# RG 065(A)

MONTAUBAN-LES-MINES AREA, ELECTORAL DISTRICT OF PORTNEUF

**PROVINCE OF QUEBEC, CANADA**

**Department of Mines**

Honourable W.M. COTTINGHAM, Minister — A.-O. DUFRESNE, Deputy Minister

**MINERAL DEPOSITS BRANCH**

**BERTRAND-T. DENIS, Chief**

## GEOLOGICAL REPORT 65

# MONTAUBAN-LES-MINES AREA

## ELECTORAL DISTRICT

## OF

## PORTNEUF

by

J. R. Smith

QUEBEC

REDEMPTI PARADIS

PRINTER TO HER MAJESTY THE QUEEN

1956

# TABLE OF CONTENTS

## MAP AND ILLUSTRATION



---

# MONTAUBAN-LES-MINES AREA

## PORTNEUF COUNTY

by

J.R. Smith

---

## INTRODUCTION

### General Statement

During the field season of 1949, the writer mapped the geology of an area surrounding the village of Montauban-les-Mines. Further information on recent developments in the area was obtained during a subsequent visit, May 29 to June 6, 1952. Zinc and lead have been produced intermittently in the area since 1913, wholly from a property known as the Tétreault mine at Montauban-les-Mines. Interest in the area has revived since Anacon Lead Mines Limited acquired the Tétreault property in 1948, and put the mine into steady production.

### Extent, Location, and Access

The area mapped is 22 square miles, covering parts of Chavigny and Montauban townships and Grondines West seigneury, Portneuf county. The southeast corner of the area is 52 miles west of Quebec City. A branch line of the Canadian National Railways joining Rivière-à-Pierre and Hervey Junction passes through the northern part of the area. The main road in the area, from Notre-Dame-des-Anges to Montauban-les-Mines, continues south to St. Casimir, which is joined by several roads to the Quebec-Montreal highway.

### Physiography

The bedrock topography of the area is typical of the Canadian shield, but it has been modified by Pleistocene deposits. The main topographic features are rocky ridges trending north-south, parallel to the prevailing structure of the bedrock. The highest ridges are 750 to 800 feet above sea level. Viewed from a ridge summit, the skyline is flat and even, defining the surface of an old peneplane which slopes gently southwestward to disappear beneath Palaeozoic strata of the St. Lawrence lowlands.

A large north-south valley occupies part of the east half of the area. The Batiscan river flows south in this valley to the centre of the area, where it turns sharply westward to cut through a ridge of gneisses at a cataract called No. 8 falls. South of the bend in the Batiscan river, the large valley is occupied only by the small, underfit Charest river and its tributaries.

The valleys of the area are partially filled with stratified Pleistocene deposits. The Batiscan river, in cutting its channel through these deposits, has formed a series of valley terraces. Remnants of the highest of these terraces are 130 feet above the present level of the river (1, p.107). Extensive flat areas lie on the lower terraces. South of the bend in the Batiscan river, the Pleistocene deposits form a flat, unterraced floor in the main valley. The terraces no doubt originated during post-glacial uplift of the land, when the Batiscan river was able to entrench itself at successively lower levels in the sediments which it had previously deposited.

## Field Work

A base map at a scale of 1 inch equals 400 feet was prepared by the writer from vertical aerial photographs belonging to Anacon Lead Mines Limited. The accompanying map, No.1095, is at a scale of 1 inch equals 1,000 feet. The aerial photographs were used, where possible, to locate outcrops in the field. The wooded parts of the area, where there are few landmarks which can be recognized on the photographs, were traversed by pace and compass at 400-foot intervals.

## Acknowledgments

The writer is indebted to Anacon Lead Mines Limited for the use of their facilities and aerial photographs; to the officials of the company, particularly S.E. Malouf, who rendered much aid and advice; and to J.D. Bie, who acted efficiently as field assistant and did part of the mapping. Records in the files of the Quebec Department of Mines were freely consulted in the preparation of this report.

## Previous Work

The first published report on the area was written by Ells in 1898 (2). Since then, reports on the area have been prepared by Uglow (3), Bancroft (1), the staff of British Metal Corporation (Canada)

---

(1) References are at the end of the report.

Ltd. (4), Alcock (5), Osborne (6), O'Neill and Osborne (7), Wilson (8), and Smith (9).

## GENERAL GEOLOGY

### General Statement

The oldest rocks of the area are highly metamorphosed metasedimentary rocks of Grenville age. They are now paragneisses and composite gneisses, but were once clastic sediments. Several layers of massive quartzite are interbedded with the paragneisses. Limestone is exposed in only two layers, one of which is the host rock for part of the zinc-lead orebodies at Montauban-les-Mines. Hornblende gneisses of uncertain origin occur in large masses which are structurally concordant with the paragneisses.

There has been much igneous activity in the area. Dykes, now altered to amphibolite, cut the metasedimentary rocks and composite gneisses near the ore zone at Montauban-les-Mines. A stock of quartz diorite orthogneiss underlies the northwestern part of the area, and the western contact of a large stock of similar composition lies near the east boundary of the sheet. Dykes and sills of granite, aplite and pegmatite which intrude the Grenville rocks are possibly related in origin to the stocks. The composition of certain paragneisses and limestone has been changed by metasomatism and by later hydrothermal activity associated with ore deposition.

Most of the rocks have some degree of schistosity which, in the paragneisses and quartzite, is commonly parallel to the bedding. The more schistose paragneisses are intricately drag-folded and distorted, but larger scale folding is thought to be relatively open. No faults were defined by the mapping.

Table of Formations

| | | |
|---|---|---|
| | Pleistocene | Stratified sands and clays |
| Unconformity | | |
| PRECAMBRIAN | ? | Pegmatite |
| | | Granite, aplite |
| | | Quartz diorite |
| | Intrusive Contact | |
| | ? | Amphibolite |
| | Intrusive Contact | |
| | Grenville Series | Composite gneiss, hornblende gneiss, paragneisses, limestone, quartzite |

## Grenville Series

### Biotite Paragneiss

Quartzose biotite paragneiss, derived from greywacke and impure quartzite, underlies a large part of the area. It makes up the greatest part of the Grenville series in the area, the other members occurring for the most part as interlayers within it. In most exposures this rock-type is fine grained, schistose, and well layered. Oxidation of disseminated sulphides has resulted in deep rusty weathering. The essential constituents are quartz, oligoclase, microcline, biotite, and muscovite. In minor layers, the micas are the most abundant constituents of the rock, in which case it grades toward mica schist. Accessory constituents, not present in all specimens are, in order of abundance, pyrrhotite, pyrite, epidote, apatite, garnet, zircon, and chlorite. Where the tenor of feldspar is high, the rock has a granitic appearance, but commonly its quartzose and banded nature serve to distinguish it from granite and aplite sills which are numerous in the area.

### Garnet-Biotite Paragneiss

Garnet-biotite paragneiss occurs interlayered with biotite paragneiss in many parts of the area. Most of the garnet-rich layers are less than a foot thick and are so erratically distributed in the biotite paragneiss that they cannot be mapped separately. All such layers are parallel to the schistosity. In some places, porphyroblasts of red garnet up to 1/4 inch in diameter stand out on the weathered surface, but normally the garnets are small, and close examination of a fresh surface with the hand lens is necessary to detect them. As is the case with biotite paragneiss, some layers of garnet-biotite paragneiss contain much mica, and grade toward mica schist. Some layers of garnet-biotite paragneiss contain only minor amounts of feldspar, and must have been derived from more argillaceous sediments than the feldspar-rich types which are more common. One specimen of feldspar-poor garnet-biotite paragneiss studied in thin section consists essentially of garnet, biotite, quartz, and sillimanite, with accessory staurolite, plagioclase, magnetite, apatite, epidote, and chlorite.

Sillimanite-bearing Paragneiss

A band of nodular sillimanite paragneiss crops out along the western slope of a ridge on lots 41, 42, and 45, range I, Montauban township. It has a maximum width of 200 feet, and is about 300 feet west of the Montauban ore zone. The weathered surface of the paragneiss is characterized by abundant white nodules up to 2 inches long and 1/2 inch thick, in a dark micaceous matrix. The nodules are made up of mosaics of quartz grains penetrated by needles of sillimanite, some of which are aggregated in radiating sheaves, or profusely scattered in random directions. The groundmass consists of quartz, untwinned plagioclase ($An_{30}$), biotite, and small amounts of sillimanite, zircon, and apatite. An exposure of somewhat similar gneiss close to the road on lot 10, range I, S.W., Chavigny township, suggests that a narrow band of the rock follows the footwall contact of a band of limestone. The sillimanite in this band of gneiss is in clots up to 1/2 inch in diameter. In hand specimens the clots are milky white, with a subvitreous lustre. They cannot be scratched with a knife, and show no cleavage, so that they are easily mistaken for quartz. In thin section, however, the clots are seen to consist of densely packed needles of sillimanite having a hair-brown colour by transmitted light. The centres of the clots, where the needles are parallel, give biaxial positive interference figures. Near the borders of the clots, the sillimanite needles fray out and penetrate the minerals of the matrix. The matrix is schistose, and consists of a mosaic of quartz and flakes of brown biotite with poorly developed orientation. A little feldspar can be detected in hand specimens, but is not present in the thin section studied.

A thin section of a specimen from a thin nodular band in biotite paragneiss, from the central part of lot 32, range II, Montauban township, contains 60 per cent quartz, 15 per cent oligoclase ($An_{25}$), 10 per cent biotite, 10 per cent sillimanite, 5 per cent muscovite, and a trace of apatite. The sillimanite needles are packed into white clots. The individual needles are roughly parallel to the biotite flakes and the schistosity, but the long directions of some of the clots are inclined to the schistosity. Such sillimanite paragneiss is interlayered with other types of paragneiss and quartzite in many parts of the area, but the layers are thin and constitute only a small part of the meta-sedimentary rocks.

