample No.	SiO ₂ %	Na ₂ O%	K ₂ O%	K ₂ O/Na ₂ O	Baryum	Calcium	Manganese	Nickel	Strontium	Zirconium	Boron	Chromium	Gallium	Lithium	Lead	Zinc	
Disraeli Formation	60J-9994	59.17	1.25	3.33	2.67	T	T	T	T	T	WT	WT	WT	WT	WT	WT	
	60J-9995	75.08	0.94	3.18	3.00	T		WT	WT		T	WT	WT	WT	WT	T	
	60J-9996	60.02	1.76	4.23	2.40	T		T	WT	WT	T	WT	WT	WT		T	
	60J-9997	59.20	1.64	4.19	2.55	T		T	T	T	T	WT	WT	WT	WT		T
	60J-9998	60.21	1.96	3.28	1.73	T		T	T	WT	T	WT	WT	WT	WT		T
Middle St. Francis-St. Juste formation	60J-9999	55.70	0.71	4.29	6.05	T		T	T	T	T	WT	WT	WT	WT		T
	60J-10000	55.97	1.17	4.18	3.58	T		T	T	T	T	WT	WT	WT	WT		T
	60J-10001	55.88	0.97	4.36	4.50	T		T	T	T	T	WT	WT	WT	WT		T
	60J-10002	44.73	0.40	6.96	17.3	T		T	T	T	T	T	WT	WT	WT		T
	60J-10003	51.50	1.47	5.27	3.60	T		T	T	T	T	T	WT	WT	WT		T

T. : traces (0.01% to 0.1%) W.T. Weak traces (0.001% to 0.01%)

St. Juste group.

Consideration of the following facts gives some suggestions as to why the K_2O content and the ratio K_2O to Na_2O are lower in the slates of the Disraeli formation. Assuming that the composition of the slates of the two formations has not changed from that of the original sediments the material of the St. Francis-St. Juste group may have been finer-grained and for that reason may have been more completely weathered before deposition. Indeed, since Na_2O is apparently removed more readily during the weathering of acid igneous rocks, the higher K_2O content may be explained by more complete weathering of the slate material. Another possibility is that potash was introduced when the sericite was formed.

The smaller SiO_2 content in the slates of the St. Francis-St. Juste group may also indicate that the original sediments were finer-grained and more completely weathered. Grout (1925) has made a thorough study of the relation between texture and composition of the clays. On page 402 of his article he writes. "The silica average show clearly as nearly all individual samples do, that the silica tends to concentrate in the fine sand (0.05 to 0.5 millimeter)". And on the following pages he concludes: "Potash averages show a clear tendency to be at a maximum in the finer sizes and most individual samples agree. Exception results from occasional coarse feldspars".

Thus the slates of the Middle St. Francis-St. Juste group may represent finer-grained and more completely weathered material eventhough, under microscope, the slates of the two formations have been found to be indistinguishable.

Metamorphism

Regional Metamorphism - Sericite is widely distributed in the rocks of this formation. Chlorite and sericite are the **characteristic** mineral assemblage of the greenschist facies, and which corresponds to the regional metamorphism of the map-area.

Contact Metamorphism - In the Stratford map-area, because of the presence of two granite stocks, the siltstones are biotite rich and the slates are black hornfels of a cherty aspect. A typical hornfels siltstone carries up to 60% biotite and 10% andalusite (6 mms across). Such crystals are very common on lots 63 and 64 of range VIII S.W. Stratford township. On lot 3 of range VI of the same township, the siltstone carries 10% biotite and 50% andalusite (8 mms across).

The hornfels slates locally contain needles of actinolite and small grains of clinozoisite. Example of this is found on lot 63 of range III S.W. in Stratford township. In general they are extremely tough and carry tiny cubes of pyrite.

Structure

General Structure - On a regional scale the trend of the outcrop of the middle formation of the St. Francis-St. Juste group is parallel to that of the major structure of the area. It has been shown by previous workers (Cooke 1957, Marleau 1958 et al) that the contact of this formation with the Compton formation (upper formation of the St. Francis-St. Juste group) is a gradational one. As mentioned earlier a similar contact has been observed by the writer between the middle and lower formations of the same group. As the latter formation represents a monoclinial sequence dipping easterly with tops to the east, the middle formation must therefore be structurally above the rocks of the lower formation and probably beneath those of the Compton formation.

This conclusion is in agreement with Marleau's interpretation of the regional structure of the area. Marleau (1958) has shown that the axial line of the Gaspé-Connecticut River Synclinorium passes 24 miles southeast of the Gould sheet-area.

Local Structure -

Gould Map-Area - In this area the rocks of the middle formation of the St. Francis-St. Juste group strike N.60°E in the southern part, and N.45°E in the northern part. The beds dip steeply southeast but rarely northwest. A strong flow-cleavage is everywhere present and is, as a rule, subparallel to the bedding plane. At some places the cleavage cuts the bedding plane and because of a difference in competency between the slate and the siltstone, the flow-cleavage intersects the slate bed at a smaller angle than the angle observed

in the siltstone bands. The flow-cleavage shows everywhere a similar orientation with beds of similar orientation and lithology (Plate LXVII).

Two other types of cleavage were noticed in the slates alone. One of them is bedding-cleavage and the other is very likely a slip-cleavage that dips everywhere, 60° to the east, striking parallel to the bedding.

In contrast to the calcareous beds of the lower formation, the rocks of the middle formation are characteristically very tightly folded. The folds are vertical isoclinal north of Gould village and inclined isoclinal, slightly overturned to the northwest, in range XI of Lingwick township. Tops were determined by observing grain size gradation reflected by the color change in the rock. The light colored siltstone bed at the base is seen to pass gradually to black colored slate at the top. Spacing between two adjacent axial lines is anything from 50 to 400 feet. The axial lines of those folds, those of the dragfolds and the lines of intersection of the bedding with the cleavage are all parallel to each other. This lineation trends S. 45° W. in the northeastern part of the Gould map-area, plunging 5° to 15° to the southwest but north of the village of Gould the trend is S. 60° W. and the plunge is 15° to the southwest. This lineation is believed to be related to the Acadian orogeny.

A few feet north of Gould village within a distance of 2500 feet measured across strike of the formation, 14 axes of vertical isoclinal folds were observed. The average spacing between two consecutive axes is thus 160 feet

Stratford Map-Area - Here the flow-cleavage in the rocks of the middle formation of the St. Francis-St. Juste group strikes true north in the southern part swinging gradually to N. 40° E. to the north. Dip is everywhere steeply to the east. Bedding strikes parallel to that of the cleavage but the dip is either steeply to the east or less commonly so to the west. Overturned beds are very common in this formation.

Everywhere the rocks are very tightly folded into asymmetrical and isoclinal folds that plunge from 0° to 60° north or south. Cross-folding is explained by forceful injection of the two Devonian granite stocks of the map-area. The distance between two consecutive fold axes is approximately 175 feet as compared to 160 in the Gould map-area. Milky quartz veins tend to follow the axial zone of the folds particularly in the Gould sheet-area. Dragfolds are very common in the calcareous siltstone of this formation as on lot 58 of range II S.W. in Stratford township. The cause of this folding could be due to some subaqueous slump (Plates LXVIII, LXIX). The very thin cherty beds intercalated with those calcareous siltstones have also been deformed in such a way that they show boudinage-like structures. Axis of the rods is oriented parallel to the axial line of the folds plunging at the above locality, 70° in a direction of $S45^{\circ}W$.

In general the siltstone of this middle formation is well jointed, an example of which may be seen northeast of the road on lot 47 of range I S.W. in Stratford township. The joints are strongly developed, lying vertical and strike northwesterly across the cleavage.

Thickness

Cooke inferred from several assumptions that in the Coaticook-Malvina area the middle formation of the St. Francis-St. Juste group, east of Massawippi lake, has a width of 14 miles. He writes on page 12 of his report (1957) that: "the quartzites so far as could be observed, are not repeated by folding and there is no repetition by faulting; an average dip of 60° to the northwest would indicate a thickness for them of about twelve miles; an average dip of 50° , eleven miles". Although Cooke believes that the quartzites are not repeated by folding, if one looks at his geological maps (417A, 1938 and 913A, 1947) numerous minor folds are revealed throughout the whole formation. Consequently, the figures suggested by Cooke are unreliable.

It has previously been shown by the writer that the rocks of the middle formation are everywhere in the map-area tightly and regularly folded. Assuming that the whole middle formation is folded in such a manner, a ratio "r" of reduction can be found by using curve A of graph 5 shown on page 36 of the writer's thesis (1961). The value " σ " used in this curve to find "r" is inferred to be 70° or 75° . Reasons for this inference have already been put forth in connection with the determination of the thickness of the upper member of the Lake Aylmer formation (graph I). Using curve A, for a " σ " value equal to 70° and 75° , values of "r" equal respectively to 0.312 and 0.475 are found. East of Gould, the outcrop width of the formation is 12.4 miles, the true thickness of this formation is therefore 20,000 or 31,000 feet (for values of " σ " equal to 70° or 75° respectively). Of this only

one fourth however is actually exposed in the map-area.

Gorman (1957, p. 110) believes that the St. Juste group, the equivalent of the lower and middle formations of the St. Francis-St. Juste group, is in the St. Magloire and St-Justine areas, tightly folded with a few cross-folds. On page III of his thesis, Gorman presented a measured section showing the intensity of plication in the rocks of the St. Juste group. The measured section is 400 feet long and the approximate thickness is 140 feet. Using this ratio, the 16 miles thickness of the middle formation at the latitude of St. Georges, becomes 29,600 feet, a figure of the same order of magnitude as that found by the writer in the map-area.

It is concluded therefore that the thickness of the Middle formation of the St. Francis-St. Juste group is probably close to 25,000 feet.

Correlation

Correlation Within Quebec - The author has traced the rocks of the lower and middle formations from the U.S. border line (Vermont) up to the St. Magloire area where Béland describes the type section of the St. Juste group. All along that band the rocks show a marked degree of similarity of lithology, structure and metamorphism. The lower formation of the St. Francis-St. Juste group is lithologically and structurally similar to MacKay's Famine series, near St. Georges, the two being also in rough strike alignment and the middle formation of the St. Francis-St. Juste group and the middle formation of the St. Francis series (as defined by Cooke, 1957 in the Coaticook-Melvina Area), are no doubt equivalent to the black slates and quartzose sandstones of Béland's St. Juste group in the St. Magloire and St-Justine areas (1957, p. 24). All those rocks lie in strike and are lithologically quite similar.

Correlation with Northern Vermont - Recently, compilation maps of the geology of northeastern Vermont by Cady (1956, 1950), Albee (1956), Dennis (1956), Marleau (1958), and the writer (1961), are in agreement in correlating the lower and upper members of the Lower St. Francis-St. Juste group respectively with the Shaw Mountain (Curier and Jahn, 1941) and Waits River formations (Barton River formation (Murthy 1957) and the Middle St. Francis-St. Juste group with the Gile Mountain formation (Westmore formation, Murthy, 1957) their lithology being about the same.

Age

In the map-area, the rocks of the Middle St. Francis-St. Juste group have not yielded fossils that could provide evidence of age.

On the other hand, the middle formation of the St. Francis-St. Juste group is correlative of the St. Juste group. Gorman who studied thoroughly the rocks of the St. Juste group wrote in connection with their age (1957, p. 113). "Within the St. Justine map-area, the fossiliferous limestone conglomerate carries a variety of corals and among these Roy has recognized, Emmonsia emmonsi, an Onondagan coral. Three localities, approximately on strike with each other, are believed to represent segments of a band of fossiliferous calcareous rocks, which lies near the base of the St. Juste group. The St. Juste group, most of which lies above the fossiliferous beds, is assigned to the Middle Devonian. The fossils of the Famine group are exposed in the Beauceville area and are of Onondagan age". And he continues on page 115: "At Morisset station, in the gorge of the Famine river, one mile west of the southwest corner of the St. Justine map-area, exposures of slate and limestone

carry a fauna consisting essentially of corals and brachiopods. Among the brachiopods, Dr. Cooper identified Brevispirifer lucasensis, an index fossil of the Dundee formation which according to Cooper et al (1942, p. 175c) lies above the Onondagan limestone and is of Middle Devonian age. In all 5 fossil localities along the south slope of the Famine river have yielded Onondagan type fossils". Gorman concludes that the overlying slate and quartzite sequence (correlative of the Middle St. Francis-St. Juste group) must be Middle Devonian.

In the vicinity of the map-area, the Middle St. Francis-St. Juste group of rocks may be slightly older than Middle Devonian. The underlying limestone formation has been shown by the writer to be correlative of the Lake Aylmer formation of post Lower Silurian but pre-Middle Devonian age, and the overlying formation (Compton) has been recently assigned by Marleau (1958) to Upper Silurian or Lower Devonian. The Middle St. Francis-St. Juste group may then be as old as Upper Silurian.

In northeastern Vermont, and northwestern New-Hampshire, a Siluro-Devonian age of the Gile-Waits River-Orfordville sequence has been generally accepted. Recently held opinions on this dating are those of Doll (1951), Cady (1956, 60) Billings (alternative, 1956), Dennis (1956) and Murthy (1957).

The middle St. Francis-St. Juste sequence is assigned to the Silurian or Devonian age. If this dating is accepted, the geological history of that part of the Eastern Townships becomes in agreement with that of northern Vermont, southern Quebec, and more like that of the Etchemin-Matapedia area.

