CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH

GEOLOGICAL SURVEY

PAPER 44-10

THE LONDONDERRY IRON DEPOSITS, COLCHESTER COUNTY, NOVA SCOTIA

(Report and Map)

BY

L. J. Weeks

OTTAWA

1944

CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH

GEOLOGICAL SURVEY

Paper 44-10

THE LONDONDERRY IRON DEPOSITS, COLCHESTER COUNTY, NOVA SCOTIA

by

L. J. Weeks

OTTAWA, 1944

CONTENTS

Illustration

THE LONDONDERRY IRON DEPOSITS, COLCHESTER COUNTY, NOVA SCOTIA

INTRODUCTION

The iron ore of the Londonderry district consists of enrichments by surface waters of numerous lenticular masses of ankeritic carbonate that occur in a complex of sedimentary and volcanic rocks within and near the south flank of Cobequid Mountains.

A detailed examination of these deposits was undertaken during the geological mapping of the Londonderry and Bass River map-areas in 1941 and 1943. During the latter season the examination was limited to that part of the district lying between Pine and Totten Brooks, and a large-scale plane-table map of that area was prepared. None of the old workings was entered, and knowledge of the ores themselves was gleaned largely from material in a large dump near the site of the old blast furnace, which presumably represented economic ore at the time operations ceased.

LOCATION AND EXTENT

The Londonderry iron district lies in Colchester county, Nova Scotia, on the south flank of Cobequid Mountains, and mainly within the southern 1½ miles between Portapique and Debert Rivers, which flow south from the mountains about 14 miles apart. The main line of the Canadian National Railways crosses this belt slightly to the east of its middle, and about 4 miles east of the village of Londonderry. Only two roads cross the belt from south to north, following respectively the valleys of Great Village and Folly Rivers. A good secondary road, termed the Base Line road, follows the south side of the belt from Matheson Brook to Weatherbe Brook. All parts of the belt are, however, accessible by wood roads, many of which could at small expense be made suitable for mechanized transport.

HISTORY

The following outline is gathered largely from Woodman's report[1], with additional information from early reports of the Nova

1 Woodman, J.E.: Report on the Iron Ores of Nova Scotia; Mines Branch, Dept. of Mines, Rept. No. 20, 1909.

Scotia Department of Mines.

In 1849 the first commercial operations were commenced by the Acadia Iron Works, utilizing six Catalan forges and a puddling furnace. In 1852 a charcoal blast furnace was put into operation and continued intermittently until 1875. In 1870 the first steel plant was inaugurated, and shortly thereafter Dr. Siemens made here his first experiments in the direct conversion of iron into steel. In 1877 the first coke ovens were built, and the use of charcoal discontinued. In 1874 the properties were purchased by the Steel Company of Canada, which went into liquidation in 1899. In 1902 the Londonderry Iron and Mining Company acquired the property and continued operations until about 1908, since when no mining or smelting has been done in the district.

It is difficult to ascertain from the early reports what specific parts of the district were being mined at any one time in its history. It is probable, however, that the earliest workings were located on the west bank of Great Village River, in that section known as the "Old Mountain"; that during a later period of the district's history work was confined largely to the area between Martin and Cumberland Brooks and, to the west of the latter, a section known as "West Mines"; and that during the last phase of activity work was commenced at East Mines, east of Folly River, and continued at Old Mountain, with some activity at West Mines.

TOPOGRAPHY

Cobequid Mountains are 10 to 14 miles wide and extend from Cape Chignecto on the west to the Carboniferous lowlands of Pictou county on the east. The top of the range is flat and featureless, lying between 900 and 1,000 feet above sea-level. The southern face of the mountains is quite abrupt, and remarkably straight for long distances. South-flowing rivers leave the mountains in deep, steep-walled gorges, the bottoms of which are usually a series of cascades or falls for some miles into the highlands. The iron deposits lie within the southern mile or so of the mountains, and it will be shown that the topography peculiar to that section has a direct bearing on the enrichment of the iron ores.

GENERAL GEOLOGY

Cobequid Mountains are underlain by a complex of pre-Carboniferous volcanic and sedimentary rocks cut by acid plutonic rocks and by minor basic intrusions. Overlying this complex on the south, and separated from it by a great erosional unconformity, are sedimentary rocks of Pennsylvanian age. Farther south these rocks, in turn, are overlain unconformably by volcanic and sedimentary rocks of Triassic age. The iron deposits are found in the pre-Carboniferous complex of Cobequid Mountains.

The Cobequid Complex

The rocks of the Cobequid complex may be conveniently divided into two groups, an older group of grey, slightly reddish brown weathering, well-bedded, sandy shales, and a younger group consisting of sedimentary and volcanic rocks of various compositions. Intruding these rocks are large bodies of granite-gneiss and granite, and smaller masses of granite porphyry, diabase of which two ages are recognized, and minor intrusions of intermediate composition.

Older Sedimentary Rocks. Sedimentary rocks of the older group are exposed near the headwaters of Matheson Brook and on Portapique River and its tributaries. It is quite probable that they occur in other districts, but were not recognized. On the second brook entering Portapique River from the east, within the mountains, these rocks are well exposed for over half a mile, their appearance conforming to the above description throughout the entire section. They dip uniformly to the south at angles of nearly 45 degrees, and thus may be assumed to be older than the mixed sedimentary and volcanic rocks found farther south on this and nearby streams. No minor intrusions were found in them, but they are believed to be cut by granite, and probably also are intruded in places by the former.