Other Types of Paragneiss

A layer of garnet-biotite paragneiss in the northwestern parts of lots 15 and 16, range IV, S.W., Montauban township, contains abundant ellipsoidal green nodules with a maximum diameter of 4 inches. The nodules are medium-grained aggregates of epidote, quartz, and green hornblende, with minor amounts of andesine ($An_{41}$), scapolite, and zoisite, and traces of biotite, apatite, magnetite or ilmenite, and leucoxene. The shape and the lime-rich composition of the nodules suggest that they are derived from calcareous concretions in the original sediment.

Paragneisses in the Montauban ore zone are in part altered to medium to coarse grained, massive aggregates of anthophyllite and cordierite, and to coarse mica schists with or without cordierite, anthophyllite, garnet, and numerous other minerals which are fully described by Wilson (8, pp.64-92). These paragneisses are designated on the accompanying map as "metasomatized paragneiss". The metasomatism was no doubt part of the cycle of hydrothermal activity which resulted in the deposition of metallic minerals, since it is confined to the immediate vicinity of the ore zone.

## Origin of the Paragneisses

The diverse rock-types described above have been grouped as one map-unit, paragneiss, a term used for gneiss of sedimentary origin, as opposed to orthogneiss which is of igneous origin. The data which led to the conclusion that the gneisses are of sedimentary origin are here summarized.

The composition of three rock-types in the area leave no doubt of their sedimentary origin: quartzite, sillimanite paragneiss, and crystalline limestone are derived from sandstone, shale, and limestone, respectively. The following criteria convince the writer that biotite paragneiss and garnet-biotite paragneiss are also of sedimentary origin:

1. They are intimately interlayered with quartzite in many places in the area, and pass into quartzite along strike. The contacts between paragneiss and quartzite are in places gradational.

2. Layers of sillimanite paragneiss are parallel to schistosity and layering in the biotite paragneiss, as are layers of garnet-biotite paragneiss. The alternation of layers is suggestive of sedimentary beds originally of different composition.

3. The garnet-biotite paragneiss and biotite paragneiss contain more quartz than common igneous rocks.

4. The most probable explanation of the presence of garnet in garnet-biotite paragneiss is that it formed from argillaceous sedimentary material.

A sedimentary rock of the composition of the garnet-biotite paragneiss and biotite paragneiss would be a greywacke containing subordinate argillaceous material which yielded the micas, and in some beds garnet, during metamorphism. Products of more mature weathering were interbedded with the greywacke, and are now represented by quartzite, sillimanite paragneiss and crystalline limestone.

Quartzite

A band of quartzite with a maximum width of 450 feet borders the quartz diorite intrusive near the east boundary of the map-area. Bedding planes and colour banding are visible in some exposures. The purest quartzites are massive and white on the weathered surface, but less pure types contain mica flakes, which, being roughly oriented in planes parallel to the bedding, impart a schistosity to the rock. Some layers of mica schist and of paragneiss, representing argillaceous material deposited with the sand, are commonly interbedded with the quartzite. Near the contacts of the quartzite band, the argillaceous layers are more abundant, the quartzite thus grading into paragneiss.

A thin section of a specimen of massive quartzite from this band contains more than 90 per cent quartz. The grains are from a fraction of a millimeter to 3 millimeters in diameter, and the boundaries are intricately sutured. Most of the quartz grains are incipiently broken and show undulose extinction. Minor constituents scattered throughout the mosaic of quartz grains are muscovite, biotite, feldspar, epidote, chlorite and pyrite.

The petrography and field relations of other occurrences of quartzite in the area are, on the whole, similar to those described above. The contacts between paragneiss and quartzite near the bridge at Notre-Dame-des-Anges are sharp, but on the extension of the same band, on lots 5, 6 and 7, range I, S.W., Chavigny township, the contacts are gradational. Small pink garnets are sparsely scattered in some of the more impure quartzite in several parts of the area.

Limestone and Calc-Silicate Rock

Only two thin beds of limestone occur in the Grenville series of the area. One of these beds is the host-rock of most of the ore mined to date in the Montauban ore zone. It is exposed at surface over a length of 2,900 feet, from the southernmost exposures of the ore zone 1,500 feet south of Anacon No. 3 shaft to a point 1,400 feet north of the shaft, where the zone passes into metasomatized para-gneisses directly on strike with the limestone bed. The width of the bed at surface ranges from 50 feet in the southernmost exposures to a maximum of 180 feet at a point 650 feet south of Anacon No. 3 shaft. North of the shaft,the exposed part of the bed is 160 to 120 feet wide. The strike of the southern part of the bed is north-northwest, and of the northern part, north. The overall dip is 60° to 70° east, but mine mapping has shown that the bed is thrown into numerous minor folds with gently plunging axes. Most of the original carbonate minerals of the limestone bed have been changed to lime-magnesia silicates, chiefly tremolite and diopside. The typical rock of the surface exposures is a grey-weathering, medium to coarse grained, massive aggregate of white or green tremolite blades, with lesser amounts of numerous other minerals. Among these, diopside in white, buff, or pale green crystals, in places attaining a length of 1 foot, is abundant. Although carbonate minerals are scarce in surface exposures of the bed, underground workings have encountered many masses of medium grained, massive, white carbonate rock, called "fireite" by the miners because of its property of giving off a cherry-red glow when struck or scratched with a pick. Other minerals of sporadic occurrence in the limestone bed are: the metallic minerals, to be described under the heading Economic Geology, pale brown biotite, phlogopite, chlorite, anorthite, zoisite, scapolite, wilsonite, talc, tourmaline, hisingerite, sphene, zircon, apatite, quartz and hydrothermal calcite, dolomite and breunnerite.

The second limestone bed is more or less continuously exposed in outcrops and trenches over a length of 700 feet near the centre of lot 10, range I, S.W., Chavigny township. In these exposures, the bed strikes east and dips steeply south, parallel to schistosity in para-gneisses in either wall. The thickness of the bed is 10 to 15 feet. Recent diamond drilling by Western Ashley Minerals Limited has shown that the bed extends west to a point near the line between lots 12 and 13, range I, S.W., Chavigny township, a total distance of 2,900 feet from the southernmost exposures, and that it is offset by minor folds or faults. Mineralogically, this limestone strongly resembles the limestone of the Montauban ore zone, being a massive, medium to coarse grained aggregate of tremolite, diopside, wilsonite and other minor constituents, and containing a few isolated pods of massive white carbon-ate rock. Unlike the limestone bed of the Montauban ore zone, metallic minerals are scarce both in surface exposures and in most of the parts of the bed explored by diamond drill holes and underground workings.

Hornblende Gneiss

Although mapped as a unit, the hornblende gneisses of the area vary considerably in structure, texture, and composition. The feature common to all varieties is a high tenor of hornblende.

A crescent-shaped ridge extends across lots 325 to 341, range I Price, St. Ubald parish, Grondines West seigneury and lots 45 to 47, range I, Montauban township. The westward-facing slope of the ridge rises steeply to a maximum of about 300 feet above the flat valley floor. The eastward slope is gentle. The ridge is capped with a tabular body of hornblende gneiss, dipping about 30° east. The calculated thickness of the body is about 500 feet near the centre of the ridge, but it decreases toward the north. In the field, the hornblende gneiss of the ridge appears to be very uniform in composition and texture. It is dark grey on weathered and fresh surfaces, and breaks into platy fragments parallel to the schistosity, which is well developed. The rock is very fine grained, amphibole and feldspar being the only minerals which can be seen with the aid of a pocket lens. Three specimens from different parts of the ridge were studied in thin section. Table 1 gives their approximate compositions.

Table 1
Volume Composition of Hornblende Gneiss

| | 1 | 2 | 3 |
|---|---|---|---|
| Hornblende | 80 | 60 | 50 |
| Plagioclase | 10 ($An_{43}$ to $An_{50}$) | 37.5 ($An_{43}$ to $An_{48}$) | 15 ($An_{58}$ to $An_{62}$) |
| Augite | -- | -- | 15 |
| Quartz | 5 | -- | 10 |
| Carbonate | -- | -- | 5 |
| Sphene (?) | 3 | 2 | 3 |
| Sulphides | 2 | 0.5 | -- |
| Apatite | Trace | Trace | -- |
| Total | 100 | 100 | 98 |

1, 2, 3.- Range I Price, St. Ubald parish, Grondines West seigneury.

The prisms of hornblende are very well aligned, and are idioblastic against the other constituents. The average grain size is about 0.2 millimeter.

Quartzose biotite paragneiss underlies the hornblende gneiss on the west scarp slope of the ridge. The paragneiss contains some hornblende for a distance up to 200 feet from the contact. The appearance of the hornblende gneiss is unchanged near the contact.

The composition of the hornblende gneiss west of Ste. Anne lake is similar in all respects to specimens 1 and 2 in Table 1. In some exposures, however, the rock is coarser grained and the schistosity is less well developed.

Hornblende gneisses occur in Chavigny township in two well defined bodies, the larger of which can be traced for almost 2 miles along the strike. The contacts of the larger body are for the most part structurally concordant, but in lot 15, range I, S.W., just east of the small lake, the contact between hornblende gneiss and paragneiss appears to lie across the direction of schistosity. The contact itself is hidden beneath forest mantle. The rock varies in composition; the predominant type is a dark grey, medium grained gneiss, with more than 60 per cent hornblende. The other constituents of the rock are zoned labradorite and a few grains of apatite. The composition of the labradorite ranges, without apparent order, from $An_{50}$ to $An_{70}$. The range is as great as 10 molecular per cent in cleavage fragments taken from different parts of the same hand specimen.