Introduction

All intrusive rocks of the map-area are believed to be related either to the Taconic orogeny (Late Ordovician) or to the Acadian orogeny (Late Devonian).

The intrusive rocks related to the Taconic orogeny are granophyre, albite granite, and albite rhyolite porphyry. Some of these rocks were not previously known to crop out in the area and were discovered during the course of mapping.

The Acadian intrusive rocks are represented by a small lens-shaped mass of diorite, a gabbroic body, two granite plutons and related dykes of feldspar porphyry, aplite, and pegmatite. One granite stock, called the Mount Aylmer granite (biotite oligoclase-granite) has an exposed surface of about 20 square miles and underlies more than 20 per cent of the Weedon map-area. The other granitic mass covers an area of about 45 square miles and is called the Winslow granite (biotite-augite-granite). This granite crops out northeast of the former stock and is exposed only along the eastern border of the Stratford sheet-area.

Intrusive Rocks Related to the Taconic OrogenyGranophyreLocation

The Weedon granophyre has only been found as pseudo pebbles, cobbles and boulders or as finely crushed material in a band of rocks called by the writer crush conglomerate and augen schist. It may be recalled that this band of pseudo conglomerate is approximately 4500 feet wide and 3 miles long and is exposed in the Weedon map-area west of

Trout lake and south of the Devonian granite against which it ends abruptly.

Description

The granophyre weathers white but is light brownish grey to light greenish or purplish grey on its fresh surface. Quartz phenocrysts (2 - 4 mm) can be recognized with the naked eye.

Under microscope, the granophyre of Weedon is essentially a combination of quartz (25 - 45%), potash feldspar (30 - 40%), and albite (An_{0-5}) (15 - 35%). Occasionally the granophyre is potash feldspar free, but more commonly microperthite, orthoclase, or microcline is found in the groundmass. The phenocrysts are either quartz or quartz and albite. The accessory minerals present in the granophyre are chlorite (1 - 2%), ilmenite and leucoxene (1% combined), calcite, pyrite, sericite, zircon, apatite, and epidote. The groundmass is normally constituted by an intergrowth of quartz and potash feldspar.

Several types of implication texture are found. These are the cuneiform or micrographic, myrmekitic, irregular, radiating fringe, and feathery or spherulitic type.

The cuneiform type shows a regular pattern of wedge-shaped intergrowth of quartz and potash feldspar (Plate LXX). This is the micropegmatitic texture of most authors. The myrmekitic type shows elongated blebs or wormlike patches of quartz in feldspar. A fine distinction between the cuneiform and the myrmekitic type of intergrowth cannot always be drawn. The irregular type still possesses

a degree of intergrowth as exhibited by the optically oriented patches of quartz penetrated in places by optically continuous feldspar (Plates LXXI, LXXII). Another type, although a less common one, is called the radiating fringe type and consists of a central core of albite from which an intergrowth of quartz and potash feldspar radiates outward (Plate LXX). On a much smaller scale, the radiating fringe type becomes the spherulitic or feathery type. The latter type exhibits an extremely fine intergrowth with individual too small for optical measurements. One, two or even three of the granophyre type of intergrowth may exist together in a single specimen.

Acicular inclusions of ilmenite and leucoxene are common in the chlorite, causing asterism on account of their arrangement along lines crossing at about 60° . Chlorite has practically replaced all biotite. Feldspars are partly sericitized and less commonly epidotized.

Comparison with Some Other Granophyres of the World

The author is not aware of any other occurrence of granophyre in the Canadian Appalachians. However, it is possible that such a granophyre be found in the belt of schists underlying the Stoke mountains, near Sherbrooke, where the geology appears to be quite similar to that of the Weedon area.

At the present time there are two schools of thought concerning the origin of the granophyre; one school believes that the rock is of metasomatic origin, and the other school to which the writer belongs, considers the granophyre to be an intrusive rock for-

ming discrete intrusions or border facies of granite plutons or else found as schlieren and veins within layered intrusion of diabase and gabbro such as those of the British Tertiary Province and those of the great lopoliths of Duluth and Sudbury in North America and of the Bushveld in South Africa.

Because the Weedon granophyre is apparently not associated with an intrusion of diabase or gabbro it must represent offshoots of an underlying granite pluton.

If that is the case, the granophyre of Weedon must have intruded the Weedon metavolcanics and it can be compared with the quartz-feldspar porphyry and micropegmatite dykes and sills of the Sapawe lake area of Northern Ontario. Hawley (1929) reports that within the basic belt of greenstones of Keewatin type, there are in the Sapawe lake area innumerable small lenticular intrusions of a grey to white weathering felsite, classed in the field as quartz porphyry. In most places, these intrusions follow the schistose structure of the enclosing rocks and range in width from a few feet to several chains.

As to the origin of these dykes of granophyre, Hawley considers (1929, p. 13) that: "The apparent gradation of the porphyries and felsites northward into the grey granite and the occurrence of gold in both may be taken as evidence that they are more or less contemporaneous and both the result of one period of igneous intrusion, the more alkaline porphyries being a differentiation of the main batholith".

The granophyre of Weedon can also be compared with the granophyre of the Northern Vosges, a mountain range of northeastern France. The Vosges granophyre was first described by Rosenbush in 1877. Von

Ellen (1960) has restudied the area and has been able to demonstrate that the granophyre dykes and sills of this area are offshoots of a granite mass (Kagenfels granite) that crops out to the north.

The granophyre of the Vosges mountains is essentially made up of quartz, microperthitic orthoclase, acidic plagioclase and a small amount of biotite, muscovite, and fluorite.

In table 5 are shown the results of two complete chemical analyses of the Weedon granophyre: one analysis representing a potash feldspar free specimen and the other one a potash feldspar rich facies. The average composition of these two specimens is also tabulated as well as the chemical composition of the Vosges granophyre. The last column represents the average composition of 5 representative specimens of granophyre genetically associated with the basic and highly differentiated rocks of the Sudbury, Bushveld, Skaergaard, Wichita, and Carrock Fell igneous complexes.

From chemical data, it is clear that there is a striking similarity between the Weedon granophyre and the Vosges granophyre. In both cases, the silica content is very high, the FeO content is less than 1% and the K₂O content is higher than that of Na₂O. It may be argued that these characteristics are not sufficient evidence to exclude the possibility that the granophyre of Weedon represent a late differentiate of a layered gabbro or diabase. This is admittedly true. However, as mentioned earlier, such basic rocks are nowhere found in the map-area and its vicinity. Moreover the Weedon granophyre as well as the Vosges and Sapawe lake granophyres weather characteristically white whereas the granophyre associated with layered gabbro is:

TABLE 5

Chemical Analyses of Granophyres

Weedon granophyre.					Vosges granophyre.	Average comp. of granophyres associated with some stratified lopoliths of the world.***
Specimen No.	6QJ-9975G(61-1)*	6QJ-9993/94G**	Average Comp.			
WEIGHT PER CENT	SiO ₂	73.19	75.50	74.34	75.20	72.18
	TiO ₂	0.32	0.29	0.30	0.15	0.39
	Al ₂ O ₃	13.28	11.90	12.59	13.15	12.74
	Fe ₂ O ₃	1.33	1.51	1.42	1.00	2.33
	FeO	1.11	0.19	0.65	0.11	1.84
	MnO	0.06	0.04	0.05	tr	0.01
	MgO	0.68	0.12	0.40	0.10	0.33
	CaO	1.25	0.24	0.75	0.85	1.24
	Na ₂ O	4.33	2.37	3.35	4.25	3.87
	K ₂ O	1.96	5.90	3.93	4.82	4.13
	H ₂ O	1.40	0.86	1.13	0.11	0.63
	P ₂ O ₅	0.08	0.10	0.09	tr	0.02
	Total	98.99	99.02	99.00	99.74	99.73

Analyst of the Weedon granophyre: Henri Boileau Q.D.M., 1961.

*Plagioclase rich granophyre.

**Potash feldspar rich granophyre.

***Average composition of granophyres associated with the Sudbury, Bushveld, Skaergaard, Wichita and Carrock Fell igneous complexes.

most commonly red and has a correspondingly higher FeO and Fe₂O₃ content.

The writer is thus led to conclude that the granophyre of Weedon represents a series of highly deformed sills and dykes derived from a still unroofed granite pluton.

Correlation

Because of the relative age of the granophyre, this rock is possibly a correlative of the Highlandcroft plutonic series of New Hampshire. The presence of granophyre in this area has not yet been reported however. The granophyre of Weedon should be correlative of any similar granophyre that might be found in the Stoke Mountain belt of schists. More detailed work is needed in this area before a final conclusion can be reached on this matter.

Relative Age

The presence of granophyre, identical to that found in the crush conglomerate of the Weedon schists, but now present as true pebbles in the basal conglomerate of the Lake Aylmer formation, indicates unequivocally that the Weedon granophyre is older than the Lake Aylmer conglomerate. For reasons that will be submitted later in connection with the age of the albite granite the rock is apparently slightly older or penecontemporaneous with the Taconic orogeny (probably Late Ordovician).

Albite Granite

Location

Two sill-like bodies of albite granite are exposed in the northern part of the Gould sheet-area. One of them (western plug) invades greenstones just south of the Weedon thrust fault. This plug is elongated parallel to the local schistosity and is particularly well

exposed along range line I - II of Weedon township. This intrusion is 1000 to 2200 feet wide and nearly 2 miles long. The other plug (farther east) just north of Salmon river, runs along the contact of the Weedon Schists formation with the St. Francis-St. Juste group. This sill-like body of albite granite has also its long axis oriented parallel to the local schistosity. This intrusion is slightly less than 2 miles long and is nowhere more than 1000 feet wide.

Description

The albite granite adjacent to the Weedon fault weathers white to slightly rusty, but it is green on its fresh surface. The rock is medium-grained and has an hypidiomorphic granular texture. The quartz grains are everywhere conspicuous on the weathered surface of the rock. The granite of this plug (western) is made up essentially of albite (An_{0-5}) (50 - 60%) and quartz (30 - 35%). Microcline or microperthite is also present but nowhere exceeds 3 per cent of the total rock volume. Chlorite (up to 5 per cent) is present as shredded aggregates suggestive of altered biotite. Minor green biotite with associated penninite is also seen. Needles of ilmenite partly altered to leucoxene, grains of epidote, apatite, zircon, and pyrite, and rhombs of rusty carbonates are all common accessory minerals.

Quartz is in part interstitial to the feldspars and also occurs as rounded fractured grains showing strain shadows. In addition a fine mosaic of secondary quartz has been developed. All plagioclases are highly saussuritized; epidote makes the albite crystals

look green. The potash feldspars are partly sericitized. Locally the granite shows strong evidence of cataclastic deformation (Plate LXXIII). A large sized inclusion of schistose greenstone was found on lot 14 of range I in Weedon township.

The eastern granite plug is made up of two facies. The granite of the southern half part of the sill is strongly porphyritic whereas that of the northern part is fine - to medium-grained.

The porphyritic granite is extremely schistose. The rock is light greyish brown. The porphyritic texture of the rock is everywhere reflected by the presence of big quartz phenocrysts (up to $\frac{1}{2}$ inch across) forming small protuberances on the weathered surface of the rock (Plates LXXIV, LXXV). Under microscope, this rock is seen to carry albite (An_{0-5}) (55 - 60%), quartz (30 - 35%), secondary sericite (5 - 10%), microperthite (1 - 2%), and pyrite (less than 1%) altered to limonite. The sericite is usually concentrated along two closely spaced sets of planes intersecting at a small angle. For that reason, the rock splits, when hit by the hammer, into wedge-shaped fragments of all sizes. At a few places, this porphyritic granite is brecciated (Plate LXXVI).

The fine- to medium-grained facies of this granite plug (northern part) is mineralogically similar to the granite of the western plug but it is, however, fresher and more massive. The rock weathers very light green and is medium green across fracture. A few inclusions of schistose greenstone are found in this granite on lots 23 and 24 of range X in Lingwick township.

The passage from the porphyritic facies to the fine-grained

facies was not seen in the field but because these bodies of granite are in good strike alignment and separated from one another by a gap of only 200 feet and also because the width of the intrusion remains the same as passing from one part to the other, the writer feels justified to assume that these two granites must be facies of the same intrusion, the passage between the two being presumably gradational.

Correlation

The mineralogical composition of the albite granite, its close spatial relation to the granophyre and its intrusive relationship to the Weedon Schists formation lead the writer to believe that it is probably genetically related to the Weedon granophyre and may be a correlative of it. The albite granite of Weedon is also probably a correlative of a very similar granite that intrudes the Stoke schists northeast of Sherbrooke. Like the Weedon granophyre, the albite granite of the map-area is possibly a correlative of the Highlandcroft plutonic series of New Hampshire. Of this series, the Fairlee quartz monzonite has a modal composition which approaches that of the granite just described.

Relative age

In view of the fact that abundant albite granite pebbles are found in the basal conglomerate of the St. Francis-St. Juste group, exposed in ranges E and D of Lingwick township,

the albite granite of Weedon is definitely older than the Lake Aylmer formation. As the granite now found as pebbles in the conglomerates are relatively schistose, this feature is believed to indicate that the period of injection of the albite granite took place sometimes before the end of the Taconic orogeny. On the other hand the greenstone inclusions in this albite granite are clearly schistose and their schistosity are necessarily older than the period of intrusion of the granite since their orientation does not follow the schistosity of the enclosing granite. If the greenstones have been affected by only two orogenies, which is a reasonable assumption when considering the age proposed for the Weedon schists, the albite granite must have been injected during or close to the end of the Taconic orogeny.