No fossils were found in these rocks. Norman[1], however,

---

[1] Norman, G.W.H.; Geol. Surv., Canada, personal communication.

found fossils in similar rocks while mapping the Oxford area, immediately to the north of the Londonderry area, in 1932. These were identified by E.M. Kindle of the Geological Survey as Monograptus ? sp., Chonetes sp., Anoplotheca hemispherica, and Orthis tenuidens, and the assemblage was referred to the Silurian. The writer, while working near Bridgeville in Pictou county in 1943, was struck by the acute resemblance between rocks underlying the Carboniferous limestone there, which have always been considered Silurian in age, and the rocks of the earlier Cobequid sedimentary group. A correlation with the Silurian cannot, however, be considered conclusive until fossils of the same age are discovered.

So far as is now known the older sedimentary rocks have no bearing on the occurrence of the iron deposits.

Younger Group of Sedimentary and Volcanic Rocks. Rocks of this group underlie the south flank of the Cobequid Mountains from the eastern limit of investigation, between Totten Brook and Debert River, at least as far west as Bass River, and possibly to the western limit of investigation, on East River of Five Islands. With the exception of intrusive rocks, they, therefore, underlie all those parts of Cobequid Mountains shown on the accompanying map. The rock types found in the group are grey-black to pearl-grey, poorly bedded to completely unbedded, fine-grained, sedimentary rocks or volcanic ash beds; poorly bedded to well-bedded grey shales; light grey to white quartzite or silicified tuff; chlorite schists showing varying degrees of alteration, and believed to be volcanic in origin; fine-grained, light grey conglomerate or volcanic breccia, containing pebbles or small bombs up to 5 millimetres in diameter; and black graphitic schist. Of these various rock types the graphitic schist appears to be the only one with a definable area of occurrence. It has been found only near the south contact of the mountains, and is in many places, but not everywhere, the first rock encountered on entering them.

In addition to the rock types enumerated above, the assemblage is cut by basic intrusive rocks of at least two ages, and by dykes and masses of intermediate rocks, many of which when seen in isolated exposures can only be differentiated with difficulty, if at all, from some of the rocks of the group they cut.

Outcrops do not in general occur in the interstream areas, and as the main brooks flowing from the mountains are between ½ and 1 mile apart it has not been possible to project lithological horizons from one stream to another, particularly as variations in the rock types are not distinct, and, in addition, are complicated by the presence of small intrusive bodies. As a result, faulting in the rocks of the mountains, unless it is post-Carboniferous and displaces the south contact of the Cobequid complex, or unless it displaces the contact between the earlier and later groups of the complex, cannot be safely appraised. That significant faulting has occurred is well indicated by zones of considerable shearing, and, in places, by the exposure of a fault plane. In no instance, however, except as noted above, can the amount of displacement be estimated, and no such faults were observed within the area of the map accompanying this report.

Thin sections were made from a number of rock specimens from this group, none of which was known definitely to be of sedimentary origin. Under the microscope, several of the sections indicated by the extreme angularity of the constituent grains that they were probably derived from specimens of fine-grained tuffs. Highly chloritized rocks, generally termed "greenstone" in the field, did not display, in thin section, features diagnostic of either extrusive or pyroclastic origin.

Large, shadowy masses of variable texture and composition could be recognized in a general mass of chlorite, but whether they represented fragments in a breccia, or altered phenocrysts in a porphyry, could not be determined.

Black, graphitic schist, as previously mentioned, occurs commonly near the contact of the Cobequid complex with Carboniferous rocks on the south. The rock is very fissile and usually extremely friable, almost approximating a fault gouge. Graphite, which gives the rock its colour, occurs as a thin coating on the parting planes of the schist. In no place is it exposed over a width greater than 20 or 30 feet, and is usually in contact on the north with grey, massive, sedimentary rocks. The schist is believed to represent a zone of considerable shearing in rocks originally similar to those found to the north of it, and probably indicates an almost east-west fault near the southern edge of the mountains.

Correlation of the rocks of this younger group with others of known age is very difficult. Plant stems have been found in the sedimentary members, but those examined by W.A. Bell were not determinable.[1] Fletcher called the sedimentary assemblage of Cobequid

---

[1] Bell, W.A.: Geol. Surv. Canada, personal communication.

Mountains Devonian, but did not subdivide it. In the detailed study of the Nictaux-Torbrook iron district, E.R. Faribault, in 1921, found a group of acid extrusive rocks interbedded with slates and shales about a mile south of the South Mountain iron bed.[2] Somewhere near

---

[2] Faribault, E.R.; Geol. Surv. Canada, personal communication.

---

these extrusive rocks is the contact between the very similar slates of Devonian age and of the Gold-bearing series, and it was not established whether the lavas formed a part of the former or the latter. Should these volcanic rocks be correlatives of the Devonian of the Nictaux-Torbrook basin, which may be considered quite possible or even probable, as extrusive rocks are not found elsewhere in the Gold-bearing series, a Devonian age for the intermixed sedimentary and volcanic rocks of Cobequid Mountains is at least strongly suggested. On the basis of contact relationships observed within the mountains themselves, the sedimentary-volcanic group is younger than that group of sedimentary rocks previously described - which has a better than average chance of being Silurian - and is older than rocks of Pennsylvanian age bounding it on the south.

Intrusive Rocks

The intrusive rocks of Cobequid Mountains compose two groups, namely, minor irregular intrusive bodies of basic to intermediate composition, and batholithic intrusions, usually of granitic composition. The first group comprises rocks of two ages, the earlier of which cannot always be distinguished from volcanic rocks.

Minor Intrusions. Within the area covered by the accompanying map fresh, diabasic, intrusive rocks are extremely plentiful along both sides of Great Village River north of Old Mountain mines, on the upper parts of Rockland River, and, less commonly, on Cumberland and Matheson Brooks. At these localities the diabase occurs as irregular masses, usually only about 100 feet across, cutting earlier sedimentary or volcanic rocks. On the road from Londonderry to River Philip, and about ½ mile south of the north boundary of the map-area, an older, very much chloritized rock is in sharp intrusive contact with sedimentary beds, and in the same exposure is cut by the later, fresh diabase. Except for the intrusive nature of its contact, the chloritized rock might readily have been classed as volcanic, and it is probable that elsewhere other, similar intrusive bodies may have been incorrectly mapped as volcanic rocks.