The larger body of hornblende gneiss in Chavigny township, especially near the contacts, contains quartz and biotite, and a higher tenor of feldspar than usual. The weathered surfaces are rusty in places, as a result of oxidation of sulphides, and the rock is commonly banded parallel to the schistosity, dark hornblende-rich layers alternating with lighter coloured layers richer in quartz and feldspar. The gneiss contains streaks and lenticles up to 1 centimeter thick which in thin section are seen to consist of sub-parallel prisms of hornblende with some interstitial quartz and feldspar. A few of the hornblende grains are partly replaced by pyrrhotite, with associated sphene. One of the lenticles examined contains coarse flakes of red-brown biotite. The space between the lenticles is occupied by a fine grained allotriomorphic mosaic of andesine and quartz, with about 15 per cent hornblende, which occurs as small irregular grains in poorly defined trains. Many small prisms of apatite are enclosed in the quartz and feldspar of the mosaic. Although it was thought in the field that the lighter material in the banded hornblende gneiss might be interbedded paragneiss, the information revealed by microscopic study suggests rather that it originated as injected igneous material, or as fine grained tuff. The origin of the hornblende gneiss itself is discussed in a later section.

On lots 16 to 18, range I, S.W., Chavigny township, the hornblende gneiss contains a band of hornblende-chlorite schist, consisting of fine to coarse grained chlorite and common green hornblende, with a few grains of pyrite and magnetite. By the increase of feldspar and decrease of chlorite, the schist grades into hornblende gneiss on either side of the band.

Near the south end of lot 9, range V, S.W., Montauban township, fine grained hornblende gneiss resembling that of the ridge in range I Price, St. Ubald parish, Grondines West seigneury, contains epidote-rich nodules such as were found in garnet-biotite paragneiss on lots 15 and 16, range IV, S.W. Montauban township. If these nodules represent calcareous concretions, as suggested above, then part of the hornblende gneiss is probably of sedimentary origin.

Field relations and petrography of the other bodies of hornblende gneiss in the area are similar to those of the larger body in Chavigny township. The central parts of the larger bodies are commonly richer in hornblende than the margins, which in places consist of irregularly banded rock.

Origin of Hornblende Gneiss

Adams and Barlow (10, pp.62-78, 87-127, 157-172) have shown that certain amphibolites in the Grenville series in Ontario were derived from limestones by the addition of material from granitic magma and that others have been derived from intermediate to ultrabasic intrusive rocks. They thought that some amphibolites thinly interbanded with limestone might originally have been layers of basic volcanic ash (10, p.166). They found these rocks of diverse origins to be very similar petrographically, so that the origin could be ascertained only from field relations (10, p.164).

Since the hornblende gneisses of the present area are nowhere associated with limestone, and not visibly with large intrusive bodies, they are probably not derived, in the manner described by Adams and Barlow, from limestone.

The large body in range I Price, St. Ubald parish, Grondines West seigneury, appears to thin both to the north and south, and the biotite paragneiss in the footwall has apparently received an addition of material from which hornblende has formed. These observations are most easily explained by supposing that this body of hornblende gneiss is derived from a sill of intermediate igneous rock. The same interpretation best explains the field relations of the other bodies. The one exception is the occurrence of hornblende gneiss in lot 9, range V, S.W., Montauban township, which contains the epidote-rich nodules. If these nodules represent calcareous concretions, as postulated, they could not have formed in an igneous rock. However, they could conceivably have formed in a bed of volcanic ash similar in composition to the sills.

With regard to the origin of the hornblende gneisses of the area, Bancroft states that "in some localities, as on lots 8 to 10, range V, S.W., Montauban (township), certain occurrences of amphibolites have plainly originated by the metamorphic processes to which dykes and small intrusive bodies of diorite have been subjected. In many localities, however, the field relations do not make plain the original character of these rocks" (1, p.118).

The hornblende gneiss may, therefore, be intrusive bodies, possibly related to the amphibolite dykes near the Montauban ore zone. Because of the doubt concerning their origin, they have been included with the rocks of the Grenville series in the table of formation.

Grey Composite Gneiss

East of the Montauban ore zone, distinctive grey gneisses form a resistant ridge which extends southward from lot 17, range I, S.W., Chavigny township, to more than a quarter of a mile southeast of the Anacon mine, where it disappears under stratified drift in the Charest valley. Exposed surfaces of the gneiss are fresh, and of a general light grey colour. On close inspection, alternating layers of lighter and darker colour are discernible. The lighter layers are from a fraction of an inch to 1 foot thick, and are separated by similar thicknesses of the darker material. The contacts between bands are gradational over about 1/8 inch.

The darker bands are a fine grained quartzose biotite gneiss, with a faint schistosity parallel to the contacts of the lighter coloured bands. In some places the tenor of quartz is high and the rock resembles impure quartzite. Typical specimens contain quartz, andesine, microcline, brown biotite, and pale green hornblende, with accessory zircon, apatite and sphene. The quartz and feldspars are in a granoblastic mosaic, with the mafic constituents evenly distributed in a sub-parallel arrangement.

The lighter coloured bands are less schistose than the darker, and have a granitic aspect in the hand specimen. Under the microscope the rock is seen to be an allotriomorphic aggregate of microcline, quartz and oligoclase, with abundant, evenly-distributed anhedra of drab green hornblende. Some of the hornblende appears to be altered to zoisite. Accessory minerals are zircon, apatite and sphene. The texture is typical of aplite.

The lighter bands are probably granitic material which was injected along the schistosity planes of the biotite gneiss. The composition of the biotite gneiss suggests that it was once a quartzose paragneiss, the composition of which was changed by emanations associated with the injected aplitic material.

Similar rocks are seen 1 to 2 miles southeast of the mine, and around the nose and western limb of the syncline east of Ste. Anne lake. The only difference in composition observed in the field is an occasional narrow garnetiferous band.

The composite gneiss in contact with the quartz diorite stock in the south end of lots 11 and 12, range IV, S.W., Montauban township,is of a different character. Medium grained granitic material is interbanded with thin layers of impure quartzite. The granitic material consists of quartz, clear microcline and sericitized oligoclase ($An_{21}$), with about 5 per cent biotite, 5 per cent clinozoisite and 2 per cent epidote. There are abundant small grains of sphene, and traces of muscovite, apatite, magnetite and allanite. The granitic material is not certainly of igneous origin, but the abundance of the accessory minerals and their composition suggest the action of solutions rich in mineralizers. It is not known whether these solutions were related to the aplitic injections in the other bodies of composite gneiss.

In some places the contacts between grey composite gneiss and biotite paragneiss are abrupt. However, the change is commonly gradual; the amounts of lit-par-lit material and of hornblende in the granitized gneiss diminish until there is no megascopic difference between the two rocks. To arrive at a field separation, the writer mapped as composite gneiss only those rocks which contain appreciable amounts of lit-par-lit material. Granitization no doubt extends beyond those limits in places but, owing to the nature of the biotite paragneiss, it is difficult to detect.

## Correlation of the Grenville Rocks

Osborne (11, pp.408-410) has divided the Grenville series near Shawinigan Falls into lower and upper parts. The lower part is characterized by amphibolites which he considers as probable derivatives of basic tuffs and flows. The upper part consists of metasedimentary rocks: "The base of the metasedimentary phase is impure quartzite which grades upward into purer quartzite followed by interbedded quartzite and sillimanite or sillimanite-garnet gneisses. These pass into more massive bands of sillimanite-garnet gneisses, which, in turn, pass into crystalline limestones" (11, p.409).

The assemblage of Grenville rocks in this area suggests that they belong near the division between the lower and upper Grenville series. The hornblende gneisses, albeit of doubtful origin, represent the amphibolites of the lower part of the Shawinigan Falls section; biotite paragneiss may be considered as very impure quartzite with subordinate interbedded purer quartzite, sillimanite paragneiss and crystalline limestone, and thus would correspond to the lower part of the metasedimentary phase of the Shawinigan Falls section.

## Igneous Rocks

### Quartz Diorite Orthogneiss

A stock of quartz diorite orthogneiss underlies all of range II, S.W., Chavigny township, within the area, and part of range I, S.W., Chavigny township. The map accompanying Bancroft's report (1) shows that this stock extends 1 mile west of the present area and at least 1 mile north of it. The western contact, on the north side of the Batiscan river, strikes north; the northern contact lies beyond the limits of Bancroft's map. The total mapped area of the stock is about 9 square miles.

The quartz diorite is megascopically uniform over a large part of the area underlain by the stock. Weathered surfaces are dark grey and fresh surfaces are lighter grey. Schistosity is pronounced near the contact, but less so in the central parts of the stock. The rock is a medium grained aggregate of feldspar, biotite, amphibole and quartz. Epidote can be seen in some hand specimens. The ratio of biotite to amphibole varies somewhat, but most specimens contain more biotite than amphibole. In some places the rock is finer grained near the contact, but normally there is little variation in grain size.

Under the microscope the rock is seen to consist of sodic andesine, quartz, biotite, hastingsite and a little potash feldspar. Accessory constituents are epidote, sphene, apatite and zircon. The gneissoid structure is due to the sub-parallel arrangement of biotite, hastingsite, lenticles of quartz, and ribbons of fine grained biotite, epidote and plagioclase. The whole is suggestive of the results of protoclastic deformation.

The west contact of another stock of quartz diorite orthogneiss crosses lots 3 to 6, range V, S.W., and lots 7 to 11, range IV, S.W., Montauban township, near the east border of the area. The part of the stock mapped by Bancroft (1) has an area of about 13 square miles. The shape of this part of the stock, as it appears on the map, suggests that the complete body underlies a much greater area. The megascopic appearance and the composition of the part of the stock lying inside the present area are almost identical with those of the stock in Chavigny township. Biotite and hastingsite appear to have crystallized while the rock was subject to directive stress, for the grains of these minerals are rudely oriented and show no signs of deformation subsequent to crystallization. As in the Chavigny stock, there is some segregation of the quartz. The two bodies no doubt originated in the same source at depth, and were subject to substantially the same conditions of cooling and deformation.