Although it has been impossible to find the age relationship between the albite granite and the granophyre, the latter is like the albite granite definitely older than the Lake Aylmer formation and is for that reason probably of the same age as the albite granite. The minerals in both rock types are alike, the essential difference being that the granophyre is much richer in potash feldspar than the albite granite.

Albite Rhyolite Porphyry

Location

Apart from the crush conglomerate and augen schist unit, the metavolcanics of the Weedon Schists formation are very commonly

intruded by sill-like bodies of albite rhyolite porphyry. Some of the sills are lenticular, but the majority of them are tabular in shape. Sills of porphyry are particularly abundant in the greenstone band exposed north of lake Elgin and in the pyroclastic beds, east of the crush conglomerate unit. The author has found, through the course of detailed mapping, that some of the sills may be more than 3500 feet long and 900 feet thick. It is estimated that from 1% to 2% of the total map-area is actually underlain by these porphyritic intrusive rocks. The best area to study the distribution, size, and character of this rock is near the old Stratford Pyrite mine.

Description

The rock weathers white to light grey and is blue, grey or green on its fresh surface. The intrusive bodies are quite commonly traversed by milky quartz veins oriented in all directions. As a rule the rock is quite fresh and extremely hard to break with a hammer. Locally the porphyry is brecciated and schistose (Plates LXXVII, LXXVIII). As the intrusions are of all sizes only the larger ones are shown on the writer's geological maps. The porphyritic texture of the rock is everywhere manifest. The phenocrysts are either quartz, albite or the two of them.

The phenocrysts (1/5 - 2 mm) represent up to 40 per cent of the rock by volume. Where the phenocrysts are smaller than 1 mm across the texture of the rock may be said to be microphyric. Very commonly the plagioclase phenocrysts form agglomerations, and hence the texture of the rock may be termed glomeroporphyritic. The quartz

phenocrysts are usually bipyramidal, rarely corroded, and they are in general slightly bigger than the plagioclase phenocrysts. The albite (An_{0-5}) phenocrysts are commonly twinned according to the albite (Plate LXXIX), periclone, Baveno, and Carlsbad laws. Out of 14 thin sections examined by the writer only one section contains zoned feldspars.

The groundmass has a felty and cryptocrystalline (1/100 mm) texture and it is made up of a mixture of quartz and albite in approximately equal amount. Characteristically the rock is free of any potash feldspar. The average modal composition of the porphyry is as followed: albite (An_{0-5}) (60 - 65%), quartz (30 - 35%), chlorite (penninite) and green biotite (1-2% combined) with a small amount of sericite, muscovite, zircon, spatite, pyrite, and magnetite. Where the rock is schistose, the sericite content may be as high as 15 per cent and the phenocrysts of quartz and albite show undulatory extinction.

Correlation

From its modal composition and relative age, the albite rhyolite porphyry is believed to be genetically connected with the albite granite. Because of this, the porphyry is probably a correlative of the Weedon granophyre and possibly of the rocks of the Highlandcroft series of New Hampshire. The Weedon albite porphyry is also very likely correlative of most quartz porphyries found as sill-like bodies that intrude the Stoke schists, near Sherbrooke.

Relative Age

Since Logan time, there has been much controversy concerning the origin and age of these porphyries.

However the writer has found during the summer of 1960 in the Stratford area, conclusive evidence as to the intrusive nature of the rock.

On lot 10 in range VI S.W. of Stratford township, 1500 feet southeast of the gravel road, a mass of albite porphyry cuts a greenstone band. The contact between these two rock types is extremely sharp and runs for more than 50 feet at right angles to the bedding of the metabasic flows (Plate LXXX). An inclusion of greenstone, many feet across, was found embedded in the porphyritic body, a few feet north of the above contact.

Similar relationships were also seen on lot 39 of range III S.W. in Stratford township. Here the porphyry intrudes greenstones in a sill-like manner along closely spaced planes. The tongues of porphyry are only a few inches thick and locally cut the schistosity plane of the greenstone to join adjacent tongues of porphyry.

The fact that most intrusions of porphyry are sill-like bodies clearly indicates that when the porphyry invaded the Weedon volcanics, the latter were already schistose. On the other hand as abundant pebbles of like porphyry are present in the basal conglomerate lenses of the Lake Aylmer and Lower St. Francis-St. Juste formations, the age of the albite rhyolite porphyry of Weedon must be older than these two formations. Because of this fact and its similar modal composition the albite porphyry is believed to be of roughly the same age as the albite granite.

As the albite rhyolite porphyry is fresher than the albite granite and the granophyre, it may have been intruded slightly later, that is during the last stages of the Taconic orogeny.

In summary, all the intrusive rocks of the area that are related to the Taconic orogeny are thought to belong to a single series of intrusive rocks. The name "Weedon intrusive series" is pro-

posed by the writer to designate this series which is characterized as followed:

1. the rocks of this series have a high albite content (above 40 per cent)
2. the rocks of this series are concordant intrusive bodies: the albite granite and the granophyre being apparently synchronous with the Taconic orogeny and the albite rhyolite porphyry being late kinematic.

If the correlation of these rocks with the like intrusive rocks of the Stoke Mountain belt proves to be correct, a better name for the series would be the "Weedon-Stoke intrusive series".

Intrusive Rocks Related to the Acadian Orogeny

Gabbro

Location

A large body of gabbro intrudes the fine-grained pyroclastics of the Weedon Schists formation, east of Trout lake, along the Wolfe-Compton county line. The plan of this intrusion is crescentic, with the upper half part missing and with the concave face looking east. The gabbroic mass is approximately 6000 feet long and 1500 feet wide and is elongated parallel to the local schistosity.

Description

The gabbro mass that crops out east of Trout lake is

greenish grey and coarse-grained in its northern part, but dark green and fine-grained in its southern extremity.

The coarser-grained (5 - 8 mm) gabbro has, under microscope, the following mineralogical composition: actinolite (55%), uralite (10%), plagioclase ($An_{45} - 50$) (25 - 30%), biotite (2 - 3%), chlorite (2 - 3%), and a few grains of titaniferous magnetite, epidote, apatite, and sphene.

Lath-shaped crystals of feldspar are commonly found as inclusions in the uralite crystals. The interstitial material of the rock is essentially made up of anhedral grains of feldspar traversed by needles of actinolite. The feldspars are sericitized or partly saussuritized. The original pyroxenes are now represented by crystals almost completely replaced by actinolite and chlorite. The coarse-grained gabbro has everywhere a blastophitic texture (Plate LXXXI). A specimen of gabbro collected on lot line 20 - 21 of range I carries about 5 per cent of pink tourmaline the occurrence of which is probably due to the nearby granite intrusion.

When going from north to south, the gabbro becomes finer-grained and eventually becomes very fine-grained. This fine-grained gabbro looks like a meta-basalt. In thin sections the rock consists of plagioclase (45 - 50%), chlorite (15%), biotite (10%), clinzoisite (10%), calcite (5%), sericite (5 - 10%), and a few small grains of sphene, quartz, and iron oxide.

The texture of the fine-grained gabbro is secondary but in some of them a porphyritic texture can be seen. The porphyritic texture is particularly well developed in the finer-grained facies of

the rock. The phenocrysts are zoned (An_{10-40}) plagioclases (Plate LXXXII) that locally represent up to 50 per cent of the rock by volume. These phenocrysts are usually small (0.02 - 0.5 mm) but some of them are almost $\frac{1}{2}$ inch across (Plate LXXXIII).

On lot 29 of range XI in Lingwick township, the porphyritic metagabbro has abundant inclusions of schistose greenstone. The fragments are set at random in the matrix and the rock is obviously an igneous breccia (Plate an LXXXIV).

Correlation

If the blotchy gabbro found in association with the limestone beds of the Lake Aylmer formation, north of Fontainebleau, and if the blotchy gabbroic masses found in the Weedon schists near Salmon river are intrusive rocks, they could then be correlative of the fine- and coarse-grained gabbro of Trout lake.

Because of its relative age, the meta-gabbro of Trout Lake is probably a correlative of the gabbro exposed in Woburn, East Megantic and Armstrong areas and which is described by Marleau (1958, p. 114) as cutting the Frontenac formation. It is also tentatively correlated with the Oliverian plutonic series of New Hampshire.

Relative Age

The intrusive relationship of the gabbro and the rocks of the Weedon Schists formation (igneous breccia) indicates the gabbro to be the younger. Because the gabbro does not seem to have suffered

much cataclastic deformation, the rock is inferred to be approximately contemporaneous with the Acadian orogeny. The intrusive relationship of the Devonian granite stock (Mount Aylmer) and this gabbro indicates, however, that the granite is the younger.

Diorite

Location

An oval-shaped body of meta-diorite intrudes limestone beds of the Lake Aylmer formation on lots 19 and 20 of range III in Weedon township. This dioritic mass is about 800 feet long and 300 wide. It has its long axis oriented parallel to the strike of the local schistosity.

Description

The diorite is medium-grained, dark green, and massive. The rock exposures of this dioritic mass are pyramidal. This feature is explained by joints in the rock.

Under microscope the rock appears to consist of plagioclases (55 - 70%), hornblende (15 - 20%), and of alteration products such as epidote, sericite, chlorite, leucoxene, calcite, and ilmenite. The rock exhibits most commonly an hypidiomorphic texture and more rarely a porphyritic texture. In the latter case the phenocrysts are hornblende crystals (2 to 5 mm long) that are partly or completely replaced by chlorite. The plagioclases (1.2 - 3 mm) are saussuritized, which hinders an accurate determination of their An

content; nevertheless they have been estimated as from An_{28-30} . Smaller grains of secondary albite are also present in the rock. The rock is here considered as a meta-diorite.

Correlation

Because of the relative age of the diorite to the Lake Aylmer formation, the rock is tentatively correlated with the sills of diorite exposed near Sherbrooke and described by Douglas (1941, p. 16) as being possibly of Silurian or Devonian age.

For the same reason the diorite is also tentatively correlated with the Oliverian plutonic series of New Hampshire. Because the diorite and the gabbro of the Weedon area appear to be roughly of the same age they are believed to be genetically related to each other.

Relative Age

The meta-diorite cuts through beds of the Lake Aylmer formation; therefore it is post-Middle Silurian and is very likely contemporaneous with the Acadian orogeny.

Biotite-Oligoclase Granite

(Mount Aylmer Granite)

Location

A biotite-oligoclase granite called the "Mount Aylmer granite", forms prominent hills in the eastern part of the Weedon map-area. The granitic mass is oval-shaped and is about 6 miles from

north to south and $4\frac{1}{2}$ miles from east to west. Only the western half part of this mass is exposed in the map-area except for a small protuberance in the south central part of the Stratford sheet-area.

A small plug, about 175 feet long and 100 feet wide, of that same granite crops out on lot 7 in range V S.W. of Stratford township, 700 feet south of the main road.

Description

The rock is grey, medium-grained, and massive.

Several sections were examined under microscope. The mean modal composition of the rock is: quartz (30%), microcline (28%), plagioclase (34%), biotite (3%), and muscovite (2%). The accessory minerals are apatite, sphene, magnetite, pyrite, chlorite, zircon, and calcite. The accessories apatite, sphene, zircon, and magnetite were apparently the first minerals to crystallize, followed by biotite and muscovite, with biotite apparently first. Oligoclase, microcline, and quartz crystallized in the order named. Quartz grains are from 0.5 to 1.3 mm. in diameter. The sericitized feldspar crystals are from 0.6 to 3 mm. long. This biotite is deep brown. The plagioclase grains are zoned, which hinders positive determination, but their range has been determined to be between An_{17-25} . The rock has a hypidiomorphic-granular texture. Poikilitic (Plate LXXXV), myrmekitic, and microperthitic texture are also common.

According to some classifications, the rock is not strictly a granite, nevertheless, it is here called as "biotite-oligoclase gra-

nite".

The granite of range V S.W. in Stratford township is megascopically quite similar to the granite of Mount Aylmer but, under microscope, it is richer in plagioclases and has the following mineralogical composition: quartz (20%), plagioclase (55%), microcline (15%), biotite (5%), muscovite (1%), and a minor amount of sericite, zircon, chlorite, and pyrite.

Biotite-Augite Granite

(Winslow Granite)

Location

An oval mass of biotite-augite granite, named the "Winslow granite", about 10 miles from north to south and 6 miles from east to west, crops out only along the eastern border of the Stratford sheet-area. The best exposures are found south of lake l'Equerre, in range II N.E. of Stratford township.

Description

This granite is medium-grained, medium to dark green and disintegrates rapidly on a weathered surface. Quartz, orthoclase, plagioclase, biotite, augite, and hornblende are determinable megascopically.

In thin section, the rock consists of quartz (25%), orthoclase (15%), oligoclase (32%) biotite (12%), augite (7%), hornblende (5%), ilmenite and leucoxene (1% combined), with scattered grains of

zircon and apatite. Augite is, as a rule, partly altered to hornblende. The texture tends to be somewhat coarse-grained with feldspar laths up to 4 mm. long set in a finer-grained base. The plagioclase crystals are usually zoned. The sodic rims have remained fresh whereas calcic cores have been partly altered into sericite. The composition of the plagioclases has been estimated to vary from An_{27-17} when passing from core to rim.