On Pine Brook, a few hundred feet north of a zone of iron carbonates, well-bedded shales are intruded by a light grey, dense rock determined under the microscope to consist of a mass of fine quartz crystals and a few small flakes of biotite lying in a finer groundmass of mainly sericite with some carbonate. Rock similar to this has been found on high ground to the immediate west of the workings of Old Mountain mines, but no relationships with surrounding rocks could be determined.

Batholithic Intrusions. Rocks of this group include, in the order of their prevalence, granite, granite-gneiss, diorite, granite porphyries, syenite, quartz diorite, and pegmatite. Within the area of the accompanying map coarse granite is exposed on the Cumberland Brook road a short distance north of the headwaters of Cumberland Brook, and represents the southernmost limit of a granitic body extending to the north side of the mountains. Although no other body of batholithic dimensions is known within the map-area, at several places the volcanic and sedimentary rocks are intruded by small bodies of granitic rock, whose presence is indicated more by the alteration of the older rocks, chiefly by granitization or lit-par-lit injection, than by the extent of the intrusion itself. Such areas occur on Great Village River north of the mines; on the high ground between Great Village and Rockland Rivers; and on Folly River near its forks, just south of the north boundary of the map-area. These intrusions, in their present position, have no bearing on the iron deposits, although it is probable that the solutions responsible for the formation of the primary ankerite bodies were related to one or another of them.

Pennsylvanian

The rocks of Cobequid Mountains are bounded on the south by reddish brown conglomerates and sandstones of Pennsylvanian age, whose correlation with other Pennsylvanian groups in the province has not been satisfactorily worked out. Separating the Pennsylvanian strata from the Cobequid complex is an angular unconformity of considerable magnitude. Although the extreme straightness of the south boundary of the Cobequid rocks might lead to the assumption that the contact is along a fault, such is not believed to be the case. That a fault exists on the south side of the mountains is granted, but it existed prior to the sedimentation represented by this Pennsylvanian group. The actual contact between the rocks of Cobequid Mountains and the Pennsylvanian beds has been observed on Folly River and on a branch of Carr Brook some 25 miles to the west. At both localities the basal conglomerate of the Pennsylvanian is composed entirely of material derived from underlying Cobequid rocks. Similar relationships were found on two other brooks without the actual contact being exposed. Two, small, isolated masses of Pennsylvanian beds have been located within the mountains proper, and at both places contacts are exposed, indicating a large angular unconformity and exhibiting lithological characteristics similar to those just described.

The Pennsylvanian rocks have no bearing on the iron deposits.

Triassic

The Pennsylvanian rocks are in contact on the south with bright red sandstones and conglomerates of the Annapolis formation. For the greater part, if not all, of the distance between Debert River and Five Islands this contact is a normal fault with a downthrow on the south side. The Triassic rocks have no bearing on the iron deposits.

MINE WORKINGS

In the interval between the inauguration of mining in the district, nearly a century ago, and cessation of operations in 1908, activities were extended to three principal areas. Although it is not always, or even often, possible to determine at what period any particular work was done, yet the excellent series of plans and sections submitted by J.E. Woodman in his report of 1909[1] give a clear impression of the total extent of the workings in 1906, when he

---

[1] Woodman, J.E.: op. cit.

---

visited the district. These will be discussed from west to east.

West Mines

The West mines include those workings between Martin and Cumberland Brooks, and those on the west side of the latter. Work apparently began in these sections about 1874, and was continued until operations in the district ceased.

West of Cumberland Brook work was carried out, and then discontinued, at a relatively early date. Three levels were driven into the hill from the brook valley, the upper one being about 1,000 feet long. Two bodies of ore were mined, the most westerly lying between the surface and the upper level about 800 feet from the portal, and the more easterly between the surface and slightly below and about 300 feet from the portal of the intermediate level. As work was usually discontinued downward when unaltered carbonates were encountered, it would appear that the line separating enriched ore and unaltered carbonate lay about 150 feet below the surface of the hill.

Between Martin and Cumberland Brooks more concentrated mining has been done than in any other section. One level, No. 5, is a tunnel driven through the ridge a distance of about 4,300 feet, with portals in each brook valley. Altogether three adit levels, Nos. 5, 6, and 7 (numbered downwards), open out into Cumberland Brook Valley, and four, Nos. 2, 5, 6, and 7, into the valley of Martin Brook. The levels are about 100 feet apart vertically, with none between Nos. 2 and 5 levels. For inter-level hoisting, three shafts were sunk in the line of workings, each reaching the lowest level at that place. The Jamme shaft, about 600 feet west of Martin Brook, reached three short blind levels below No. 7; the McClellan shaft, about halfway between the brooks, was sunk to a depth of one level below No. 7; and the Dufferin shaft, 1,425 feet east of Cumberland Brook, reached two levels below No. 7. In addition a number of shallow air shafts reached the upper levels only.

The mineable ore apparently extended to quite varying depths in different parts of the section between the brooks. It reached its greatest depth about 600 feet west of Martin Brook, in workings tapped by the Jamme shaft, where ore was stoped to 300 feet below stream level. This ore shoot was apparently small, as it was mined for less than 150 feet from the shaft. At 1,500 feet west of Martin Brook unaltered carbonate was found apparently closer to the surface than at any other point, mining having been carried to a depth of only 50 feet below the surface. Beginning just west of the Jamme shaft is a zone 1,200 feet long in which no mining was done below 150 feet from the surface. Between there and Cumberland Brook, however, mining was extended over large sections to depths of 150 feet below brook level, and, according to Woodman, did not in all cases bottom in unaltered carbonates.