The only unusual facies observed in either body is in the southeast ends of lots 20, 21, 24 and 25, range I, S.W., Chavigny township. The quartz diorite in these localities is massive, fine to medium grained, and dark grey to black. It contains as much as 50 per cent hastingsite, and andesine, biotite, quartz, epidote and sphene. The intruded rock here is hornblende gneiss, of which there are several inclusions in the quartz diorite. The inclusions are difficult to distinguish from the fine grained mafic-rich type of quartz diorite. The high tenor of amphibole in the intrusive rock could be the result of incorporation of material from the hornblende gneiss.

Although Bancroft (1, p.121) concludes that the stocks are of granodiorite, the preponderance of plagioclase and the relative scarcity of potash feldspar in the specimens examined by the writer suggest that the term quartz diorite orthogneiss is preferable.

Intrusive bodies of quartz diorite orthogneiss of similar composition to that described above occur at Rivière-à-Pierre, about 15 miles northeast of this area (12, pp.419-425). Since the geology of most of the intervening area is unmapped, a discussion of correlation would be too speculative to be of value.

Migmatite

A large body of gneiss, thought to be a hybrid facies of the quartz diorite orthogneiss, occurs on lots 16 to 20, range I, S.W., Chavigny township. A smaller body of the same rock is exposed on lots 15 and 16, range II, S.W., Chavigny township, near the line between ranges I and II. Weathered surfaces of the gneiss are dark grey to black, whereas fresh surfaces are lighter grey. Schistosity is well developed, but layering is absent except near the contacts with paragneiss. Hand specimens have an equigranular, granitoid appearance; the grain size ranges from a fraction of a millimeter to 1 millimeter in different localities, the finer grained types not being necessarily closer to the contacts. Feldspar, amphibole, quartz, biotite and small red garnets are visible megascopically. The smaller body cuts discordantly across a band of hornblende gneiss, and the northern limit of the larger body truncates a thick sequence of paragneiss and hornblende gneiss. Near the northwest end of the line between lots 16 and 17, range I, S.W., Chavigny township, just east of the small lake, sheets of migmatite 1 foot thick are interlayered with very siliceous, rusty paragneiss, so that if the north contact of the migmatite in this locality were shown in detail, it would be very intricate. The east contact appears to be gradational. As the contact zone is approached, the tenor of mafic constituents in the migmatite decreases and the rock becomes banded and siliceous, passing into siliceous biotite paragneiss. The west contact with quartz diorite orthogneiss was not observed, but near the south end of the small lake referred to above there are two exposures 60 feet apart, one of fine grained, but otherwise normal quartz diorite orthogneiss, and the other of migmatite. There may be a gradation between the rock-types of these exposures.

Thin sections of typical specimens of migmatite consist of oligoclase, quartz, hastingsite, biotite, garnet, and a little potash feldspar, with accessory sphene, apatite, and zircon.

The discordant field relations suggest that the migmatite is partly of igneous origin. Although the composition is different from that of any other rock-type in the area, it compares somewhat with the quartz diorite orthogneiss in that both rocks contain hastingsite, plagioclase feldspar, quartz, subordinate potash feldspar, and a common suite of the accessory minerals sphene, apatite, and zircon. Compared with quartz diorite orthogneiss, the migmatite has more sodic plagioclase, a higher tenor of hastingsite and of quartz, garnet instead of epidote, and granoblastic instead of protoclastic texture. It is possible that the migmatite formed from a part of the quartz diorite magma which had assimilated some material from the country rock.

Amphibolite

Amphibolite dykes and sills up to 60 feet thick intrude the paragneiss and grey composite gneiss near the ore zone at Montauban-les-Mines. Some of the dykes exposed in underground workings cut the limestone. In places they are in part altered by mineralizing solutions. They are therefore younger than the Grenville rocks near the ore zone, but older than the mineralizing solutions.

The weathered surfaces of the dykes are dark grey, with a distinctive pepper and salt appearance. The rock is medium grained and has a faint schistosity parallel to that in the wall rocks. Some of the dykes contain abundant coarse garnets near their contacts. Thin sections of typical specimens of amphibolite contain 40 to 50 per cent hornblende, 30 to 50 per cent andesine, about 5 per cent biotite, 5 per cent quartz, and minor amounts of sphene, apatite, and pyrrhotite or pyrite.

The size of the hornblende and plagioclase grains ranges from 2 millimeters to 0.05 millimeter in the same thin section. The larger grains of hornblende are rudely aligned, and there is a suggestion of grouping into lenticles parallel to the alignment.

The marginal facies of the dykes are commonly fine and even grained. The tenor of hornblende and quartz is higher than at the core. Coarse red garnets with a refractive index higher than 1.80 make up as much as 15 per cent of the selvages of some of the dykes.

The relations of the amphibolite dykes to other igneous rocks in the area are unknown.

## Granite and Aplite

There are numerous sills and dykes of granite and aplite in the area. Many such bodies are shown on the accompanying map, but many more are too small to be shown at the scale of mapping.

Granite occurs in tabular bodies, most of which are concordant with the structure of the country rock, but which show minor discordant features which establish their intrusive origin. Some of the bodies are dykes which cut across the schistosity of the country rock. The typical granite of the sills and dykes is a light buff coloured, medium grained rock with very faint to distinct schistosity. The smaller bodies commonly contain about 3 per cent coarse red garnets throughout, whereas the larger bodies are garnetiferous only near the margins, suggesting that the garnet is derived from material absorbed from the wall rocks. Thin sections show that the approximate composition of the granite, calculated without garnet, is 50 per cent microcline, 25 per cent quartz, 15 per cent zoned oligoclase ($An_{17}$ to $An_{21}$), 7 per cent reddish brown biotite, and 3 per cent muscovite. Zircon and epidote are present as accessory minerals. The texture shows the effects of protoclastic processes; large rounded grains of microcline and roughly oriented flakes of biotite and muscovite are contained in a finer grained groundmass of quartz and feldspar, which appears to have consolidated while the rock was subjected to directed pressure, since there is a crude alignment of the greater dimensions of elongated grains.

The large sill-like bodies in lots 3, 5, 6 and 7, range V, S.W., Montauban township, are of somewhat different composition. The percentage of biotite is higher, and oligoclase slightly exceeds potash feldspar. It is possible that the granite bodies of the area are differentiates of the quartz diorite magma, and that the large sills are intermediate in composition between quartz diorite and granite. This relationship, however, is not made clear by field evidence.

There is no sharp distinction between granite and aplite. The finer grained types of granite have textures which approach that of aplite, and for this reason the rocks are shown together on the map. Lit-par-lit injections of aplitic material have been described under Grey Composite Gneiss. It is not known whether or not these are related to the larger bodies of aplite in the area. The typical aplite of the larger bodies is a fine, even grained rock of a very light grey colour with minute, well oriented flakes of biotite marking the schistosity. A dyke of such aplite occurs on the northwest shore of the Batiscan river in lots 1 to 3, range I, S.W., Chavigny township. A thin section of a specimen from the dyke consists of 45 per cent microcline, 30 per cent quartz, 15 per cent oligoclase ($An_{18}$), 7 per cent green biotite, and 3 per cent (in order of abundance) penninite, sphene, clinozoisite, apatite, zircon, muscovite and pyrrhotite. The feldspars and quartz are in an allotriomorphic mosaic in which the other constituents are evenly distributed, forming a typical aplitic texture. Dykes of similar composition and texture intrude hornblende gneiss in lots 9, 10 and 11, range V, S.W., Montauban township, and biotite paragneiss in lot 34, range II, Montauban township. In both of these occurrences the aplite contains irregular patches of white pegmatite.

## Pegmatite

Exposed bodies of pegmatite intrude all the other rock-types in the area, with the exception of the migmatite in Chavigny township. It is therefore the youngest intrusive rock in the area. At least part of the pegmatite is older than the metasomatic solutions which altered the rocks along the Montauban ore zone, because a pegmatite dyke east of Anacon No. 3 shaft is itself altered by the solutions (see p.28).

Most of the pegmatite bodies are discordant, and have locally contorted the intruded country rock. In places the intrusion of composite gneiss and paragneiss by pegmatite is extremely intimate, resulting in a contorted mass of gneiss mixed with irregular bodies of pegmatite. A dyke in lots 410 and 411, range II Price, St. Ubald parish, Grondines West seigneury, contains crystals 1 foot in length consisting of microcline graphically intergrown with quartz. Normally, however, the grain size does not exceed a few inches. The dykes are white to very light grey and contain predominant microcline and quartz with, in places, subordinate oligoclase, biotite, muscovite and black tourmaline. Some of the bodies have fine grained, garnetiferous selvages which resemble the granite described above.

The close association of granite, aplite and pegmatite in the area suggests that all three are late differentiates of a common parent magma, the main body of which possibly consolidated as the stocks of quartz diorite.

## Pleistocene Deposits

The distribution of the Pleistocene deposits is shown on the accompanying map. The Batiscan river has deeply dissected these deposits; minor streams have also cut deep V-shaped gullies into them. Where the stream banks are not grown over, the material forming them is seen to be clean, fine sand. Although slumping of the banks has for the most part destroyed the original structures in the sand, horizontal stratification is preserved in a few places where admixed clay renders the sand more competent. At the bottoms of one or two gullies, well stratified clay is exposed. No fossils were found in the sands nor in the clays, but no extensive search was made for them, and no microscope work was done to search for microfossils.

Bancroft (1, p.106) considers that the stratified sand and clay were deposited in an arm of the sea which flooded the St.Lawrence valley and the tributary valleys after the retreat of the continental ice sheet and that subsequent uplift of the land elevated the deposits to their present position.