The accessories apatite, zircon, and ilmenite, were apparently the first minerals to crystallize and were followed by augite, then biotite. Oligoclase and orthoclase solidified next but their mutual relationship is not definite. Quartz was the last mineral to come out of solution.

Structure and Mode of Emplacement of the
Mount Aylmer and Winslow Granites

Structure

Burton who has studied in detail some of the structures of the Mount Aylmer granite in a quarry located 1 mile east of the Weedon map-area just south of Elgin lake reported that (1933 p. 199): "the rift is about horizontal, or dips easterly at low angles. Judging by the manner in which the stone was worked the grain is vertical and strikes about N. 70°E., the hardway at right angles to rift and grain. The structure may vary in other parts of the intrusive, but from the writer's observations in granites of this type throughout the Eastern Townships, the rift is likely to be horizontal, or nearly so, throughout".

"Joints and sheets are well defined but do not seem to be closely spaced. In the above quarry, a major set of joints strikes N. 70°W. and dips 74° southwest, with the joints variably spaced up to 20 feet apart. The sheets are from 4 to 6 feet thick and lie horizontal or dip easterly at low angles".

From the few exposures of the Winslow granite located in the map-area, the writer has been unable to draw any conclusion concerning the internal structures of this rock. Such a study remains to be done.

The two granite plutons must underlie all the eastern section of the Stratford sheet-area at no great depth, judging by the numerous dykes of porphyry cutting the sediments of this section. This inference is in agreement with the observations made by Cooke (1950, p. 100): "The Winslow and Mount Aylmer granites are probably the exposed parts of a single larger body that in the gap, lies only a short distance beneath the present surface".

The structural relationship of the granites to the enclosing rocks differs widely from one place to another. At the Weedon mine, for instance, the granite contact, above the 15th level, dips inward and parallel to the local schistosity, that is 45° to the east but below that level this same contact dips steeply to the west and across schistosity. Obviously the schistosity of the invaded rocks has, on a small scale, controlled the advance of the granite magma. Interfingering of the granite with the rocks of the St. Francis-St. Juste sequence is also widespread in the map-area and it is best displayed near the top of Mount Aylmer. A similar relationship has been interpreted from core recovered by drilling on lots 4, 5, and 6 of range VII S.W. in

Stratford township.

Mode of Emplacement

For the most part the granite of mount Aylmer appears to have been intruded with relatively little disturbance to the invaded formations. Cliff-like exposures of dolomitic quartzite are seen completely surrounded by granite, 1000 feet south of Moose pond. A few hundred feet farther south, the granite is filled with inclusions of black hornfels. On top of mount Aylmer in the Stratford map-area, circular patches, about 800 in diameter, of hornfels siltstone were mapped as inclusions in the same granite. These inclusions of metasedimentary rocks are probably part of the original roof of this igneous body. The presence of abundant inclusions (Plate LXXXVI) in this granite suggests that it has made its way upward partly by magmatic stoping. On the other hand cross folding in the metasedimentary rocks of the St. Francis-St. Juste sequence exposed in the gap between the two granites indicates that the granite has some of the distinctive features generally attributed to the type of forceful injections. Thus the mechanism by which the Mount Aylmer granite has displaced upward appears to be a complex one.

The Winslow granite has presumably followed a similar mode of injection.

Correlation and Relative Age of the
Mount Aylmer and Winslow Granites

Correlation

The two granites are similar in mineralogical composition, texture and alteration to the granite of Scotstown and St. Sébastien collected by Burton (1931) and to the Spider Lake granite described by Marleau (1958). The Winslow and Mount Aylmer granites seem to be genetically related to the crosscutting plutons of the St. Francis-St. Juste, Frontenac, and Vermont sequence.

Relative Age

By using the K-Ar method, the Mount Aylmer would apparently be 379 m.y. old (± 25 m.y.) (Middle Silurian) (G.S.C., 1960).

In the map-area, the granite intrudes folded sedimentary rocks of the lower and middle formations of the St. Francis-St. Juste group. The granite must therefore be post Middle Silurian.

In Gaspé, batholiths of a similar granite are unconformably overlain by flat-lying Carboniferous rocks. This fact suggests that the granite of the map-area would also be pre-Carboniferous. As the Acadian orogeny is believed to have culminated sometimes during the

Devonian period, the granite is probably of Middle or Late Devonian age.

Feldspar Porphyry Dykes

Location

Several dykes of feldspar porphyry from 2 to 40 feet thick, occur in the map-area, particularly near the old Stratford Pyrite mine, in the part of the Stratford area underlain by rocks of the St. Francis-St. Juste sequence, and on lot 17, range V S.W. of Stratford township.

Description

The rock is greyish-brown on fresh surfaces and weathers light brownish-grey. It is very difficult to break, fine-grained, and porphyritic. The intrusive relationship with the rocks of the St. Francis-St. Juste group has been ascertained many times in the field (Plate LXXXVII).

Under microscope, the matrix appears to be an aggregate of quartz and feldspar grains, of biotite, sericite, calcite, epidote, and other deuteritic minerals. Some specimens have a groundmass in which quartz and feldspar are finely intergrown with each other. The phenocrysts are 0.3 to 2.6 mm. across and are sodic plagioclase and orthoclase crystals. These phenocrysts make up 25 per cent of the rock by volume. The plagioclases are zoned and clear, but the potassic feldspars are partly altered to a grey amorphous-looking substance that may be a mixture of clay minerals and sericite (Plate LXXXVIII). The plagioclases are commonly twinned according to the Baveno law. The plates of biotite are

about 0.7 mm in length.

Correlation

Burton noted (1933, p. 195) that these "dykes are common associate of the grey granite in many parts of the Eastern Townships". A correlation between all these dykes is thus suggested. This correlation of all dykes associated with the younger granites of southern Quebec may also be valid for all porphyry dykes found in association with the Acadian granites of the Gaspé area and of the Vermont, Maine, and New Hampshire states.

Relative Age

In the map-area, several dykes of feldspar porphyry intrude the granite with which they appear to be genetically related to. Because of the relative age of the granite, the dykes were probably intruded in Upper Devonian time.

Aplites and Pegmatites

Location

Aplites and pegmatites, in irregular masses and thin veinlets, cut the two Devonian granites (Plate LXXXIX) and more rarely the invaded sedimentary and volcanic rocks. The veinlets are often persistent for considerable distances.

Description

The aplites are white on fresh surfaces but weather rusty. They are characterized by an even grain size that rarely exceeds 2 mm. and by an allotriomorphic-granular texture. In, hand specimens they appear sugary. Three specimens were examined under the microscope and were found to consist principally of quartz (90%), microcline (3%), and muscovite (5%). The accessory minerals are epidote, zircon, pyrite, and magnetite. Sillimanite is present in minute needles penetrating quartz in all directions.

The pegmatites are quite similar in general appearance to the granite. They are composed of coarse-grained feldspar, at least part of which is sodic plagioclase, quartz, muscovite, garnet, tourmaline, and pyrite all in well developed crystals.

Relative Age

The aplites as well as the pegmatites were obviously derived from the granite, filling joints and cracks in the cooling intrusive.

Although none of them were seen cutting feldspar porphyry dykes, the aplites and pegmatites are believed to be slightly younger than the porphyry.

PLEISTOGENE AND RECENT

Introduction

No rock formations younger than the Devonian granite and associated dykes occur in the map-area. Auriferous gravels of Tertiary age are important in the Beauceville area (MacKay, 1921), but if ever present within the map-area, they were destroyed by the intense Pleistocene glaciation.

The destructive effects of the Labrador ice sheet are much less apparent in the map-area than are the constructive effects. The destructive role has resulted in a general smoothening of the hills, plucking, and the development of striations, and also in deepening the lake Aylmer basin and the St. Francis river valley by scouring. The constructive effects of the glacier are more conspicuous, and have resulted in a thick blanket of unconsolidated material that covers the lower parts of the area and the flanks of hills.

Erosional Features

Numerous observations of glacial striae indicate a S. 60°E. direction of ice movement. In a few exposures two sets of glacial striae can be observed with differences between the trends up to 30

degrees. At these places, attempts to distinguish the younger from the older striae were unsuccessful.

Coarser grooves, a few feet long and in most cases less than an inch thick, are scattered throughout the map-area, particularly on the rock exposures located on the northern half-lots 47 to 51 of range I S.W. in Stratford township.

Lunate fractures, resembling crescentic gouges and presenting their concave face downstream, were observed here and there. These fractures are steepened by plucking on the southeast side and indicate a southerly direction of ice movement.

Roches moutonnées, smoothed and rounded on the stoss side and steepened by plucking on the lee side were locally seen in the map-area, particularly on top of mount Aylmer. The plucking, also indicates a southerly direction of ice movement.

Depositional Features

Erratics - Erratic blocks, many of which are 10 feet in diameter, are numerous and occur throughout the map-area. Many boulders of serpentine, of boulder conglomerate (derived from the Lake Aylmer formation), and of quartzite (Caldwell type, Cooke 1950) are found in the Gould, Weedon, and Lake Aylmer sheet-areas. Their distribution southeast of the assumed outcrops again indicates a southeasterly motion of the continental ice sheet.

Ground Moraines - The higher elevations are either bare or covered by a very thin mantle of till, but heavy deposits of the lat-

ter were laid down in the depressions, and this material remained largely unsorted. The ground moraine, locally consists of fields of boulder lying loose on the surface of the ground. Many streams are strewn with boulders of all sizes, the finer material having been washed away. A good example of this can be seen along Red river, in range X of Lingwick township. Where the unstratified till has not been reworked, it is seen to consist of clay, silt, sand, gravel, pebbles, and boulders. In general the unstratified material is represented in the map-area by a thin blanket of boulder clay that lies on top of thick fluvioglacial deposits. It is therefore concluded that there has been, in connection with the Labrador or Laurentian ice sheet, at least two periods of deposition. This conclusion is in accord with the presence in the map-area of two directions of ice movement that have been alluded to previously.

In a boulder clay deposit, south of the village of Stratford, several boulders of pink granite gneiss were found by the writer. These boulders have obviously been transported by glaciers from the Laurentians and are considered as unequivocal evidences in support of the idea that during the last glaciation, the Eastern Townships were, for a certain period of time, covered by a continental ice sheet that had spread southward from the Laurentians.

Glacial Stream Deposits - Kame terraces with a typical delta structure can be seen in gravel pits bordering Moffat brook and Salmon river (south of Red river). The material is made up of sand, gravel, and cobbles and shows relatively poor sorting. Torrential cross-bedding is well displayed west of the village of Fontainebleau (Plate XC).

Chalmers' Hypothesis

In the Eastern Townships, erratics are said to occur north of their most northerly outcrops and Chalmers (1897, p. 255) explained this by postulating the development of an ice-sheet (Appalachian glacier) along the boundary between northern New England and the Eastern Townships of Quebec, which spread radially, later followed by at least two Laurentian ice sheets, the first of which moved south to southeasterly and the other southwesterly. Chalmers (1897, p. 26J) also believes that: "Towards the close of the glacial period, during the melting or retiring stage of the glacier systems referred to, a number of local glaciers crept down the slopes in various directions as they were influenced by the topographical features".

Evidence to support Chalmers' contention was found in the southeastern half part of the Gould sheet-area. Indeed, twelve boulders of biotite granite (Scotstown type) were seen scattered in an area that lies northwest of the granite stock from which they have been derived. It is true that the granite of the village of Scotstown is megascopically similar to the Mount Aylmer granite but the former carries only biotite as a mica mineral whereas the latter carries biotite as well as muscovite in approximately equal amount. For that reason, it is relatively easy to tell them apart in the field. One boulder of such a granite was found, near the road, on lot 25, range I of Lingwick, more than three miles north of the most northerly outcrop. It is therefore concluded that the map-area has been covered by a northward moving glacier, probably of local origin, at a time that must have clo-

sely followed the period of melting of the continental ice sheet since its debris lie on top of the material brought in by the Laurentian glacier.

Burton (1933, p. 204), Clark (1937, p. 215), and Cooke (Clark 1937, p. 221) have also reported evidence of northward moving ice in southeastern Quebec during a late stage of the last glaciation.

Aftermath of Glaciation

Most of the lakes in the map-area owe their origin, at least in part, to late glacial deposits. The lakes and ponds occupy ground where bedrock or glacial till form the enclosing rim and floor. The watercourses are also partly controlled by glacial deposits.

Alluvial deposits are abundant in the map-area and consist mainly of silt, sand, and gravel. They occur in the valley of all streams and are abundant at the heads of Weedon and Aylmer lakes. They are derived from glacial and pre-glacial deposits. These accumulations are observed to thicken where tributaries join the main streams.

Much of the sediment carried by the streams is finally deposited at the head of lake Aylmer and lake Weedon where deltas are being formed. The delta found at the head of lake Weedon is a striking feature, as seen on the aerial photographs. The greater part of the deltaic deposits consists of silt and sand.

A thin flood plain deposit is present along the valley of the meandering Salmon river. In the map-area, this river is bordered by several meander cutoffs and point bar deposits. A good example of this can be seen on lots 13 and 14 in range IV of Weedon township.