Old Mountain Mines

This section, in which some of the earliest, as well as the latest, work was performed, lies on the steep west bank of Great Village River about 3,000 feet north of the bridge on the Base Line road. Although not generally included in this group, and not connected with it by underground workings, for convenience the openings on Cook Brook will also be dealt with in this part of the report.

The Cook Brook workings consisted of three levels, each with two openings, one on the west side of the valley and one on the east. The workings were not extensive, the upper and longest level being driven 600 feet on the west and 450 feet on the east. The intermediate level was apparently exploratory and was driven only a few feet on the west and about 150 feet on the east. The lowest level, because it had to surface considerably downstream from the ore zone, was quite long on both the east and west, but apparently just reached the ore zone. It is not known how much ore, if any, was obtained from these workings, but there are no indications of a narrow-gauge railway to the workings, suggesting that production had been small.

On the west bank of Great Village River, six adit levels were driven, Nos. 1 and 2 being at the same elevation, but unconnected. Of the others, No. 3 is the only one of any extent, Nos. 4, 5, and 6 being exploratory holes driven a short distance into the hillside.

No. 1 level was driven 900 feet into the hill from a point 250 feet above the river, and apparently was not at any point more than 50 feet below the surface, which flattens after the steep slope from the river. Mining was carried out along this level, mainly from a series of open-cuts from which the broken ore was dropped through chutes into the level and drawn to the portal. Caved ground is quite extensive along this level, indicating that mining was carried almost to completion between the level and the surface.

No. 2 level has its entrance about 600 feet north of that of No. 1, and, as mentioned, at about the same elevation. The workings extend about 1,000 feet west of the portal. No open-cuts were made above the workings, but the latter may be traced quite easily on the surface by a succession of slumps.

No. 3 level lies about 80 feet below No. 2, and is connected with it by one hoisting shaft near the west end. One large open-cut was apparently mined by discharging into this level in a section not tapped by No. 2. The adit is in such a condition as to suggest that with a small outlay the mine could be entered, and indeed it was entered as late as 1938, but the portal has since caved.

Below No. 3 in the north and No. 1 in the south are Nos. 4, 5, and 6 levels. These are driven 300, 120, and 40 feet respectively into the hillside, but are not connected with workings of a productive nature. It is understood that work was being done on these levels when operations ceased.

East Mines

The East Mines district lies about 5 miles east of the village of Londonderry, and at one time was connected with East Mines Station on the Canadian National Railway by a full-gauge railway, which was used to transport the ore to Londonderry for treatment. Work was apparently commenced in this district quite late in the history of the mines, and was being carried out when operations ceased. At the East mines there were two sets of openings, the westerly, called the Gory Brook workings, connected directly with the full-gauge railway line, and the easterly, or Weatherbe Brook openings, connected with the Gory Brook workings by a narrow-gauge railway. In addition, the roadbed for another railway was being constructed to a point about 1 mile west of Gory Brook when work ceased. No workings were driven at the latter point.

Gory Brook Workings. The main opening of these workings was on the hillside directly north of a loading trestle at the end of the full-gauge railway. From the adit, levels were driven north 700 feet to the ore zone, from which point 1,500 feet of east-west workings were cut in the ore. Several open-cuts exist along the ore zone, two at least of which must have been mined by discharge into the workings below. Seventy five feet below the workings tapped by this adit is another level whose workings have an east-west extent of 3,000 feet, and which was apparently entered from another opening on Slack Brook, about ½ mile west of Gory Brook. Ore from this level, however, was handled from the Gory Brook adit, being hoisted to the upper level in a shaft near the ore and north of the Gory Brook portal. Apparently this lower, or Slack Brook, level was driven mostly in unaltered carbonates with small pockets of ore.

Weatherbe Brook Workings. These workings are on Weatherbe Brook, about ½ mile east of the Gory Brook workings. Two parallel zones, about 1,200 feet apart, were tapped from the main adit on the brook, the northern zone being worked almost entirely from underground workings and the southern by large open-cuts and underground workings. Ore was won in places at a depth of 150 feet below the surface, but deeper levels apparently did not find any. It is believed that a dump at Londonderry of some thousands of tons of ore was derived either from the Weatherbe or the Gory Brook workings, as it is piled where it would have been dumped from the full-gauge railway over which East Mines ore was brought to the furnaces.

Ankerite Quarries

Although the early operators did not consider ankerite an ore, yet that material was quarried extensively for use as a flux in the furnaces, in lieu of limestone that would add no extra iron to the melt. The ankerite was obtained from two localities, one at Old Mountain, and one at East Mines.

Two quarries were operated at Old Mountain, the largest in a steep cliff face of the west bank of Great Village River, and a little to the south of the mine workings there. The quarry cutting was some 30 feet wide, with a difference of elevation between top and bottom of about 120 feet. The bottom of the quarry was about on the level of the roadway along the west river bank. The second Old Mountain quarry is on the flat top of the hill, and although originally operated as an open-cut quarry was finally connected to the underground workings of No. 1 level. It is of interest in that, although normal ankerite was obtained from the quarry, yet the mine workings below it obtained some enriched ore.

At East Mines one of the eastern open-cuts of the Weatherbe Brook workings is marked on Woodman's plan as "ankerite open-cut". It is assumed, although no other mention is made of it, that the material from this cut was used as flux, as was the material from the quarries at Old Mountain mines. This open-cut is located on a relatively flat piece of land, about 400 feet east of Weatherbe Brook, and is surrounded on three sides by open-cuts from which iron ore apparently was obtained.