# STRUCTURAL GEOLOGY

## General Statement

Folding in the Grenville rocks of the area can be traced locally by mapping distinctive horizons and the attitude of schistosity, which in the paragneisses is parallel to layering. However, the relations between the structures of the different isolated areas of outcrop are now known. Any extrapolation of geological contacts through the extensive drift-covered areas would be too speculative to be of value. Therefore, no complete correlation of the local structures will be attempted in the ensuing discussion.

## Schistosity and Layering

Schistosity, here used to denote planar orientation of platy and elongate grains, is exhibited to varying degrees by all the rocks in the area with the exception of pegmatite. It is most intense in those rocks which contain the highest proportions of platy and elongate minerals, such as the hornblende-chlorite schist in Chavigny township and the mica schist layers in the paragneisses. Schistosity in the layered rocks of the Grenville series is parallel to large and small scale layering; where the layers are folded, the schistosity is parallel to layers both on the limbs and on the noses of the folds, a good example being an open, symmetrical syncline east of Ste. Anne lake which is defined both by the attitude of schistosity and by a thick quartzite bed near the nose.

Schistosity in grey composite gneiss and in the intrusive rocks is in general parallel to geological contacts and to schistosity in the layered paragneisses, although there are numerous local exceptions to this rule.

## Lineation

The schistosity, especially in the more micaceous varieties of paragneiss, is deformed in drag folds with amplitudes from a fraction of an inch to several feet. The axial lines of the drag folds define a lineation which is, in some cases at least, parallel to the axial direction of larger-scale folds. Other types of lineation in the paragneisses, namely rodding of quartz associated with pegmatite injections, boudinage* of pegmatite and aplite stringers, and parallel orientation of elongated concretions and of sillimanite nodules, conform with this direction. Grey composite gneiss, quartzite, and some of the more quartzose paragneisses have in places a mullion structure developed on the schistosity surfaces. The distance between adjacent mullion ridges is commonly 2 or 3 inches, and the grooves between them are shallow and rounded. This lineation is in general conformable with the other varieties.

Lineation plunges 5° to 25° north in the south half of the area, and about 25° northeast in the north half. The change in direction may be the result of a buttressing effect of the rigid stocks of quartz diorite orthogneiss, or it may be a deformation caused by the intrusion of the stocks.

## Folding

The syncline east of Ste. Anne lake is, with the exception of drag folds, the only relatively complete fold structure seen in the area. The schistosity at the nose of the syncline dips 25° north, indicating the plunge of the fold. Near the nose of the syncline, axial lines of drag folds in schistose paragneiss have the same plunge. This supports the suggestion made above that lineations in the area are parallel to axial lines of large-scale folds. The thick, massive quartzite on the east limb of the syncline dips about 20° northwest, and schistosity in paragneiss and composite gneiss on the west limb dips about 30° east-northeast, so that this part of the syncline is symmetrical and open. The dip of schistosity in paragneiss inside the quartzite on the east limb becomes very steep as the limb is traced to the northeast, suggesting that the fold tends to be overturned to the west.

---

*The formation of sausage-shaped remnants of beds, dykes or veins.

Part of what appears to be the nose of an anticline overturned to the west is exposed in the southeast parts of lots 16 and 17, range I, S.W., Chavigny township, but the relative importance of the structure is not made clear by the part exposed.

To the north and west of the anticline, schistosity in general is parallel to the contact of the stock of quartz diorite orthogneiss, but the detailed structure is complex. In the neighbourhood of Notre-Dame-des-Anges two thick bands of quartzite converge between the stocks of quartz diorite orthogneiss, which appear to control the structure in this part of the area. Bancroft's map (1) shows that farther to the north intrusive bodies of granite and granodiorite are separated by thin, sheet-like remnants of Grenville rocks.

Schistosity in paragneisses and quartzite of the northern part of the long ridge near the east boundary of the area is parallel to the contact of the eastern stock of quartz diorite orthogneiss. Structure in the paragneiss of the southern part of the ridge is characterized by undulations of the schistosity surfaces which in general dip gently to the northeast.

## Jointing

The most continuous joints in the southern part of the map-area have strikes ranging from N.80°E. to S.70°E. and dips from 80° north to 80° south. Such joints are especially numerous near the Montauban ore zone, where some of them are filled with coarse, massive sulphides. Some joints with similar strikes and dips were found to have matching walls, and others are filled with vein quartz, suggesting that they are the result of tension in a north-south direction, although there are minor displacements on a few of them. The largest pegmatite dyke in lot 33, range II, Montauban township, is cut by east-west joints dipping steeply north. The east-west joint set appears, then, to have formed after the intrusion of the pegmatite, but before the deposition of ore along the Montauban ore zone.

There are many other small discontinuous joints, especially in the more competent rocks of the area, but no other set was recognized in the field.

# ECONOMIC GEOLOGY

## History of Mining Operations in the Area

Anacon Lead Mines Limited — Sphalerite and galena were discovered near Montauban-les-Mines in 1910 by Elzéar Gauthier (1, p.128). In 1911 Pierre Tétreault acquired the mining rights for the northeast parts of lots 322 to 327, range I Price, in St. Ubald parish, Grondines West seigneury,and lots 39 to 42, range I, Montauban township. In 1912 he started development work and built a small gravity-concentration mill. The first attempts at milling the ore failed to produce a marketable concentrate. However, some high grade crude ore was shipped in 1913 and 1914.

In 1914,the Weedon Mining Company Limited leased a part of the Tétreault property, which included 900 feet of the ore zone immediately south of Mine lake, and began remodelling Tétreault's mill to include oil flotation. The Zinc Company Limited was incorporated in 1915 to operate the Weedon lease. This company built a zinc oxide plant at Notre-Dame-des-Anges. In 1916,they built a 200-ton mill on the Tétreault property. The circuit of the new mill included some oil flotation cells. The Zinc Company operated successfully until 1921, when their lease expired and the property reverted to the Pierre Tétreault estate. Meanwhile Tétreault had done some exploratory and development work on his holdings to the north of the property which was leased to the Zinc Company.

In 1923, the Tétreault mine, which had been shut down since 1921, was reopened by the Pierre Tétreault estate and operated until 1924, when the property was leased by the British Metal Corporation (Canada) Limited. This company remodelled the mill, incorporating differential flotation, and operated the mine continuously until 1929, when the property again reverted to the Pierre Tétreault estate.

Following another period of idleness, the Tétreault mine was again operated by the Pierre Tétreault estate from 1935 to 1937.

In 1942, Siscoe Metals Limited acquired the Tétreault property and operated it until 1944 as a war measure under the supervision of Wartime Metals Corporation.

In 1948, Anacon Lead Mines Limited acquired the Tétreault property and the mining rights on the extension of the mineralized zone north to the Batiscan river, with the exception of the ground held by United Metals Limited. They have operated the Tétreault mine continuously from 1948 until the time of writing.

According to information compiled by the Quebec Department of Mines (13, p.28), the ore and concentrates shipped from the Montauban deposits, from the time production started in 1913, up to 1948, yielded approximately 77,000 tons of zinc, 24,000 tons of lead, 40,000 ounces of gold and more than 4,000,000 ounces of silver. The concentrates produced by Anacon Lead Mines Limited from 1949 to 1952 inclusive contained, according to the annual reports of the company, 31,167 tons of zinc; 10,235 tons of lead; 9,431 ounces of gold and 1,527,605 ounces of silver. Production figures for 1948 are not available; the mill was in operation during the month of December only.

Exploration and development activities in other parts of the area were confined to three periods.

The first period of exploration activity commenced shortly after the Tétreault mine came into production and continued until 1916.

The Laurentide Mining Company started exploration in Montauban township in 1914. They did some surface work on lots 44 and 45, range I. On another claim group they sank 2 shafts; No. 1, a vertical shaft in the southwest corner of lot 6, range V, S.W., which was sunk to a depth of 30 feet, and No. 2, a 40° inclined shaft in lot 7, range IV, S.W., near the boundary of lot 8, which was sunk to a depth of 62 feet. From the bottom of the inclined shaft a crosscut was driven 15 feet northeast.

In the same mineralized zone, another 40° inclined shaft was sunk in 1915 to a depth of 26 feet in lot 8, range IV, S.W., Montauban township.

The Montauban Mining Syndicate started work on lots 43 to 45, range I, Montauban township in 1914. They sank 2 vertical shafts 34 feet and 50 feet deep respectively in lot 44. From the bottom of the deeper shaft they drove a crosscut 68 feet southeast and from the crosscut they sank a 70° winze to a depth of 56 feet. Lateral workings having a total length of 382 feet were driven from the shaft and winze at the 28-, 50-, and 106-foot levels. In 1916, the syndicate built a mill on their property, but no machinery was installed.

There was a second period of exploration activity during the years 1928 and 1929.

Adanac Mines Exploration Limited started work in 1928 on their property in Montauban township which comprised lots 1 to 5, range V, S.W., and the north halves of lots 3 and 4, range IV, S.W. During 1928 and 1929, they sank a shaft on lot 4, range V, S.W., inclined 50° to the east, to a depth of 204 feet. On the 135-foot level 30 feet of crosscutting, 14 feet of drifting and 22 feet of raising were done. Some diamond drilling was also done on the property.

The Eastern Quebec Lead and Zinc Company Limited did assessment work in 1928 on parts of lots 6 to 10, ranges IV, S.W. and V, S.W., Montauban township.

The Montauban Metal Corporation which held mining rights in parts of lots 6 to 19, range I, S.W., Chavigny township and parts of lots 40 to 42 and block C, range II, Montauban township, explored their property during 1928 and 1929. They sank an inclined shaft to a depth of 218 feet near the centre of lot 10, range I, S.W., Chavigny township, and drifts 340 feet and 95 feet long were driven on the 100- and 200-foot levels respectively. The drift on the 100-foot level is connected with the surface. Some diamond drilling was also done.