ECONOMIC GEOLOGY

Metallic Deposits

History of Mining of the Area

Copper has been known in the Eastern Townships of Quebec since 1841. The first official report on account of copper occurrences came from the Director of the Geological Survey of Canada, Sir William Logan who examined copper prospects in 1847 and suggested some favorable areas for prospecting. The earlier geologists of Canada recognized that one of the main geological features of the Eastern Townships consists of the presence of three belts of highly schistose rocks that give rise to three ridges which are approximately parallel and trend northeasterly. These three ridges in which most copper deposits of the Eastern Townships happen to be found, have been designated by Dresser as when going from west to east, the Sutton belt, the Ascot or Stoke Mountain belt, and the Lake Megantic or Boundary belt. Most of the known occurrences of copper minerals in the Eastern Townships lie within the Sutton and the Ascot belts. In the map-area, all known metallic deposits lie in the Weedon schists belt which is the northern extension of the Stoke Mountain belt.

From 1859 to 1866, the Eastern Townships were prospected by many "shafts", many of which were no more than small holes or trenches. At first, the deposits were worked for their copper content only, but commencing about 1877, sulphur was also produced from the

associated pyrite and used for the manufacture of sulphuric acid.

Between 1886 and 1939, 170 million pounds of copper were produced in the Eastern Townships, namely from the Acton, Eustis, Capelton, and the Weedon mines. The Weedon ore body was found in 1909, and the Stratford pyrite deposit, one year later. The Weedon ore body was mined intermittently from 1913 to the spring of 1960. The Stratford ore body was mined in a small way in 1914 and 1915.

A new copper-zinc ore body was discovered by Cyprus Exploration during the winter of 1958, just north of the village of Stratford. Since this discovery, active prospecting has been carried out in the Stratford area and in general over the whole belt of the Weedon schists. This renewed interest has lead Solbec Copper Mines Ltd, (the owner of the Cyprus find), to the discovery of a new major copper-zinc deposit, 13000 feet south and in strike with the Cyprus find.

Stratford Pyrite Deposit

Location - This pyrite deposit is on the northwest flank of mount Aylmer, more exactly on the southern half-lot 8 of range VI S.W. in Stratford township.

History - Discovered in 1910, as a result of the prospecting activity that followed the discovery of the Weedon mine (1909), an inclined shaft was sunk on the original showing to a depth of about 40 feet. Some diamond drilling was also done during that same period. The property was leased in 1914, and during that year, the shaft was enlarged and deepened to 75 feet, and a drift was started at the 50 foot horizon

in a southwesterly direction. It is reported that 1,600 tons of pyrite were shipped from this operation. The following summer (1915), a mining plant was installed, mining was resumed and it is estimated that about 10,000 tons of pyrite were shipped. The plant was destroyed by fire in 1916, and this ended all mining operations on the property. At the present time, the mine is filled with water and at surface the workings have the shape of a trench which is 225 feet long and 30 feet wide. At each extremity of this trench, there is an inclined shaft (Plate XCI).

Geology - The Stratford deposit consists of two lenses of granular pyrite found in a sill of albite rhyolite porphyry of inferred Taconic age which has intruded a greenstone band of the Weedon Schists formation. The greenstone has been called in the field chlorite schist and the rhyolite porphyry, quartz sericite schist. Each lens is parallel to the local schistosity which strikes N. 38°E. and dips 60° southeast towards the Mount Aylmer granite stock, exposed 600 feet farther east.

The surface indications, and the development work that has been done on this property, suggest that the major lens (northern lens) is about 75 feet long and 12 feet thick maximum. The other lens, found 110 feet farther south in strike and 20 feet farther east across strike, is less than 10 feet long and 2 feet thick. The major lens apparently tapers at a depth of 75 feet but no information could be gathered concerning the down dip extension of the minor lens. Bancroft, who made a detailed investigation of this deposit in 1915 reports (p. 285): "Their mode of occurrence suggests that with depth these lenses may be

arranged "en échelon" and may be expected to occasionally enclose bands of barren schists, even as the workings of the similar, though many times larger deposits of the Eustis and the Capelton mines, near Sherbrooke. "It is also possible, according to Woodcock (1951) that : "The formations as well as the vein (major one) plunge or rake northward".

The writer has found that the Weedon ore body, near Fontainebleau, has a rake to the south. If Woodcock's contention is correct it would appear that the rake in each deposit has not been caused by the same factors eventhough the geology of each deposit is quite similar.

Mineralogy - The broken material of the old dump shows considerable sulphide mineralization. It is mostly pyrite of a granular (1 - 4mm) type. Little or no chalcopyrite was noted.

Examination of two representative specimens of ore under the microscope has revealed that the gangue minerals are quartz (35%), chlorite and light brown biotite (25% combined), sericite and muscovite (20% combined), cordierite (15%), and a few grains of tourmaline of the dravite-uvite series, carbonate, and green spinel enclosed in the cordierite crystals.

Cordierite shows polysynthetic twinning, and is inclusion-rich, highly altered to chlorite, sericite, or light brown biotite and is apparently everywhere optically positive. Chlorite is light green to colorless and is, in part, of the penninite variety that shows the abnormal blue interference color.

Origin and Age of Formation - The type of mineralization present at the Stratford Pyrite deposit varies from disseminated to

massive. Sulphides and gangue minerals replace in part or in whole a sill of sheared albite rhyolite porphyry and to a lesser extent the chlorite schist hanging wall.

The proximity of the Stratford deposit to the Mount Aylmer granite (less than 60 feet) and the occurrence of tourmaline and cordierite as gangue minerals are, to the writer's mind, sufficient evidence to consider the Stratford Pyrite deposit as a contact metasomatic deposit.

It will be shown later that the Weedon ore body, about 4 miles south of the Stratford deposit, is younger than the Mount Aylmer granite but apparently older than the aplites related to that granite. Because the Stratford and Weedon ore deposits are both located close to the same granite batholith and have both similar gangue minerals, the writer believes that these two deposits are probably of the same age (Middle or Upper Devonian), and are both considered to be genetically related to the Mount Aylmer granite.

Weedon Pyrite-Copper-Zinc Deposit

Location - The Weedon ore deposit is located on the northern half-lot 22 of range II, in Weedon township, along range line II-III and approximately 1 mile north of the village of Fontainebleau.

History - This ore body was discovered in the latter part of August, 1909 by Mr. John McDonald of Sherbrooke. The Weedon Mining Company Ltd extracted from it, between 1913 and 1921, 584, 677 tons of ore averaging 3.5 per cent copper and 40 per cent sulphur. The mine was closed in 1921. Mining operations were resumed in 1951 by the

Weedon Pyrite and Copper Corporation, later called (1959) the Weedon Mining Corporation Ltd. In 1955, a new 45 degrees inclined shaft (No. 4) was sunk parallel and about 100 feet west of the original (No. 3) shaft (Plate XCII). In spring of 1960, the hanging wall of the No. 1 ore zone caved in and the workings became flooded. Since then, mining operations have ceased. Just before caving the rate of mining was 440 tons a day and development work was being carried out on the 17th level. From 1951 to the end of 1958, the Weedon Mining Corporation Ltd and the Weedon Pyrite and Copper Corporation Ltd had shipped: 19,059,492 pounds of copper, 4,838,727 pounds of zinc, 113,546 ounces of silver, 1,106 ounces of gold and 199,820 tons of pyrite.

Geology - Above the 15th level, the Weedon ore body consists of two lenticular zones of massive sulphides that replace sills of albite rhyolite porphyry of Taconic age. These sills intrude a greenstone band (southern segment) of the Weedon Schists formation. The Devonian Mount Aylmer granite lies on surface about 1200 feet northeast in the hanging wall but intersects the ore zones on the 14th level. (cf. geological plan No I, appendix) The zones are both parallel to the local schistosity which strikes N. 35°E. and dips 45°E. The zones are approximately 60 feet apart from one another.

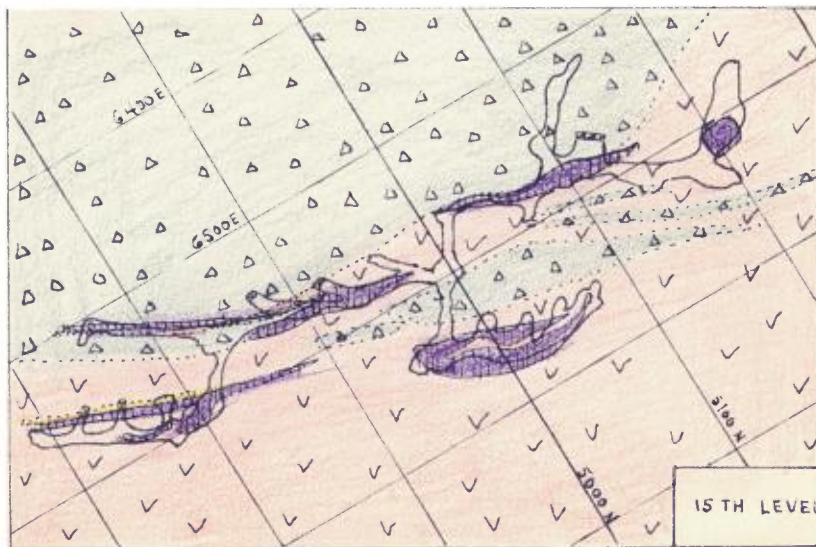
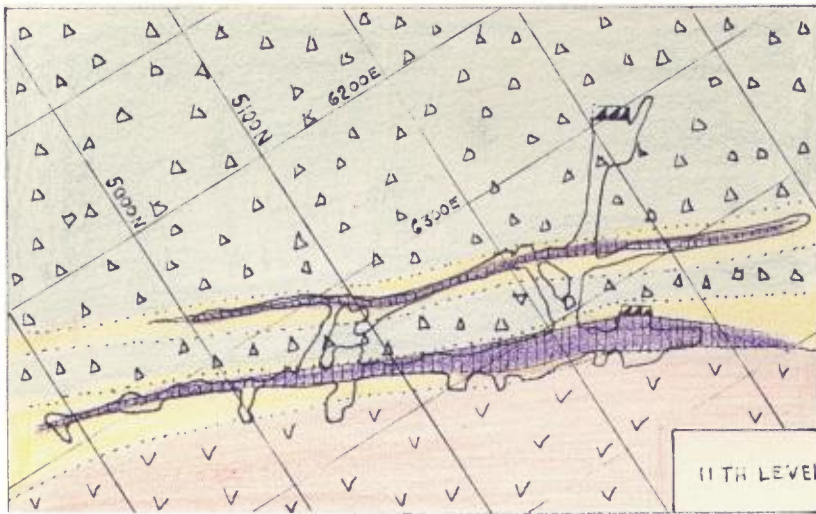
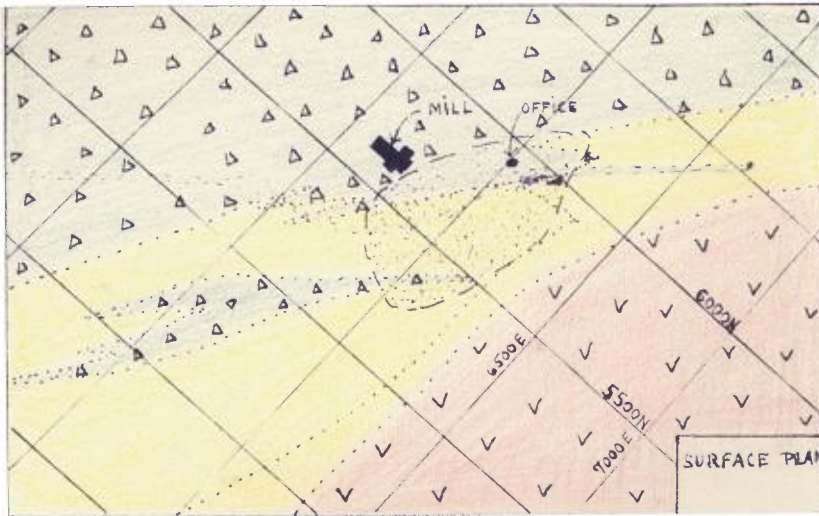
Below the 15th level, only a part of the No 2 ore zone remains. The No. 1 ore zone is replaced by abundant pockets of massive sulphides that are sporadically distributed in the granite and invaded rocks. (cf. Figure 4 on next page and geological plan No 2, appendix).

Alteration Zone - The No. 1 and No. 2 ore zones are found adjacent and locally within an alteration zone which has roughly the

FIGURE 1




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Geological Plans of the Weedon Mine





LEGEND:

DEVONIAN

-  Ore
-  Alteration zone
-  Biotite-oligoclase granite

PRE-TACONIC

-  Albite rhyolite porphyry
-  Greenstone (Weedon Schists fnt.)

Geology by: Gilles Duquette,
1958.

shape of a much flattened pipe the long axis of which lies roughly parallel to the dip of the enclosing schists. On surface the long and small axes of this zone of alteration are respectively 800 and 400 feet long (Figure 4). Within this zone, the rock has been highly altered by hydrothermal solutions from the sulphide invasion, with the development of cordierite, anthophyllite, quartz, calcite, and chlorite. This rock weathers to a very rusty, green and friable mass that shows locally relic banding. The average composition of three specimens collected from this zone, is as follows: cordierite (50%), chlorite (20%), anthophyllite (15%), quartz (10%), sulphides (4%), and sericite (1%) (Plates XCIII, XCIV, XCV).