PROSPECTED AREAS

In addition to those sections in which actual mining was performed, some work of an exploratory nature has been done in various other parts of the district, both by the companies operating the Londonderry mines prior to 1908 and by individuals and companies at later dates. A summary of this work and the results, if any, will be given, traversing the district from west to east.

Matheson Brook Section

Matheson Brook is about $1\frac{1}{2}$ miles west of Cumberland Brook and is not shown on the accompanying map. In 1942, two parties prospected the immediate environs of the brook, one under Mr. Bernard Sky, operating for himself, and one under Mr. George Coolan, operating for the Dominion Steel Company.

The first-named party sank two shallow pits three-eighths mile apart, east and west, on Whetstone Brook, a tiny tributary from the east of Matheson Brook, and 1 mile north of the Base Line road at Mr. W. Carroll's farm. In the western pit, about 200 feet from the confluence of the two brooks, was a north-south striking vein of oxidized iron carbonates about 6 inches wide. The eastern pit showed some oxidized carbonates on the dump, but no vein could be found in the pit.

Coolan's party sank several shallow pits on the flat top of the mountain about $\frac{1}{2}$ mile west of Matheson Brook, and about a mile north of the Base Line road, and in addition drove a short adit into the hillside on the west bank of the brook at a point where the flat top of the mountains gives way to steep slopes down to the lower land to the south. The first-mentioned pits were purely exploratory, and, so far as is known, nothing was found. The short adit was driven at a point where several stringers of specularite were visible on the cliff, and a few more stringers were exposed in the adit, but nothing to approximate commercial ore.

Derry Hematite

About $\frac{1}{2}$ mile north of Old Mountain mines, and on the steep north bank of a tributary of Great Village River, a body of flinty black hematite was discovered lying between the almost vertical contact of fine-grained diabase on the north and sedimentary rocks on the south. An open-cut was sunk 10 or 15 feet on the outcrop of the ore, and an adit driven to intersect the body from a point farther down the hillside. A bore-hole was then drilled at an angle of about 45 degrees to intersect the ore-body at a depth of around 200 feet, at which depth the diabase was entered without encountering any ore. No further work was done thereafter.

Section Between Great Village and Folly Rivers

Of this section, Woodman[1] says: "Although the iron-

[1] Woodman, J.E.: op. cit., p. 160.

bearing zone has long been known to extend through the country between Old Mountain and East Mines, little has been done to explore it. A few short drifts, such as the Drummond, Ferguson and Boutilier levels have been run, but no attempt appears to have been made to follow the ankerite and siderite for any distance. This may be because of an evident scarcity of brown and black ores, compared with the abundance in earlier years on Old Mountain and thence westward.

On the hill between the two branches of Great Village River[2] are a number of shallow pits as well as short levels.

[2] Great Village River and Rockland River, on the map.

Thence eastward a few pits have been sunk to ore; but there is no underground development, except on Weigh-house brook, ... The extent of this is not known, but it is not great."

With the exception of two caved adits, one at the head of a small brook entering Rockland River just north of Londonderry, and the other at the head of the middle of three forks of a branch of West McElman Brook, there are few signs today of any work having been performed in this section. The first-mentioned brook may be the "Weigh-house Brook" of Woodman, no brook being known by that name today.

Pine Brook - Totten Brook Section

Pine Brook lies a little over ½ mile east of Weatherbe Brook and Totten Brook about ¾ mile east of it. This section, therefore, is a direct continuation eastward of the East Mines district.

A large body of ankerite was discovered early in the century near the top of the steep east bank of Pine Brook and about ¾ mile north of the continuation of the Base Line road. About 500 feet east of this exposure a small open-cut into a hillside showed the body at this point to have a width of at least 70 feet, with scattered isolated exposures nearby indicating that the width might be greater. On the steep bank of Pine Brook, and 45 feet below the first-mentioned exposure, a short adit was driven into the hillside, and apparently mostly in ankerite. The length of this level is not known, but it would appear from the size of the dump to be about 80 to 100 feet long. The writer was informed by local farmers and by Mr. Coolan that this section was being developed when operations ceased over the entire district.

About ½ mile east of Pine Brook, at the point referred to above, and extending eastward almost ½ mile to Totten Brook is a low, linear swamp 200 to 400 feet wide, having an elevation only a few feet above Totten Brook, and known locally as Peter Totten Meadow. Exposures of massive iron carbonates, both with and without oxide enrichment, had been discovered along the steep north side of the meadow, and several trenches and one small open-cut were dug in them. Where enrichment has occurred the ore was of good grade, and the small amount of it hauled to the furnaces was of considerably better grade than that obtained from East Mines.

So far as is known, no other prospecting has been done in the district.

IRON DEPOSITS

The deposits of iron ore are apparently[1] oxide enrichments, by surface waters, of lenticular masses of iron-bearing carbonates, of which ankerite, a calcium-magnesium-iron carbonate, is most common. Owing to the inaccessibility of the deeper workings, carbonate below the zone of oxidation and enrichment has not been observed by the writer, and is described by Woodman merely as "spathic ore and ankerite" (siderite and ankerite), terms that may be used to cover the possible carbonates present in depth, or, on the other hand, to indicate more precisely that both are present and have been observed.

[1] The possibilities of the enrichment being due to processes other than those of surface waters will be discussed on page 21.

In general the unenriched carbonates have no possibilities as ore. This statement, however, may be amended to admit that a body of siderite of large size and free of ankeritic impurities (two conditions that are not at present known to exist in this district) may be classed as a low-grade ore of iron.

A possible use, other than as an ore, exists, however, for ankerite. During the period of production at Londonderry no limestone was used in the furnaces as a flux, ankerite being used exclusively for this purpose. Limestone, of course, added no iron to the melt, whereas ankerite, carrying from 10 per cent or more of metallic iron, often added considerable amounts of this metal, and apparently was as satisfactory as a flux.