The New Montauban Zinc and Copper Company Limited did some surface exploration in 1928 on parts of lots 1 to 9, range V, S.W., Montauban township. In 1929 they drove an adit 290 feet long in lot 1, below the falls on the Batiscan river. At 200 feet from the portal a crosscut 30 feet long and a winze, said to be 27 feet deep, were driven.

The Shawinigan Mining and Smelting Company Limited did some surface exploration in 1929 on block C, range II, Montauban township.

St. Lawrence Metals Limited made a geophysical (electrical) survey of lots 42 to 45, range I, Montauban township, in 1929, and also drilled 4 diamond drill holes on the property.

The third period of exploration activity has extended from 1949 up to the time of writing.

Ausable Mines Limited carried out a magnetometer survey of the northeast halves of lots 394 to 413, range II Price, St. Ubald Parish, Grondines West seigneury, during December 1951 and January 1952. A program of diamond drilling to test the magnetic anomalies was planned for the summer of 1952.

Batiscan Mines Limited carried out a resistivity survey of lots 8 to 19, range II, S.W., the southeastern parts of lots 20 to 25, range II, S.W., and the northwestern parts of lots 20 to 25, range I, S.W., all in Chavigny township.

Chateau Mines Limited did some stripping and trenching on lots 3 and 4, range V, S.W., Montauban township, which work was in progress at the time of the writer's visit on June 5, 1952.

Grandines Mines Limited drilled 4 diamond drill holes, having a total length of 3,843 feet, in lot 310, St. Thomas range, St. Ubald parish, Grondines West seigneury, in 1951.

Grawmont Mines Limited carried out a resistivity survey in September 1950, on the northeast parts of lots 325 to 337, range I Price, St. Ubald Parish, Grondines West seigneury, and on the central parts of lots 43 to 47, Range I, S.W., Montauban township. From October 1950 to April 1951 the company drilled 12 diamond drill holes with a total length of 7,998 feet to test the anomalies revealed by the above mentioned resistivity survey. The property was idle in June, 1952.

Harricana Gold Mine Incorporated (1939) drilled 3 diamond drill holes with a total length of 2,955 feet in lot 32, range I, Montauban township during the period March to May, 1951. A fourth hole is reported to have been drilled, but the writer has no information on it. The property was idle in June, 1952.

Montauban Mines Limited, incorporated in 1950, and United Lead and Zinc Mines Limited, incorporated in 1951, acquired ground from Anacon Lead Mines Limited and United Metals Limited, respectively, on the north part of the Montauban ore zone. In November 1951, the two companies jointly began the sinking of a vertical shaft near their mutual boundary, which is the line between lot 43, range I, S.W., and block C, Montauban township, and the construction of a surface plant.

By the end of December, 1952, according to company reports, the shaft had reached a depth of 539.5 feet. In addition 4,170 feet of drifting, crosscutting and raising had been done and a 500-ton concentrator had been nearly completed. Cornwall (14, p.3) reports that 71,487 feet of surface diamond drilling had been done on the property by the end of 1952.

In 1950, Nocana Mines Limited drilled 27 diamond drill holes with a total length of 4,788.5 feet on the northwest ends of lots 7 and 8, range IV, S.W., Montauban township. Twenty-five of the holes are in the immediate vicinity of the old Laurentide shaft in that locality. Further drilling was undertaken in 1952, and was in progress at the time of the writer's visit in June of that year. The hole being drilled at the time was collared about 50 feet east of the mineralized zone and, according to workmen, was one of a number of vertical holes drilled at 50-foot intervals on a line extending north from the Laurentide shaft at the boundary between lots 7 and 8, range IV, S.W., Montauban township. The writer has no information on the amount of drilling done in 1952.

O'Brien and Fowler Limited drilled 2 diamond drill holes, one in May and one in September, 1951. Hole number 51-1, 1,475 feet deep, is collared in the small roadside outcrop in the centre of lot 324, range I Price, St. Ubald Parish, Grondines West seigneury. Hole number 51-2, 902 feet deep, is 160 feet due east of the shore of Ste. Anne lake, and 10 feet south of the line between lots 313 and 314, range I Price.

Western Ashley Minerals Limited drilled 18 diamond drill holes with a total length of 4,359 feet during the period April to June, 1952. The holes were drilled along an east-west line crossing the central to northern parts of lots 10 to 13, Range I, S.W., Chavigny township. Six other holes were drilled in this locality, but the writer does not have the footages. Another hole was drilled in the southeast end of lot 13, range I, S.W., Chavigny township. Three holes were drilled near the Batiscan river, in the southeast end of lot 19, range I, S.W., Chavigny township. One of these is 1,467 feet northwest of the Batiscan river along the line between lots 18 and 19, and 56 feet southwest of that line. This hole, the only one of the three for which information has been received, was drilled west at minus 45° to an inclined depth of 998 feet in May 1950. The company has also carried out a magnetometer survey of part of their holdings, results of which have not been seen by the writer.

## Description of Properties

### Montauban Ore Zone

Three companies, Anacon Lead Mines Limited, Montauban Mines Limited and United Lead and Zinc Mines Limited own the mineral rights on the exposed part of the Montauban ore zone.

Anacon Lead Mines Limited has the mineral rights on lots 33 to 36, range I, the northeast parts of lots 37 to 41, range I, and the southwest halves of lots 38 to 41, range II, Montauban township; the southwest parts of lots 312 to 322, range I Price, St. Ubald Parish, Grondines West seigneury, and mining concession No. 374 which covers parts of Montauban township and Grondines West seigneury.

Subsequent to the writing of this report Montauban Mines Limited and United Lead and Zinc Mines Limited were amalgamated under the name United Montauban Mines Limited. The new company holds the mineral rights on the southeast parts of lots 15 to 18, range I, S.W., Chavigny township,and D.L. 1751, range I, D.L. 2957, range I, block C, range II, the southwest half of lot 42, range II, mining concession No. 410, C.26203, claim 1 and lots 12 to 16, range V, S.W., in Montauban township.

The Montauban ore zone has been traced on surface in a general north-south direction for a distance of 8,500 feet, from the southernmost exposure in lot 322, range I Price, St. Ubald Parish, to the northernmost in block C, Montauban township. The southern 2,900 feet of the zone is marked by hydrothermal alteration and mineralization of a bed of limestone and of paragneisses in either wall. Limestone is absent in surface exposures of the northern 5,600 feet of the zone, which is marked by metasomatism and mineralization of paragneisses. The average width of the zone at surface is 80 feet; it swells to a maximum of 200 feet.

All the rock types within and in the neighbourhood of the ore zone have been described under "General Geology",and their distribution is shown on the accompanying map. A much more detailed description of the rocks in the vicinity of the ore zone, and of the alterations which have affected them, is given by O'Neill and Osborne (7), and by Wilson (8). It is interesting to note that the youngest igneous rocks, as well as the Grenville metasediments, have been altered by solutions related to the ore-forming solutions. Amphibolite near the ore zone is in many places altered to black biotite schist, the essential constituents of which are plagioclase, biotite and hornblende, with minor quartz, pyrite, apatite and sphene. The schist also contains a little sphalerite in places, indicating that it is older than the ore. Pegmatite and granite within the ore zone are in places altered to bytownite, which preserves the textures of the original rocks. Wilson (8, p.54) notes this type of alteration on the south end of the pegmatite dyke east of Anacon No. 3 shaft, and the writer found similar alteration in a small sill of granite in the southernmost exposures of the zone.

The grey composite gneiss of the hanging wall passes gradationally into sericitic paragneiss near the ore zone. The scarcity of metasomatism and mineralization in the composite gneiss shows that it was highly impervious to circulating solutions. This is probably a result of sealing of channelways and pore spaces in the rock by the _lit-par-lit_ granitic injections and the emanations associated with them prior to the advent of metasomatizing and mineralizing solutions.

The structure of the ore zone is complicated in detail by convolutions of schistosity surfaces and of the limestone bed, but the generalized structure is more simple. In plan, the schistosity in the paragneisses west of the ore zone has the form of a gentle arc, striking northwest south of Mine lake, north to the west of the central part of the zone, and north-northeast to the west of the northern part. West of the southern part of the ore zone dips are 20° to 30° northeast, steepening to 40° to 50° northeast in the immediate footwall of the zone; west of the central part of the zone they are 40° to 50° east, but in the immediate footwall of the zone a roll in the schistosity is indicated by dips of 25° to 50° west; west of the northern part of the zone, dips are 35° to 45° east-southeast. Many local variations of dip in the footwall paragneiss indicate the presence of rolls with gently plunging axes, but the general attitude is that of a warped surface dipping 20° to 50° east. Schistosity in paragneisses and grey composite gneiss in the hanging wall of the ore zone presents the same warped surface, also with local contortions. The ore zone itself has in plan the same arcuate form as the wall rock schistosity. The detailed structure of the south central part of the zone has been studied in the extensive mine workings. Figure 1 shows a vertical east-west section through the ore zone at a point 870 feet north of Anacon No. 3 shaft. Z-shaped folds of the silicated limestone bed, typical of the structure in the south-central part of the zone, are well shown, as is the overall 60° to 70° east dip of the zone. The limbs of the folds representing the cross bars of the Z are thin, apparently a result of plastic flow of material from these limbs to the noses of the folds. The axial lines of the folds plunge gently north in most parts of the mine workings.