On the 15th level, the rock of this alteration zone is everywhere well banded (Plate XCVI). Under microscope this rock consists of chlorite (35%), biotite (30%), anthophyllite (18%), cordierite (10%), pyrite and pyrrhotite (7% combined), and a minor amount of quartz and a few small grains of gahnite (Plate XCVII). Anthophyllite is normally found as needles (4mm.) that form rosettes (Plate XCVIII). Cordierite is optically positive, inclusion rich, shows polysynthetic twinning, and locally exhibits a strong yellow pleochroism. The cordierite is also very commonly altered to chlorite (Plate XCIX). The presence of cordierite as a gangue mineral at the Weedon mine is apparently here reported for the first time. Buckley (1959) who studied in detail the mineralization at the Weedon mine describes the banded rock of the alteration zone as follows (1959, p. 41 - 42) "In thin section, the central part of the dark band consists of dark green

chlorite appearing almost opaque brown under crossed nicols". And he continues: "the matrix is feldspar and quartz, with feldspar predominating. The feldspar content is much higher in this rock type than in the quartz sericite schist. The composition of the feldspars cannot optically be determined as they are too highly altered, and contain no well developed reasonably homogeneous crystals". The writer has re-examined Buckley's thin sections and is convinced that Buckley has mistaken cordierite for a plagioclase feldspar.

No.1 Ore zone - The No.1 or main ore zone was the first to be discovered and mined. It is approximately 600 feet long and averages 18 feet in width although a breadth of up to 500 feet has been reported. As previously mentioned, it strikes N. 35°E. and dips approximately 45° southeast. A sericite schist is the hanging wall whereas a chlorite schist constitutes the footwall. The sulphides are confined to the sericite schist and they become more disseminated southeastward into the hanging wall. The chloritic footwall is not mineralized. The northern limit of this zone rakes about 75° to the south whereas the southern limit follows a line which is parallel to the dip of the enclosing schists. These two limit lines meet on the 15th level.

The host rock as well as the hanging wall rock are believed to be the altered equivalent of albite rhyolite porphyry sills that have intruded greenstones (footwall) because outside the ore zone and in strike with the hanging wall the rock (quartz sericite schist) is a typical albite rhyolite porphyry, a rock which has been shown to be intrusive in the Stratford sheet-area. Close to the ore zones, the por-

phyry is highly fractured along planes that conform to the general schistosity of the region. This deformation probably originated at about the same time as the zone of rock, which has now been replaced by sulphides, was ground and milled to a mylonite. These fractures were originally filled with biotite which has since nearly all been hydrothermally altered to chlorite by the sulphide invasion. The extra iron contained in the biotite, when it was altered to chlorite, crystallized out as magnetite. Megascopically these fractures appear as fine black lines in the bluish grey rock. Within the zone of alteration, particularly on surface, the sericite schist is altered to a quartz-cordierite-anthophyllite-chlorite rock. On the lower levels this rock also carries sericite and biotite. The combined volume percentage of these two minerals nowhere exceeds 20 per cent.

The chloritic footwall rock is part of a band of greenstone which is approximately 200 feet wide and extends strikewise to the south for $\frac{1}{4}$ mile. To the north this band extends for an unknown distance because of a lack of exposures. Close to the mine but outside the alteration zone, the footwall rock is well banded and locally dragfolded. The band spacing varies from 1 to 7 mm. The light colored bands are outside the alteration zone, feldspar and quartz rich whereas the dark green bands are chlorite and actinolite rich. Within the alteration zone the rock is a quartz-cordierite-anthophyllite-chlorite-biotite rock. Banding is given by cordierite rich layers separated by chlorite, anthophyllite, biotite rich layers.

Because this banded rock, where least metamorphosed, is me-

gascopically and microscopically similar to the pillowed greenstones of the Weedon Schists formation it is inferred to be the altered equivalent of a basic volcanic flow or flows.

No.2 Ore Zone - As mentioned earlier this zone lies parallel and is about 60 feet west of the No. 1 ore zone. The No.2 ore zone is about 200 feet long on the surface and 350 feet on the 15th level. On this level, the No.2 zone lies between a granite tongue of the Mount Aylmer granite (hanging wall) and a biotite-chlorite schist (footwall rock) (Figure 4). On the 11th level, however, both wall rocks are quartz sericite schists that carry some biotite. No information could be gathered concerning the nature of the wall rock in the upper levels.

The quartz sericite schist band in which lies the No.2 ore zone, is approximately 100 feet wide and is, for the same reason as that given earlier in connection with the origin of the hanging wall rock of the No.1 ore zone, considered to be the altered equivalent of a sill or sills of albite rhyolite porphyry. Outside and in strike with the No.2 ore zone, this rock is a massive bluish grey rhyolite porphyry with quartz and albite phenocrysts. Close to the ore zone but outside the alteration zone, the porphyry is highly brecciated. The fragments are from 2 to 5 cm long and are surrounded by quartz, sericite, and disseminated sulphides. Within the ore zone the rock is extremely schistose and carries abundant quartz porphyroclasts. Flakes of sericite are seen in the matrix and are oriented in the direction of maximum shearing stress. Biotite is omnipresent but nowhere exceeds 15 per cent of the rock by volume. Needles of antho-

phyllite are also common, particularly on the lower levels.

Mineralization below the 15th Level - Below the 15th level and east of the No.2 ore zone, partly to completely biotitized inclusions of greenstone are found elongated parallel to the schistosity plane of the invaded rock. Some of the larger masses resemble large inclusions but they are actually part of the invaded rock that has been wedged off by the advancing granite.

The smaller inclusions are commonly replaced by sulphides. Where replacement is partial, the sulphides are seen in the outer part of the inclusion. The sulphides show locally a zoning structure: the outer rim of the replaced inclusion is usually made up of pyrrhotite and the inner rim of chalcopyrite. However, reversal of this order has also been seen. Massive sulphides are also present along the zone of contact of some of the larger blocks with the enclosing granite. These sulphide zones are as a rule less than 3 inches thick.

All mineralized inclusions are surrounded by a zone of alteration, the width of which varies with the size of the inclusion. For instance a pocket, one foot in diameter, of massive sulphides is surrounded by a 3 inches wide zone of alteration in the granite (Plates C, CI). Within this zone, the granite is much lighter colored. Under the microscope, the granite, in the outermost part of this zone, is seen to carry, secondary quartz that replaces in a worm-like manner the plagioclases. In this part of the zone, the quartz content of the rock may be as high as 60 per cent. In that same rock biotite is partly replaced by muscovite (Plate CII).

In the central part of this zone of alteration, biotite is completely replaced by muscovite and the amount of secondary quartz is roughly equal to that noted in the outer rim. Grains of calcite and needles of anthophyllite are found at random in the rock. The feldspars, in particular microcline, are partly replaced by cordierite (Plate CIII). Along the contact of the alteration zone with the massive sulphides, the granite is less altered than that of the middle and outer parts of the alteration zone: biotite is wholly replaced by muscovite, but the amount of secondary quartz is less high (10 per cent) (Plate CIV).

Below the 15th level, the granite carries normally 1 to 2 per cent disseminated sulphides. These sulphides have preferentially replaced biotite.

Mineralogy and Paragenesis - The sulphide minerals are at the Weedon mine: pyrite, chalcopyrite, sphalerite, pyrrhotite, and galena.

Pyrite is the most abundant sulphide, with chalcopyrite next, then sphalerite. Pyrrhotite occurs somewhat erratically in the ore lenses, but commonly as disseminated grains in the granite or as massive pockets in the mineralized inclusions. Pyrite occurs as well rounded grains surrounded by chalcopyrite and less often by sphalerite and galena. Galena is present only as disseminated grains in the ore.

The type of sulphides varies across the lens, especially in the No.2 lens. On the border of each lens, the sulphides consist of chalcopyrite and sphalerite with only the occasional well rounded pyrite grains. Closer to the center of the lens, the mineralization changes such that approximately two thirds are pyrite and one third is

chalcopyrite and sphalerite. Each lens contains similar sulphides but varies slightly in ore grade. For example ore grades, as of January 1958, were:

Main lens

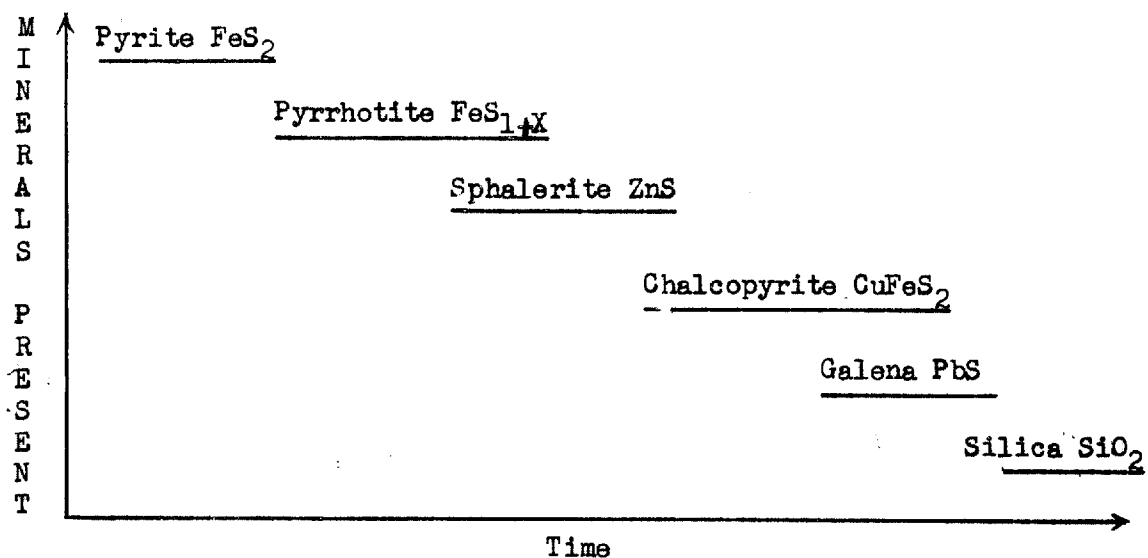
2.15% copper
32.25% sulphur
1.05% zinc

Number 2 lens

2.02% copper
20.72% sulphur
1.24% zinc

The main lens is richer in copper and sulphur but the zinc grade is lower than in the No.2 lens. Lead is also found in all assays but not in economical quantities. Gold and silver are included in the copper concentrate.

From the study of numerous polished sections, Buckley (1959, p. 75) concluded that the paragenesis of the sulphide minerals at the Weedon mine is as follows:



Origin and Age of Formation - Hunt (1850), Logan (1863), Selwyn (1877), and Ellis (1886) all agreed on considering most copper-bearing deposits of the Eastern Townships as of sedimentary origin. It was James Douglas (1870), followed by Dresser (1906) and Bancroft (1915) who first pointed out that the so-called copper-bearing beds of the Eastern Townships vary much in their width and in their copper content and should therefore be classed as "impregnations". This implies that the ores were deposited subsequently to the formation of the rocks within which they are now found.

There is no doubt that by far the majority of the copper deposits of the Eastern Townships are associated with more or less highly altered igneous rocks. A large proportion of the deposits have been formed by the irregular impregnation of the relatively more schistose bands along shear zones within the metamorphosed igneous rocks. In other instances the schists have been replaced in such a manner as to give rise to a series of lenticular bodies of ore. The Weedon ore deposit apparently falls into the latter category and is believed to be genetically related to the Mount Aylmer granite.

It seems that the more basic volcanics exposed at and close to the Weedon mine yielded to shear induced by the advancing granite by shearing along closely spaced parallel planes whereas the younger rhyolite porphyries being more competent, became mylonitized. It is believed that the sulphides were then brought up by hydrothermal solutions derived from the granite, along these shear or mylonitized zones and formed the two known ore lenses. That these mylonitic zones

were replaced by sulphide minerals is clearly indicated by the occasional occurrence of masses of unreplaced sericite schist within the massive sulphide lenses. The writer thinks that the biotitized country rock inclusions as well as the biotite crystals of the granite were also replaced by sulphides during that same period of mineralization.

The Weedon ore zones are thus considered to be the result of hydrothermal replacement of sheared rhyolite porphyry by sulphide-bearing solutions very likely derived from the nearby granite. For reasons that will be submitted later the Weedon ore body is considered to be a contact metasomatic deposit.

Bancroft (1915, p. 276) arrived at no conclusion about the genesis of the Weedon ore. Earlier, he thought the ore was genetically related to the Mount Aylmer granite. Then, he studied other mines in the area such as the Eustis (1915, p. 89) and found that these mines did not occur near any granite intrusion. This information coupled with the fact that an aplite dyke cuts the ore at the Weedon mine, led Bancroft to conclude that the ore at Weedon must be older than the granite.

Eventhough it has been found impossible to re-examine the old workings the writer is willing to accept Bancroft's evidence concerning the occurrence of an aplite dyke cutting the ore at the Weedon mine, but refutes his belief that, because of this, the period of mineralization must be older than the granite. Because of the occurrence of disseminated sulphides in the granite and because of the presence in the granite of an alteration zone around each pocket of mas-

sive sulphides, the writer thinks that the period of mineralization at the Weedon mine took place after the granite intrusion. This period of mineralization would be, however, older than the aplitic stage of injection. The age of formation of the Weedon ore body is therefore probably Middle or Upper Devonian.