Primary Carbonate Bodies

The primary carbonate bodies lie in close proximity to, and almost strictly parallel with the pre-Pennsylvanian fault marking the south face of Cobequid Mountains. The bodies are a series of roughly parallel lenses, whose boundaries in detail are exceedingly irregular. Fragments of country rock occur throughout the carbonate mass, but show no signs of having been brecciated to their present shape. The carbonate crystal grain varies from quite sugary, with about ½ millimetre grain size, to coarsely crystalline. The width of the carbonate bodies varies from mere stringers to masses 50 to 100 feet across. There are no signs in the carbonate of banding or other structures such as might indicate bedding inherited from replaced sedimentary rocks.

The above features, together with the fact that at no place were clean fissure walls found bordering the carbonate, suggest that although access was undoubtedly provided originally by fissures yet the actual formation of the carbonate took place by replacement of the rock bordering the fissures. The coarse grain of the carbonate in places cannot be considered as detrimental to such a theory, as occurrences of equally coarse-grained carbonate are known elsewhere to be entirely the result of replacement.

The deepest workings, and in fact all workings that were sunk below the zone of enrichment, bottomed in unaltered carbonates. This fact alone may be considered as strongly favouring a hypogene origin for the carbonate bodies, and such a theory was also held by Woodman. He, however, mentions one fact that might militate against such a theory, although it does not sway him, namely, that he was unable to find carbonate crossing the beds of brooks, even where well exposed on the slopes above them. The writer paid particular attention to this statement when traversing streams that cut across the ore zones, and found that no stream had a completely solid section of rock across such zones. When it is remembered that the carbonates are much softer than the country rocks of the mountains and much more soluble, the flat statement that massive carbonate bodies do not cross the brooks cannot be accepted.

Granting a hypogene origin for the carbonate bodies, the actual source of the carbonatizing solutions is not immediately apparent. The assumption is that the solution emanated from some not too distant igneous mass during its period of intrusion. Although in parts of the iron belt granite is either exposed nearby or its proximity is suggested by other features yet in other equally productive sections the nearest known granite is several miles away. The diabasic intrusions are not at all plentiful in the carbonate zones, in fact certain sections of the iron belt are almost unique in the complete absence of such rocks. The minor intrusions of intermediate composition, however, have only been definitely established in the Pine Brook section, and are believed to exist in the Old Mountain section. Mention has been made of the difficulty, barring actual exposure of an intrusive contact, of differentiating these rocks from some of the volcanic rocks, and it may be assumed that rocks of this type are more plentiful than can be definitely stated. Thin sections taken from the only known intrusive body shows the presence of carbonate as a very late interstitial mineral, but with nothing to suggest that it has replaced an already consolidated rock. The writer, however, considers these facts suggestive of a relationship rather than as conclusive evidence of such.

The age of these various intrusive rocks is not definitely established, but they may be considered to be related to the main batholithic intrusions of the province, which are believed to be Devonian. An establishment of the age of the intrusive parent of the carbonatizing solutions would define an earlier or concurrent age for the fissures that gave access to the solutions. As these fissures are believed to be connected in age with the main fault of the south face of the Mountains, the time of uplift of the mountain block by faulting could be similarly defined.

As was mentioned previously, the composition of the carbonate below the zone of oxidation and enrichment is not known. It would be of considerable value to know whether it is ankerite and whether the known occurrences of siderite are the result of supergene processes; or whether mixtures of ankerite and siderite made up the primary bodies. The reasons will be clear, because if the former is true no bodies of siderite (which as mentioned above might be considered a low-grade ore) will be found below the zone of ground water enrichment, whereas if the latter is true lenses of siderite might go to any depth reached by the carbonates as a whole.

Mention should be made of two accessory minerals occurring in the carbonates. Pyrite is occasionally present in tiny euhedral crystals. That it is not present in any quantity is shown by extremely low percentages of sulphur in the various analyses quoted in Woodman's report. The other mineral, specularite, is extremely plentiful in places. It occurs as veinlets, seams, and isolated needle-like forms. Under the microscope it appears in part to have been deposited simultaneously with the carbonates, and in part to be a little later. The former relationship, if well substantiated, would alone indicate a hypogene origin for the primary carbonate bodies.

Enrichment of the Carbonate Bodies

The weathering of the carbonate bodies, the subsequent transportation downward of iron-rich solutions by percolating surface waters, and the later deposition in the carbonate bodies of various iron oxide minerals from these solutions, gave origin to lenses in the carbonate that could profitably be mined as ores of iron. The products of this supergene enrichment are mostly forms of limonite, together with small amounts of hematite, and possibly some siderite. Mention will be made in this section also of occurrences of specularite as a minor primary constituent of the carbonate, mainly because such occurrences definitely "enrich" the rock, and might conceivably be plentiful enough in any one place to raise an otherwise low-grade carbonate to the status of an ore.

When it is remembered that mining operations were pursued in this district for about 80 years, it is inevitable that a number of terms descriptive of the ores should come into local usage, and be well understood by those familiar with the district, although having a very inexact application if used in any other mining district. Where no confusion can exist, these local terms will be retained in the description of the ores.