As the zone is followed north past the limits of the limestone surface exposures, a change in the structure is apparent. Since the writer has not studied the information made available by recent underground development work and diamond drilling, only the principal features will be outlined. The part of the zone referred to by Anacon Lead Mines Limited as the C zone extends north from a point 1,800 feet north of No. 3 shaft. Here the zone at surface is in metasomatized paragneisses dipping 50° east. Down the dip in the underground workings the zone flattens, and the paragneisses pass into silicated limestone which forms a regular sheet-like body dipping 25° east, known locally as the A zone. About 400 feet east of the surface exposures of the zone, the limestone is overlain by paragneisses which are in turn overlain by grey composite gneiss. Since any interpretation of the structure of the ore zone must necessarily take into account this flat-lying limestone bed and its relations to the complex folding to the south, no general interpretation will be attempted here. It appears that the limestone body, like the axial lines of the minor folds, plunges north and rakes east.

The assemblage of sulphides found in the Montauban ore zone is, in order of abundance, sphalerite, galena, and pyrrhotite, with subordinate chalcopyrite. Molybdenite, arsenopyrite, pyrite, and marcasite are of sporadic occurrence. Other minerals which have been reported are tetrahedrite, electrum, native gold and silver and graphite. The gangue minerals are mainly those produced by metasomatism of limestone and paragneiss, namely fireite (calcite with some dolomite),

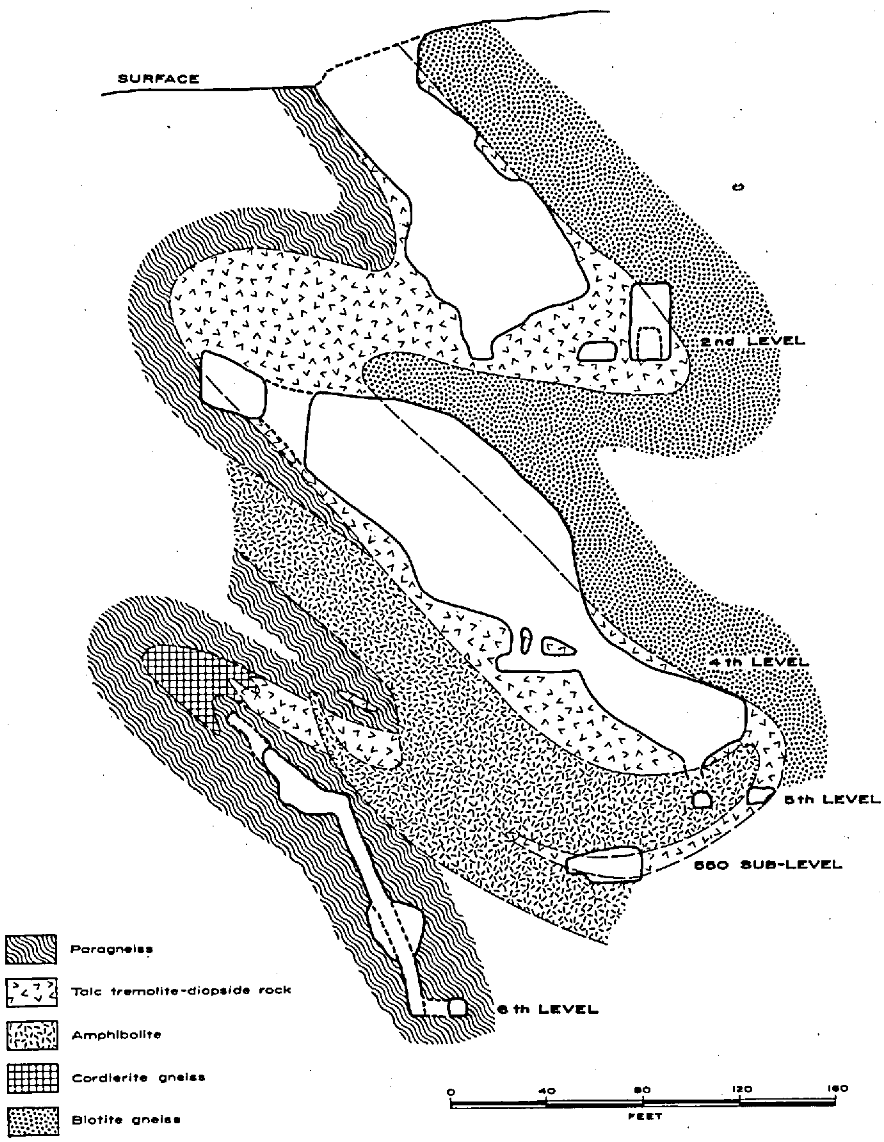


FIGURE I

**EAST-WEST SECTION THROUGH ANACON ORE ZONE 870 FEET NORTH OF No. 3 SHAFT**

Department of Mines, Quebec, 1958 No. 1112 tremolite, diopside, wilsonite, cordierite, anthophyllite, the micas, bytownite, scapolite, talc, and apatite; hydrothermal gangue minerals, apparently introduced penecontemporaneously with the sulphides, occur in only minor amounts, and are quartz, calcite, dolomite, breunnerite, chlorite and hisingerite. Vein quartz is more abundant in the northern part of the zone.

In the old mine workings a small amount of coarse, massive sulphide ore was mined from east-west tension cracks, but by far the greatest amounts of ore were found in the limestone bed, with lesser amounts in the paragneisses in either wall. Ore shoots were found along the east noses of the minor folds, and in the limbs up the dip from the east noses. Both underground and on surface, many barren bodies of wholly silicated limestone can be found, and underground there are many masses of more or less pure fireite containing only sparse sulphides. The rock most favourable to ore deposition appears to have been partially silicated limestone. In such rock the sulphides appear to have selectively replaced the carbonate portion, leaving the silicate portion more or less intact. Small grains and veinlets of sulphides are found in some silicate crystals, but most of the silicate crystals retain sharp, euhedral outlines, on which the sulphides are molded. Typical ore in the south part of the zone is, then, massive rock consisting of euhedral to subhedral tremolite and diopside in a matrix of fine to coarse grained sulphides. Within such ore are found barren silicate rock masses, some lean banded ore, fireite in isolated pods, and micaceous or talcose material in slips. In the paragneisses of the northern part of the zone, the sulphides occur in lenticular veins, commonly with quartz, in the schistose rocks, and in small masses and disseminated grains in massive cordierite-anthophyllite rock.

The average grade of the ore in the different parts of the zone is best shown by production and sampling records of the mining companies. During the time the British Metal Corporation operated the Tétreault property, the ore averaged 9 per cent zinc, 3 per cent lead, 0.1 per cent copper, 0.09 ounces of gold per ton, and 8.3 ounces of silver per ton (4, p.365). From December 1934 to May 1937, approximately 260,000 tons were milled, from which were extracted, on the average 3.73 per cent zinc, 1.15 per cent lead, 0.0139 ounces of gold per ton, and 2.03 ounces of silver per ton (7, p.4). From records of tonnages milled and millhead samples in the annual reports of Anacon Lead Mines Limited for 1949 to 1952 inclusive, the writer has calculated that the ore milled during that period contained 4.57 per cent zinc, 1.48 per cent lead, 0.020 ounces of gold per ton, and 3.09 ounces of silver per ton.

Anacon Lead Mines Limited, in their annual report for 1952, estimated ore reserves at the end of 1952 to be 772,024 tons of base metal ore containing 3.62 per cent zinc, 1.10 per cent lead, 0.011 ounces of gold per ton and 1.65 ounces of silver per ton, and 282,363 tons of precious metal ore containing 0.262 ounces of gold and 1.54 ounces of silver per ton.

Montauban Mines Limited, in their annual report for 1952, estimated their ore reserves at 379,000 tons, grading 3.5 per cent combined lead and zinc, and about 0.5 ounces of silver per ton.

According to figures given in the annual report of United Lead and Zinc Mines Limited for 1952, ore reserves at the end of 1952 were 439,363 tons of base metal ore containing 3.73 per cent zinc, 1.20 per cent lead, 0.08 ounces of gold per ton, and 0.79 ounces of silver per ton, and 81,041 tons of precious metal ore containing 0.27 ounces of gold per ton and 0.74 ounces of silver per ton.

Nocana Mines Limited

The company holds the mineral rights on lots 6 to 9, range IV, S.W., and the southeast halves of lots 6 to 11, range V, S.W., Montauban township.

The property covers the southern 2,000 feet of a continuous zone having a total length of 4,500 feet along which sphalerite and chalcopyrite are found sporadically in surface exposures. The northern part of the zone is on the property of Chateau Mines Limited (see p.33). The zone strikes N.5°E. and dips 40° to 50° east. The southernmost exposures are in the northwest end of lot 8, range IV, S.W., Montauban township; the northernmost are in the central part of lot 3, range V, S.W., Montauban township. The zone is parallel to schistosity and layering in the rocks of the hanging wall and footwall, which are rusty-weathering quartz-feldspar-biotite paragneisses containing partings of mica schist and numerous layers of pegmatite, aplite, and vein quartz parallel to the schistosity. The paragneisses are intruded by a stock of quartz diorite orthogneiss, the contact of which is parallel to, and 100 to 200 feet east of, the mineralized zone. A sill of granitic orthogneiss 200 to 300 feet wide lies 100 to 200 feet west of the mineralized zone, so that the paragneisses form an eastward-dipping sheet between the two intrusive bodies. The observed parts of the mineralized zone range in width from zero to a maximum of 7 feet. Veins and lenticles of coarsely crystalline black sphalerite, with less pyrrhotite, chalcopyrite, pyrite and rare galena, appear to have selectively replaced small, discontinuous layers within the zone. Unreplaced rock in the zone is poorly layered, quartz-rich biotite-feldspar paragneiss. Some layers are brownish to greenish in colour, suggesting the presence of silicates of lime and magnesia. A few needles of tremolite were identified on close inspection. Pods and small lenses of carbonate, probably of hydrothermal origin, are rather common in the mineralized zone. They commonly contain a little disseminated sphalerite.