Comparaison with Other Cordierite-Anthophyllite Type Deposits of the World - Cordierite and anthophyllite are thus present at the Stratford and Weedon ore deposits. Such a mineral assemblage associated with sulphides is not found elsewhere in the map-area except on lot 31 of range XI in Lingwick township where disseminated sulphides are found in a cordierite, anthophyllite, and biotite rich rock.

Outside the map-area, the occurrence of anthophyllite associated with sulphides has been reported by Stevenson (1937) who studied the mineralization of the Eustis mine found in the Stoke schists belt, near Sherbrooke. From Stevenson's description, anthophyllite appears to be of metamorphic origin since it is seen only where the sulphides have been heated up by the intrusion of a dyke of camptonite. It is nevertheless worth mentioning since the Stoke schists are considered to be correlative of the Weedon schists. The writer is not aware of the occurrence of cordierite or anthophyllite as gangue minerals in any other deposits of the Canadian Appalachians.

Elsewhere in the province of Quebec, cordierite and anthophyllite are found at the Montauban mineralized zone which has been described by Osborne (1939, p. 712) as a sulphide deposit found in Grenville paragneiss and which has sphalerite, galena, chalcop-

rite, pyrite and sulphides of iron with a gangue of skarn or cordierite and anthophyllite. Osborne mentions that the skarn is developed near or in limestones and passes by a series of transitional mineral associations into a cordierite-anthophyllite rock developed in the absence of limestone.

Wilson (1935) and Copeland (1951) also report the occurrence of cordierite and anthophyllite in the Keewatin metavolcanics of the Amulet mine area of the Noranda district. The cordierite-anthophyllite-bearing rock is called dalmationite by Wilson and is found close to or adjacent to the sulphide deposits of that area.

Bray (1929), after a petrographic study of certain cordierite-bearing metavolcanics of the Gull Lake area of north central Newfoundland, concluded that cordierite and a so-called colorless actinolite (anthophyllite?) are everywhere found in close association with sulphide deposits.

South of the U.S. border, copper and pyrite ores, found in the Ellsworth schists exposed near Blue Hill, Maine, have been described by Lindgren (1933, p. 745) as being accompanied by a considerable amount of quartz and cordierite.

Gillson (1929) reported the occurrence of cordierite and anthophyllite in the Manhattan schists of the Peekskill emery deposit of the New York state.

The last two deposits are considered by Lindgren as contact metasomatic deposits.

In all the above localities as well as at the Weedon mine, the anthophyllite and cordierite-bearing rock has a very high MgO

content regardless of the original composition of the rock. Because of this, most writers agree on considering this rock as a metasomatic rock that has, on a large scale, been enriched in MgO.

Tilley (1935) who studied the greenstone-hornfels of Kenidjack and Botallac area, Cornwall, came to the same conclusion. He believes that prior to metamorphism, the greenstones of that area had been subject to shearing and dynamic metamorphism so that banded types are prevalent among them. Then, according to Tilley, alteration took place in the greenstone which became richer in MgO and poorer in CaO than the original greenstone. As suggested by Tilley himself, this type of alteration cannot be explained by a chemical weathering process since one of the characteristic features of the analyses of weathered basaltic rocks is the low content of magnesia and lime they show. Tilley therefore concludes that the process is in reality one of contact metasomatism. He believes that the greenstones have suffered this loss of lime and have been enriched in MgO during the period of contact alteration as a result of the passage of solutions derived from granitic magma, solutions which eventually gave rise to the rich tin and copper deposits which characterize the Botallac area.

The writer feels convinced that the greenstones and rhyolite porphyries of the Weedon mine area, have been, like the greenstones of the Botallac area, first subject to shearing, were then locally altered by MgO rich hydrothermal solutions given off by the cooling granite, and were later replaced by sulphides brought in by solutions that had been derived from the same granitic magma.

Because of its proximity to the Mount Aylmer granite and because of the occurrence of cordierite and anthophyllite as gangue minerals, the Weedon ore body is like most of the above deposits considered to be a contact metasomatic deposit or, as defined by Bateman (1956), a pyrometasomatic type of deposit.

Solbec Copper Mine

Location - The present Solbec Copper Mines property is $1\frac{1}{2}$ mile north of the village of Stratford in the township of Stratford, Wolfe Co., and comprises lots 30 to 45 in range II S.W., lots 30 to 40 in range I S.W. and I N.E., and lots 30 to 36 in range II N.E. The shaft is 2300 feet north of range line I S.W. - II S.W., and is 200 feet east of lot line 34 - 35.

History - Following a ground E - M survey completed in September 1957 by the Hastings Mining and Development Co. over a group of claims located north of the village of Stratford, the Cyprus Exploration Corp. financed a diamond drilling program to test an E - M anomaly picked up on lot 34 of range I S.W. and which coincide with a strong magnetic anomaly shown on the airborne magnetometer survey map (156G) published by the Geological Survey of Canada.

The drilling program started in mid-January 1958. By fall of 1959, twenty-one diamond drill holes had been completed. The occurrence of a lens-shaped ore body of massive sulphides was clearly indicated from drill cores. It was estimated, at that time, that drilling indicated 643,800 tons to a vertical depth of 500 feet. It was also

reported that grade was 2.6 per cent copper, 3.41 per cent zinc, 0.02 ounce of gold per ton, and 1.55 ounces of silver per ton.

Early in spring of 1960, East Sullivan Mines jointly with Sullivan Consolidated Mines and Quebec Lithium, took control over the Hastings property. The Sullivan group formed a new company which they named the Solbec Copper Mines Ltd, a wholly owned subsidiary of the Hastings Mining and Development Co. Hastings, is in turn, controlled by the Sullivan group which is financing the project. The Sullivan group controls 84% of Hastings with the East Sullivan Mines having 42%, Sullivan Consolidated Mines 16.8% and Quebec Lithium 25.2% in the participation.

Additional drilling was done by Solbec in spring and summertime of 1960. By mid-October of that same year, a total of 63 holes had been drilled over the original discovery ground. Although actual tonnage figures were not released by mine officials it is estimated to be in the neighborhood of 1,500,000 tons grading 2.15 per cent copper, 3.9 per cent zinc, 1.2 ounces of silver per ton and 0.015 ounce of gold per ton. In September 1960 shaft sinking got under way (Plate CV). It is planned to go to a depth of 1400 feet, and expected to be completed by the end of May 1961. Plans are made for a 1000 tons a day operation. In October 1960 many of the mine and auxiliary buildings were already covered and a permanent office and warehouse were soon to be ready for occupancy.

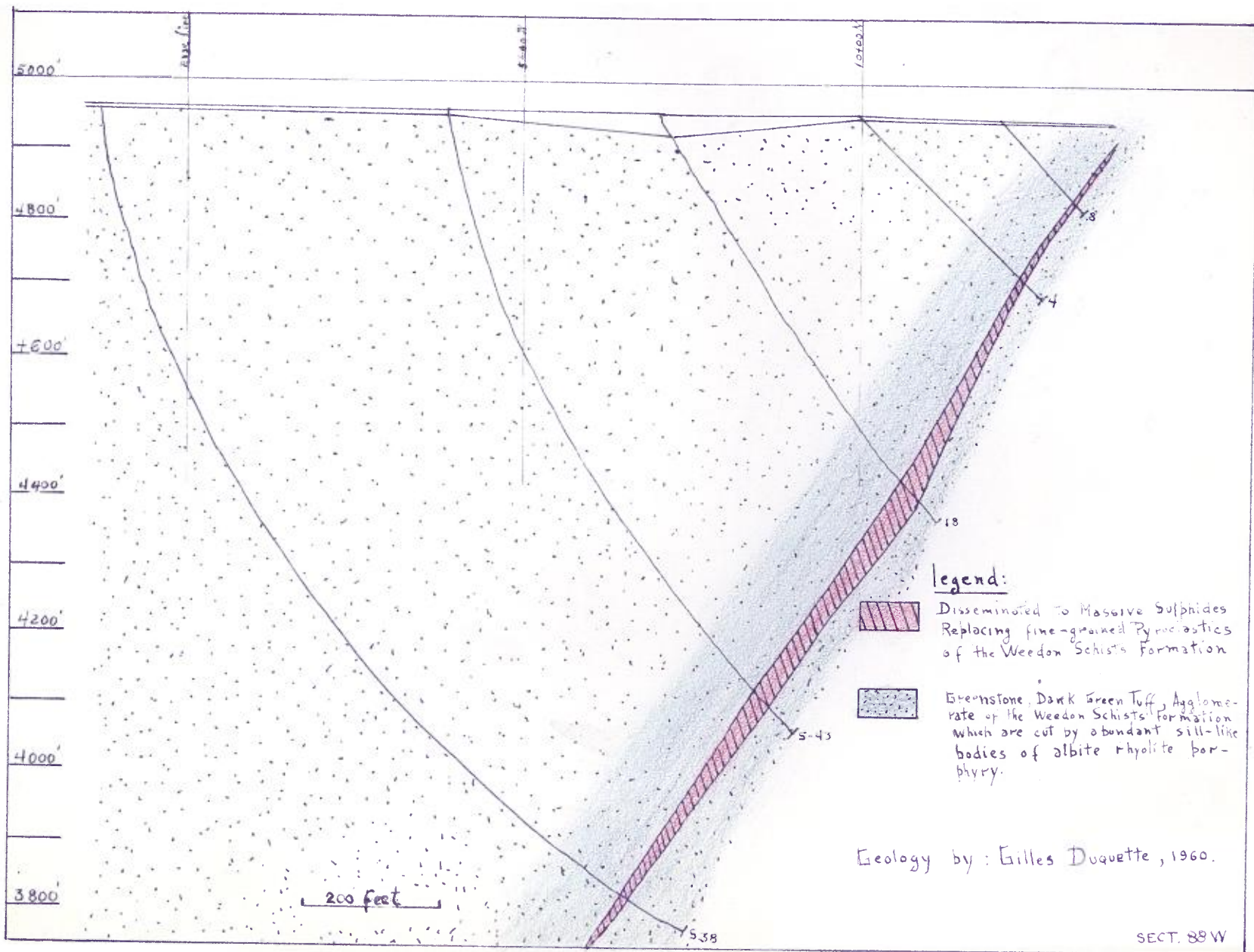
Geology - The Solbec sulphide lens occurs in a sericitic pyroclastic band associated with greenstones (northern segment) of

the Weedon Schists formation. The lens would, by up dip projection, crop out along the eastern part of lot 34 in range I S.W. It lies parallel to the local bedding and schistosity, striking N. 40°E. and dipping 45° southeast. Mineralization has locally followed three subparallel zones separated from one another by a two foot thick layer of barren chlorite schist. Under the microscope the rock is seen to consist of dark layers (1 - 2 mm) made up almost exclusively of chlorite and which are interlaminated with light colored bands (3 - 4 mm) that consist of quartz and ankeritic dolomite.

The lens is approximately 1500 feet long and has a maximum width of 25 feet. The lens extends from surface to the 1000 foot level where it apparently pinches out (Figure 2). The contact of this massive sulphide lens with the chloritic footwall is everywhere quite sharp. From regional mapping, the host rock of the sulphides appears to be a band of fine-grained pyroclastics represented mostly by crystal tuffs. The host rocks are meta-greenstones. The mineralized band of pyroclastics nowhere exceeds 40 feet in thickness. In general only the bottom part of this band has been highly replaced. The poorly mineralized upper part of this band represents the hanging wall rock but in some rare instances, such as where the pyroclastic band is only a few feet thick, the hanging wall rock is a banded greenstone that also carries disseminated sulphides. Disseminated sulphides are found in the hanging wall rock up to a distance of 50 feet from the sulphide lens. In the footwall rock section, the chlorite schist adjacent to the ore zone shows a distinct banding and is identical

Figure 2

Cross-section of the Solbec Copper Mine Orebody.



to the banded chlorite schist found as horses in the overlying sulphide lens. Farther below from the ore body, the rocks are mostly greenstones. The greenstones of both the footwall and hanging wall sections are commonly cut by sill-like bodies of albite rhyolite porphyry of the Weedon intrusive series. This porphyry is blue, grey or green and is locally found one foot below the sulphide lens. This intrusive rock is as a rule highly fractured and rarely carries disseminated grains of sulphides.

Mineralogy - The ore is massive to semi-massive and is made up of sulphides that are by order of decreasing abundance: pyrite, sphalerite, chalcopyrite, galena, and a few small grains of the tetrahedrite-tennantite series. Pyrite is granular (0.02 mm - 8 mm) and brass yellow. Pyrite is clearly the first sulphide mineral to have crystallized and is replaced by all other sulphides.

The paragenis of the sulphide minerals of the Solbec mine is being studied by Jean Lacasse (personal communication to the writer) at Laval University. Results of this work will be submitted in a forthcoming (1962) M.Sc. thesis.

From a study under the microscope of 5 specimens collected from the ore body, the hanging wall, and the footwall rocks, the following gangue minerals have been identified: quartz, sericite, barite, chlorite, and ankeritic dolomite. Quartz and sericite are by far the most abundant gangue minerals. Dolomite is present only in the banded greenstone. Barite is seen in the hanging wall rock and in the sulphide lens. Chlorite has a small 2V angle, is optically positive and is, in part at least, of the penninite variety.