Types of Ore. Paint ore is yellow-brown, earthy, ochreous limonite, and is found on or within a few feet of the surface. Bottle ore is hard, black, botryoidal limonite or goethite,[1] and was found either as residual bodies in the soil

[1] An analysis for combined water was made by the Mineralogical Section, Geological Survey, on a specimen of bottle ore found on a West Mine dump. The results showed the mineral to be intermediate between limonite and goethite, the combined water content being 12.3 per cent.

overlying ore-bodies, or as cavity fillings in the rock close to the bedrock surface. Red ore is, as might be suspected, red, earthy hematite, and was rather uncommon. White ore is siderite sufficiently free from ankerite to be classed as a low-grade ore. Specular ore or specularite occurs as thin, platy deposits in cracks in the carbonate, and also as needle-like aggregates in solid carbonate. Woodman states that it is a surface mineral only and is not found at any depth, a statement that is somewhat out of keeping with its known high temperature origin. Brown ore and black ore are terms used in Woodman's report, which the writer finds rather confusing, as specimens of ore satisfying both these descriptions have been found to be essentially the same, namely, a hard sintery mass of limonite replacing, almost completely, the carbonate that originally made up the rock.

Bottle ore and paint ore, as mentioned, were found only close to the surface, and generally over the whole mined extent of the district, but the former was particularly plentiful in that part of West Mines between Cumberland and Martin Brooks. Bottle ore carried about 57 per cent iron and paint ore 35 to 38 per cent.

Of the specular ore, Woodman[1] says:

[1] Woodman, J. E.: Op. cit., p. 152.

"Another fairly superficial ore is the specular. Doubtless it should be called specular hematite; but its streak is brown rather than red, often even yellowish, and it contains a variable percentage of water. There is need of a variety name to designate such a mineral. The specular ore is fine to coarse, and occurs in form from thin filaments and stringers in other ore up to large pockets of many tons. Like the bottle ore it is one of the most recent formations; but it is in far larger amounts than the former and does not line cavities but forms a dense mass. It is developed locally, owing to causes which are not apparent. In some instances it is near igneous rock, which, however, long antedate its formation. In others it has no environment which might be used as a clue. Thus, analyses of the Totten Brook old workings at East Mines show a comparatively large percentage of specular ore, while westward toward Slack Brook there is little, limonite being the oxide. In this case proximity of igneous rocks might at first sight appear to account for the change to specular ore. But in the western part of the property now worked - Cumberland Brook and West Mine - the ore west of the brook consists of a mixture of ankerite, siderite and specular iron. .... In this case intrusives could under no circumstances have influenced the ores. ...."

Specularite is a high temperature mineral, and as such may be produced by primary igneous activity, by hydrothermal alteration, or by deep-seated metamorphism. At Londonderry specularite is in part contemporaneous with, and in part slightly younger than, the primary carbonate bodies. The latter circumstance, however, cannot be considered as proving that the specularite is not in all cases related to the primary carbonate bodies in origin. Considering all these circumstances, it is difficult to see why this mineral should be limited to zones near the surface. However, as the writer has in no case had access to parts of workings other than those near the surface, Woodman's statement that it so occurs must be accepted. Regarding his statement that it is a hydrous variety of specularite with a brownish streak, the writer has often obtained such a streak, but in no case has been convinced that the specimen tested was free from limonite, which could be deposited between the lamellae of the specularite and be secondary after it; in all cases the rock surrounding the specularite containing considerable limonite.

As Woodman remarks, specularite is very common in the Pine Brook-Totten Brook district, particularly in the old workings on Peter Totten Meadow. It has been observed in fair amounts in dump rock on Cumberland Brook, and may well be much scarcer in the intervening sections than at these extremes. The writer would suggest that the non-proximity of intrusive rocks on the surface does not necessarily indicate that such intrusive rocks are not nearby in depth, and it may well be that the zones showing abundant specularite in the carbonate are in reality closer to the parent source of the carbonate (and specularite) than are those zones in which the mineral is less common.

Apparently otherwise unenriched carbonate may contain enough specularite to class the rock as a whole as an ore, as Woodman mentions on the west side of Cumberland Brook. This would be the only case in which such a classification could be applied to the carbonate where unaffected by supergene enrichment. If a hypogene origin is accepted for the specularite, as it must be, Woodman's statements notwithstanding, there is no reason other than local structure why such concentrations of specularite in the carbonate could not be encountered at any depth regardless of the level of supergene enrichment. With the meagre information at hand regarding the occurrence of this mineral, it would be exceedingly difficult, if not impossible, to anticipate such concentrations.

Another ore having local extent is the red ore, formed by enrichment of the carbonate bodies by red hematite. Woodman does not discuss any occurrence of this material, but mentions its presence. The writer found such an ore in place in the open-cut on Peter Totten Meadow, a vertical body of red ore consisting of hematite with some limonite lying against a similarly oriented body of black-brown limonite. Some enrichment by hematite was also observed in an open-cut about 1,000 feet east of Pine Brook, but there the hematite was present only in sufficient quantity to give a red colour to the rock.

The above-mentioned enriching minerals, although of considerable interest, and in some places the producers of very superior ore, did not by any means supply the bulk of the mined material in the district. This bulk consisted of what was known as black or brown ore, and was nearly pure limonite, the original carbonate having been almost lost in the enriching process. It differed from the paint ore, which was distinctly a surface product, in being quite hard and non-ochreous, and in addition was often porous. With the exception of fragments from dumps, no such ore can be seen in any of the exposed mine workings today, but a band of such ore is exposed in the prospect open-cut on Peter Totten Meadow, in juxtaposition, as has been mentioned, to a band of red ore. So far as is known from the descriptions of mine workings, similar material was mined in depth in all the mines, and finally, in the deepest workings, gave way to unaltered carbonate.

In a discussion of supergene enrichment processes, it should be proper to mention processes of supergene de-enrichment, which also took place, but fortunately on a very small scale. By this is meant the deposition in an already slightly limonitized carbonate rock of fresh iron-calcium-magnesium carbonate, containing less iron than the rock that it replaced. Such processes may be suspected from the examination of hand specimens of brownish to black ankerite containing euhedral crystals of white carbonate, and are proved by the microscopic examination of thin sections taken from them. The dark ankerite is found to have minute films of limonite deposited along cleavage and fracture planes, and this material is replaced by fresh white carbonate containing no such limonite. It is also conceivable, and in one place thought possible, that such a process could replace the compound carbonates with siderite, thus resulting in a deposit with a higher iron content than the material replaced.