The old Laurentide shaft (see p.23), now rehabilitated by Nocana Mines Limited, is near the south end of the mineralized zone on the line between lots 7 and 8, range IV, S.W., Montauban township. In June, 1952, the shaft was flooded to within 25 feet of surface. Near the shaft collar, discontinuous veins of sphalerite were estimated to make up 10 to 20 per cent of a zone seven feet wide. Smaller amounts of chalcopyrite and pyrrhotite, and a few grains of galena, are associated with the sphalerite. Some specimens of massive sphalerite from the shaft contain lenses of vein quartz and coarse books of biotite up to 2 inches in size. In a trench 45 feet north of the shaft the mineralized zone is 6 inches thick, and contains 10 to 20 per cent sphalerite and a little chalcopyrite. A small amount of pyrite, chalcopyrite, and sphalerite is sparsely scattered in minute veinlets in the hanging wall. Only a little pyrite was found in incompletely exposed rock in trenches 30 feet and 75 feet south of the shaft, on strike with the trend of the zone. In a trench 125 feet south of the shaft and 45 feet east of the line of the mineralized zone, small lenticles of sphalerite make up less than 5 per cent of a band 10 feet wide which also contains some vein quartz with a little chalcopyrite and a few veinlets of coarse magnetite. Only very small quantities of sphalerite in sparsely scattered, minute veinlets were seen in other partly flooded trenches and in outcrops to a distance of 1,500 feet north of the shaft, but exposures of the mineralized zone are scanty. Gneiss similar to the sulphide-bearing gneiss near the shaft is exposed in some of the trenches. In a north-south trench 1,500 to 1,640 feet north of the shaft, sphalerite makes up 10 to 20 per cent of a layer 10 inches wide which is exposed over a length of 40 feet. Minor chalcopyrite is associated with the sphalerite. In the hanging wall, for a distance of 1 foot, there is a little very fine grained sphalerite. Old trenches farther north are filled with forest débris.

The sulphides apparently have selectively replaced thin, discontinuous limy layers which occur in the paragneisses at a certain horizon. The only ore shoot of considerable size exposed at surface, that in the old Laurentide shaft, occurs where a greater thickness of the limy layers coincides with an apparent offset of the mineralized zone. The offset may be due to minor folding, which occurs in other parts of the mineralized zone, the axes of the folds plunging about 35° northeast. It is possible that the ore shoot is more continuous in the direction of this plunge than it is horizontally or down the dip of the schistosity. In both of these directions the cores of 25 diamond drill holes, bored by the company in 1950 in the immediate vicinity of the old Laurentide shaft, indicate that the mineralization becomes very scant in short distances. Diamond drilling in progress in June, 1952, to intersect the mineralized zone at intervals of 50 feet, and at depths of 50 to 100 feet, will no doubt shed more light on the economic possibilities of this property.

Chateau Mines Limited

The company holds the mineral rights on the northwest half of lot 1, range IV, N.E., lots 1 to 3, range IV, S.W., lot 1, range V, N.E. and lots 1 to 5, range V, S.W., Montauban township.

The eastern part of this group of claims is outside of the map-area.

The claims cover the northern 2,500 feet of a northerly trending mineralized zone which is the northern extension of the mineralized zone in Nocana Mines property to the south (see p.31).

At the time of the writer's visit in June, 1952, the inclined shaft, sunk by Adanac Mines Exploration Limited in 1928 and 1929 (see p.23), was flooded to within 40 feet of the surface. The mineralized zone had been stripped over a length of 150 feet near the shaft, revealing rusty-weathering quartz-feldspar-biotite paragneisses striking north and dipping 50° east. A zone of sphalerite-chalcopyrite mineralization, discontinuous and ranging in thickness from zero to 3 feet, is exposed in the stripped area south of the shaft for a distance of 100 feet. Sphalerite makes up less than 10 per cent of this mass, being in small lenticles and discontinuous layers, associated with chalcopyrite, which makes up 1 to 2 per cent of the mass. A few minute veins of the sulphides occur in the immediate hanging wall and footwall. Just north of the shaft there is a change in the attitude of the schistosity in the paragneisses, carrying the mineralized zone, if it exists there, out of the stripped area. In a flooded pit 150 feet north of the shaft, sphalerite makes up 5 to 10 per cent of a zone 2 feet wide in paragneisses. In a trench 350 feet north of the shaft, no sulphides were seen. Near a flooded trench 700 feet north of the shaft, numerous fragments of banded sphalerite-chalcopyrite mineral, apparently from the trench, were seen. The writer has not examined all the exposures north of this point on strike with the mineralized zone, but the northernmost exposures were mapped in 1949. In lots 2 and 3, range V, S.W., Montauban township, 1,200 to 1,600 feet north of the shaft, the contacts of a sill of granitic orthogneiss and of a stock of quartz diorite orthogneiss, between which the mineralized zone lies, are 250 to 80 feet apart, converging sharply to the north. Within the area mapped there are no exposures north of this point, on the strike of the mineralized zone.

Western Ashley Minerals Limited

The company owns mineral rights on lots 3 to 13, range I, S.W. and the southeast halves of lots 19 and 20, range I, S.W., Chavigny township, and the northeast halves of lots 38 to 41, range II, lots 9 to 14, range III, S.W. and lots 12 to 16, range IV, S.W., Montauban township.

The claims cover an area underlain by a bed of silicated limestone, described already on page 8. The underground workings driven by Montauban Metal Corporation in 1928 and 1929 (see p.24) encountered only a small pod of sphalerite. The present company has done upwards of 4,300 feet of diamond drilling to explore the limestone bed (see p. 26) intersecting it at a maximum depth of 180 feet, and tracing it for a distance of 2,900 feet west of the easternmost exposures. Apart from an isolated mass of pyrrhotite in paragneiss, which according to company assays contains no gold, the holes encountered only one or two occurrences of very sparse galena-sphalerite mineralization over widths of 1 foot or less in the limestone.

According to H.G. Kobler, who was engineer in charge of the company's field operations at the time of the writer's visit in June, 1952, a magnetometer survey disclosed strong positive anomalies along the site of the limestone bed. This is puzzling, in view of the almost complete absence of metallic minerals in surface exposures and in diamond drill cores.

The diamond drill hole 1,467 feet northwest of the Batiscan river (see p.26), according to H.G. Kobler, passed through composite gneiss and paragneiss, and ended in hornblende gneiss; only scattered mineralization, mostly pyrrhotite, was encountered.

## Conclusion

Many of the older prospect openings examined by the writer were in rusty paragneisses containing no more than their average complement of pyrite or pyrrhotite. No southerly extension of the Montauban ore zone was discovered by the wide-spaced diamond drill holes of Grandines Mines Limited (p.25 ) and Harricana Gold Mine Incorporated (p. 25) in the drift-filled valley southeast of the Anacon mine. The northerly extension of the zone across the Batiscan river is possibly represented by the hornblende-chlorite schist layer, which is probably metasomatized hornblende gneiss. It is interesting to note that the two continuous mineralized zones in the area, the Montauban ore zone and the Nocana Mines-Chateau Mines mineralized zone, lie close to the footwalls of impervious rocks, respectively grey composite gneiss and quartz diorite orthogneiss. It is possible that the concentration of metallic minerals was contingent on hydrothermal solutions migrating up these impervious footwalls and encountering easily-replaceable rock such as the limestone bed of the Montauban ore zone or the limy layers in paragneiss of the Nocana Mines-Chateau Mines zone.

## REFERENCES

1.-BANCROFT, J.A., The geology of parts of the townships of Montauban and Chavigny and of the seigniory of Grondines; Que. Dept. of Colon. Mines and Fisheries, Mines Branch, 1915, pp.103-143.

2.-ELLS, R.W., Geology of the Three Rivers map sheet; Geol. Surv. Can., Ann. Rept. Vol. 11, 1898, pp.45J-47J.

3.-UGLOW, U.L., Lead and Zinc deposits in Ontario and in eastern Canada; Ont. Bur. Mines, Vol. 25, Pt. II, 1916, pp. 3-5.

4.-British Metal Corporation (Canada) Limited. Mining and milling at the Tétreault mine; Can. Inst. Min. and Met., Bull. No. 191, March 1928, pp.347-366.

5.-ALCOCK, F.J., Zinc and Lead deposits of Canada; Geol. Surv. Can., Ec. Geol. Series No. 8, 1930, pp. 79-90.

6.- OSBORNE, F.F., The Montauban mineralized zone, Quebec; Ec. Geol., Vol. 34, 1939, pp.712-726.

7.- O'NEILL, J.J. and OSBORNE, F.F., Tétreault mine, Montauban-les-Mines, Portneuf county; Que. Bur. Mines, P.R. No. 136 (1939).

8.- WILSON, N.L., An investigation of the metamorphism of the Orijarvi type deposits at Montauban-les-Mines, P.Q.; McGill Univ. unpublished Ph. D. thesis (1939).

9.- SMITH, J.R., The geology of the Montauban les Mines mineralized area; Laval Univ. unpublished M.A. Sc. thesis (1950).

10.-ADAMS, F.D. and BARLOW, A.E., Geology of the Haliburton and Bancroft areas; Geol. Surv. Can. Mem. No. 6 (1910).

11.-OSBORNE, F.F., Intrusives of part of the Laurentian complex in Quebec; Am. Jour. Sc., Fifth series, Vol. 32, 1936, pp.407-434.

12.-OSBORNE, F.F., The contrasting plutonic massifs of Rivière à Pierre, Quebec; Am. Jour. Sc., Fifth Series, Vol. 27, 1934, pp.417-431.

13.-DUFRESNE, A.O. et al, The mining industry of the province of Quebec in 1949; Que. Dept. Mines.

14.-CORNWALL, F.W., United Montauban property; Que. Dept. Mines unpublished report, Aug. 12, 1953.

ALPHABETICAL INDEX