Comparison with Other Pyritic Copper Deposits of the Canadian Appalachians - The geology of the Solbec ore body is remarkably similar to that of the Aldermac Moulton Hill, Eustis, and Suffield deposits, near Sherbrooke and the Buchans deposits of Newfoundland.

Hawley (1945), who studied the mineralization at the Aldermac Moulton Hill deposit, reports that the hypogene minerals are by order of deposition: pyrite, chalcopyrite, tennantite, galena, sphalerite, gold, barite, quartz, and carbonate. These minerals have replaced sericitic and schistose metavolcanics interbedded with greenstones of the Stoke schists belt. According to Hawley (p. 397): "The ore gives no indication of having been formed at a very high temperature and is contained and replaces white mica schists; there has been no pronounced wall rock alteration, except for the possible development of some chlorite along the footwall".

After a detailed study of the mineralization and metamorphism at the Eustis Mine of Québec, Stevenson (1935), p. 335) reports that: "The ore bodies consist of four large pyrite-chalcopyrite lenses arranged en échelon and extending down the dip of the enclosing schists at a greater depth than 6,500 feet". He also reports that the sulphide minerals are by order of deposition: arsenopyrite, pyrite, sphalerite, tetrahedrite, tennantite, chalcopyrite, and galena and the gangue minerals are by order of abundance, quartz, ankerite, muscovite and chlorite (diabandite). Stevenson considers (p. 357) that: "The ore bodies of Eustis present features indicating that they were formed from hydrothermal solutions and not from aqueo-igneous melts".

Carrière (1954) who has described in detail the geology of the Suffield mine reports (p. 65): "the ore of the Suffield mine occurs as replacement massive in the porphyritic rhyolite and is found mainly in sheared and brecciated zones". The paragenesis of the sulphide minerals is, according to Carrière: pyrite, sphalerite, chalcopyrite, galena, and tetrahedrite. Quartz, chlorite, sericite, and ankeritic carbonate are listed as gangue minerals. Following Lindgren's classification of ore deposits, Carrière considers the Suffield ore deposit as a mesothermal deposit.

A description of the geology of the Buchans sulphide deposits of Newfoundland has been given by Newhouse in 1931. He reports that schistose and sericitic tuffs interbedded with basic metavolcanics of the Buchans series of inferred pre-Carboniferous age, have locally been replaced by sulphides. The ore is reported to be a massive intimate mixture of fine-grained sulphides which are by order of deposition; pyrite, sphalerite, chalcopyrite, galena, and very little tetrahedrite. By order of abundance the gangue minerals are reported to be: barite, quartz, and calcite. Newhouse concluded (p. 414) that: "The mineralization at Buchans belongs to the mesothermal type of deposit".

Obviously all the above deposits, as well as the Solbec ore body, are mineralogically and genetically very much alike. Indeed, they are all made up of the same sulphide and gangue minerals and are all believed to have been formed under similar conditions of temperature and pressure. Moreover the host rock of all these deposits, is either a schistose pyroclastic or a highly fractured rhyolite porphyry.

Origin and Age of Formation - The ore, at Solbec, was clearly introduced after the last period of deformation (Acadian) which affected the rocks of the area since the grains of sulphide are apparently not cracked or deformed. The reason for deposition of the ore along the contact between acidic pyroclastics and a greenstone band may be best explained by the development of a shear zone along this contact and later used as a channelway by the sulphide bearing-solutions. The reason for the marked replacement of acidic pyroclastics as compared with greenstone is probably due to a greater permeability of the solution in the pyroclastic rock. It may also be due to the chemical character of that same rock. It is a well known fact that some rocks are unquestionably more congenial hosts to ore than others, and often for no observable reasons.

It is believed that the Solbec ore body belongs to the category of mesothermal deposits, as defined by Lindgren (1929). Support to this idea is, in a large part, given by the marked analogy of the Solbec ore body to the Moulton Hill, Eustis, Suffield, and Buchans deposits. These deposits have all been described as mesothermal.

It has been mentioned earlier that the period of mineralization at the Solbec mine appears to be younger than the Acadian orogeny. Because of this, the only intrusions to which the Solbec mineralization can be genetically related, are the Mount Aylmer and Winslow granites which have been shown to be of post-Acadian age (probably Late Devonian). Hence, the Solbec ore body appears to be contemporaneous with the Weedon and Stratford deposits.

Hastings - Sullivan Copper - Zinc Deposit.

Location - This deposit is found on lot 4 and 5 of range VI S.W. in Stratford township, 13000 feet south and in strike with the Solbec Copper Mine ore body, that is, 1 mile southwest of the village of Stratford.

History - Following the discovery of the Solbec ore body by the Cyprus Exploration Co. in 1958, heavy staking was done during the winter of that same year, all over the Weedon schists belt exposed in the Stratford and Lake Aylmer areas. Agreement was reached at that time that part of the open ground, south of what is now called the Solbec property, would be staked jointly by the Cyprus Exploration Co. and the Hastings Mining and Development Co. Following staking, a ground E. - M. survey was run over this jointly staked property by the same companies. At the same time, the Sullivan group was also running a E.- M. survey over a group of claims, south and adjacent to the Cyprus-Hastings ground. E.-M. anomalies were found by the Sullivan group over lot 5 in range VI S.W. of Stratford township. Some of these anomalies were later traced north over lot 4 of the same range, by the Cyprus and Hastings companies. Part of the anomalies were thus extending across the boundary line of these two properties.

In winter 1959, drilling was started by the Sullivan group on lot 5. The Sullivan group, after having taken option on the Cyprus-Hastings ground, extended their drilling program northward over lot 4. By fall 1960, 30 holes had been completed on lots 4 and 5 of range VI S.W. and had disclosed the occurrence of a major copper-zinc sulphide deposit. It was estimated at that time that more than 500,000 tons of

ore had been indicated by drilling. It was also reported that the grade in copper is higher and the zinc content lower than those of the Solbec ore body.

It was rumored at that time that shaft sinking would be started as soon as the shaft sinking operation had been completed on the Solbec property.

Geology - The sulphide lens is about 600 feet long and has a maximum width of 15 feet. It lies parallel to the local schistosity which strikes N. 40°E. and dips 45° southeast. The long axis of the sulphide lens lies parallel to the dip of the enclosing schists and apparently extends below the 1200 foot level. The sulphides have replaced a fine-grained pyroclastic band of the Weedon Schists formation. Abundant hor- ses of poorly mineralized pyroclastics are found within the ore zone. The wall rocks are schistose and sericite rich pyroclastics that show graded bedding with tops facing to the southeast. Disseminated grains of sulphide, mostly pyrite, are found in both wall rock sections up to a distance of 40 feet from the ore zone. Some of the pyroclastic beds of the hanging wall rock section have been stained black by carbon which is believed to be of hydrothermal origin. A 2 to 10 foot thick band of greenstone is seen 30 to 40 feet below the ore zone. This greenstone is well banded and is very similar to the footwall rock of the Solbec ore body. The hanging wall and footwall rocks are commonly cut by sill-like bodies of albite rhyolite porphyry of the Weedon intrusive series. This porphyry is blue, grey or green and where brecciated, carries disseminated grains of sulphides.

Mineralogy - The ore is fine-grained massive to semi-massive. The sulphides are by order of abundance, pyrite, sphalerite, chalcopyrite, bornite, galena and possibly tetrahedrite or tennantite. Silver and gold are present. Pyrite is granular (0.1 - 1 mm), brass yellow and clearly the first sulphide mineral to have crystallized. The following gangue minerals have been identified under the microscope: quartz, sericite, barite, chlorite (+2V) and ankeritic dolomite. The last minerals were seen only in the greenstone band of the footwall rock section. All other minerals are found in or close to the ore zone. The original and unreplaced plagioclase crystals (Albite) of the pyroclastics are in the ore zone characteristically altered to clay minerals at their periphery.

Origin and Age of Formation - This deposit is mineralogically similar to the Solbec ore body. With the exception of bornite, the sulphide and gangue minerals are the same. The host rock is also the same and the shape of these two ore bodies is similarly lenticular. Lastly, as mentioned earlier, the Solbec and Hastings-Sullivan deposits, are found in strike with each other and only 13000 feet apart from one another.

It is therefore reasonable to conclude that the origin and age of formation of the Hastings-Sullivan copper-zinc ore body are the same as those suggested previously for the Solbec deposit.

Other Sulphide Occurrences

The metavolcanics of the Weedon Schists formation very commonly contain disseminated sulphides of iron, zinc, and copper. Here is a list of the most important localities where disseminated sulphides have been found:

On lot 20 in range II of Weedon township, stringers of pyrite with traces of copper are found along a shear zone in a greenstone band. This occurrence is in strike and 4,000 feet south of the Weedon ore body.

On lot 31 in range XI of Lingwick township, a mineralized shear zone has been mapped as striking N. 40°E. and dipping 50° east. The analysis of a grab sample yields 0.36 per cent copper and 0.01 per cent zinc. Under the microscope the same specimen is seen to carry approximately 65 per cent cordierite, 30 per cent biotite, and 1 to 2 per cent anthophyllite.

Disseminated grains of pyrite were seen at the contact of acidic pyroclastics with basic volcanic rocks in lot 38 of range X in Lingwick township.

On lot 4b, in range F of Lingwick township, east of the road to Fontainebleau, a rusty zone in a quartz sericite schist can be traced for more than 1000 feet. The zone is about 20 feet wide and carries from 5 to 10 per cent pyrite.

On lot 26-a, in range X of the same township, 250 feet north of the lot line 25-26 and 2000 feet east of the range line X and XI, two pits were dug out in silicified and very slightly mineralized with pyrite acidic pyroclastic rocks. The two pits are 100 feet apart and are about 8 by 12 with a maximum depth of 6 feet.

In the same township, on lot 26b, 150 feet from the lot line 26-27 and 1700 feet from the range line IX-X, another pit, similar in size to the above ones, was found in the same kind of rock. Here again some pyrite was found.

On the lots 27-a and 27-b, at 800 feet from the range line IX-X, of the same township, another similar occurrence of pyrite mineralization can be seen on the walls of an old pit which was almost completely filled up at the time of our visit.

Other very similar pits can also be examined on lot 28. Two of them are 100 feet from the lot line 27-b and 28 and 800 from the range line IX-X and a third one is 600 feet from the lot line 28-29 and 1400' from the same range line.

All those pits were made before 1955 by Jean Fortier and his sister whose address is Gould, Lingwick township.

In all the pits, the pyrite content is always very low and the mineralized rocks are everywhere silicified acidic pyroclastics.

In March 1959, Terra Nova Explorations Ltd, drilled two holes on Lot 3 of range E in Lingwick township in order to check some ground E.-M. anomalies. Drilling disclosed that granite rich silty limestone beds were giving the observed E.M. anomaly.

In the Stratford map-area, sheared greenstones containing about 10 per cent pyrite and traces of sphalerite occur on lot 30 in range II S.W. of Stratford township.

In strike with the Stratford pyrite deposit, in range VI S.W. of Stratford township, there are abundant mineralized patches, 5 to 30 feet long and 5 to 6 inches wide. The sulphides are pyrite and pyrrhotite with traces of sphalerite.

On lot line 4 - 5 in range V S.W. of Stratford township, 700 feet east of the line that divides longitudinally and in two equal parts

range V S.W., a 6 inch thick band of massive chalcopyrite and pyrrhotite was drill-intersected by the Sullivan group in 1959. The host rock is a quartz biotite rich rock associated with schistose, acidic, and fine-grained pyroclastics of the Weedon Schists formation.

A small exploration pit was found on lot 10 in Range VI S.W., 400. north of Range line Vi-VII S.W. in Stratford township. Some pyrite was seen in the same kind of rock as the mineralized rock at the old Stratford Pyrite mine.

A 10x10 feet pit was also examined on lot 9 in Range VII S.W. of Stratford township close to Range line VI-VII S.W. Here the mineralization and host rock is identical to the above one.

A similar pit was found on lot 8 in Range VII S.W. of Stratford township, approximately 700 feet Northeast of the former one. The host rock and mineralization is again the same as above but the hanging-wall rock is a biotite-muscovite granite of the Stanstead type.

At approximately 150 feet south of the above location, another pit was examined. The opening is 10 feet by 10 feet and it follows downward the line of dip which is 70° to the southeast. The rock was too highly rusty in order to establish the type of rock that had been mineralized.

On the same lot, 100 south of the former locality, a 100 feet long trench was dug out across strike. No mineralization was seen in the dump. The trench is cutting through hornfel rocks of the St. Francis group.

On lot 5 of range VII S.W. in Stratford township, 200 feet west of the road going to Mount Aylmer, a small pit was seen. Stringers

of pyrite are found in a highly schistose, sericitic and chloritic metasedimentary rock that belongs to the St. Francis group. The veinlets strike parallel to the enclosing schist that is N. 45°E. dipping 60° to the southeast. The pit is approximately 20 feet deep.

Non Metallic Deposits

Sand and Gravel Pits

In all, 12 sand and gravel pits have been exploited in the map-area. Seven out those 12 pits are found along the Salmon river valley, two, west of the village of Fontainebleau, one, along lot line 18 - 19 of range IV S.W. in Stratford township, and the remaining two just south of the village of Stratford.

The size of those pits is variable: some are less than 300 feet across, others are about 1000 feet in diameter. A description of this unconsolidated material has previously been given in the chapter dealing with the Pleistocene geology, and will not be repeated.

The material is used locally for road building and other purposes.

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