<u>Chemistry of Enrichment</u>. Iron carbonates may be enriched by two processes - by oxidation of iron carbonate to limonite, which increases the iron content of the rock per ton, but leaves unaltered the iron content per cubic foot; and by replacement of all the carbonates present by limonite. Microscopic seams of limonite have been observed following cleavage and fracture lines in ankerites taken from near the surface, and it is assumed that during the solution of iron from the upper parts, some oxidation to limonite

occurs, the results of which are left in the rock. The point may be raised whether those rocks that are almost entirely limonite may not have been produced by oxidation rather than by replacement. Specific gravity determinations were made on two specimens, one being a surface ankerite composed roughly of 92 per cent carbonates and 2½ per cent limonite, the other specimen being a highly enriched ore composed of about 8 per cent carbonates and 89 per cent limonite. The results showed the ankerite to have a specific gravity of 2.9 and the limonitic rock of 3.1. If enrichment were the result only of oxidation of iron carbonate to limonite, accompanied by solution of such calcium and magnesium carbonates as were present, the resulting rock would have a specific gravity considerably below that of the ankerite, so it is quite evident that considerable iron is added to the rock in the enrichment process in addition to any that may be left there by oxidation of the iron carbonate.

The agents by which iron is dissolved and transported are: (a) sulphuric acid derived from the weathering of pyrite, and possibly from sulphate deposits such as gypsum; (b) organic acids derived from decomposing vegetable matter; and (c) carbon dioxide derived mainly from the atmosphere, but also from the decomposition of organic matter.

Pyrite, although present as a primary mineral in the carbonate bodies, occurs in quantities too minute to permit its being considered as a possible source of sufficient sulphuric acid to account for the extensive solution that has occurred. That some solution by sulphates has taken place is suggested by Woodman's statement that a considerable increase in the amount of sulphur present in the ore was noted in the lowest levels west of Cumberland Brook.

The possibility of overlying gypsum beds supplying sulphate solutions for the transport of the iron must also be considered very slight. Rocks of Windsor age, the only gypsiferous group in the Maritime Provinces, do occur on the flat mountain top north of Five Islands, and some 20 miles west of Londonderry, but no indications of such rocks have been seen elsewhere on the mountains, nor do gypsum beds occur there. Finally, had sulphate solutions been at all active in transporting the iron, the consequent deposition of the iron would give rise to considerable masses of other sulphates, particularly calcium sulphate, by the replacement of calcite by limonite, whereas such sulphur-bearing minerals are extremely rare.

Organic acids, similarly, cannot be considered as a principal factor in the solution of the iron. A swampy, wet terrain, such as would be required for the formation of large quantities of organic acids, cannot be assumed to have existed on the mountains so close to their edge. And conversely, if the south face of the mountains had been elsewhere at the time of enrichment, or if the area to the south of the mountains had been filled to their level by later sediments, then the differences of relief required to promote water circulation to the depths at which enrichment is encountered would be lacking.

No such objections, however, can be produced to a theory of solution of the iron by carbonic acid. Iron is soluble as the bicarbonate, and as it existed already as the carbonate, a smaller amount of carbon dioxide would be required to effect its solution than would be necessary had it existed in any other form. The supply of the solvent material would be unlimited, as it existed in the atmosphere, and the presence of secondary carbonates of calcium, magnesium, and iron in some of the slightly enriched ankerites indicates that such solution was occurring, because secondary carbonates are precipitated only from bicarbonate solutions.

Iron as the hydrous oxide or carbonate, is precipitated from a bicarbonate solution by release of pressure; by contact with organisms requiring carbon dioxide in their life processes; by the admixture of certain organic acids; and by encountering a mineral salt whose basic radical is exchanged for the iron in the bicarbonate solution.

As a bicarbonate solution is essentially a solution of one molecule of the carbonate in the presence of one molecule of carbonic acid, the latter being carbon dioxide in aqueous solution, it can be clearly seen that any lessening of the pressure on the solution will result in the dissolution of the carbon dioxide, leaving the much more insoluble carbonate in the water. Such a release of pressure may be obtained when the solutions reach the surface by way of a spring, or when, after seeping downwards through dense rock with some hydrostatic column behind them, they reach a broken or fractured zone where circulation is freer. Such a zone need not be anywhere near the surface to effect a release of pressure sufficient to de-carbonatize the solutions.

The precipitation of iron by contact with organisms cannot be considered as a method by which the bulk of the iron was precipitated, nor can such precipitation occur through the admixture of organic acids, although both processes undoubtedly were responsible for the formation of minor amounts of limonite in the upper parts of the enriched zones.

Precipitation of iron by molecular exchange is in effect replacement, and undoubtedly played a large part in the formation of the limonite deposits. Undoubtedly both the calcium and the magnesium carbonate in the ankerite underwent such replacement, as both minerals are almost lacking in the better grade limonite ores. It is unfortunate that ores from the deepest zones of enrichment are not available today, at least with any certainty as to their original locality, as without them it is impossible to outline the actual processes by which the limonite came into its present positions.

Although the iron precipitate from a bicarbonate solution is essentially in the form of the carbonate, the change to limonite occurs in most cases almost coincidental with the original precipitation. In fact, unless the change takes place immediately, the resulting carbonate is very likely to remain as such unless and until acted upon by oxidizing solutions.

Effect of Topography on Enrichment. The general topography of the district has already been described. The details, however, vary considerably in different parts, and will be outlined in an attempt to derive a relationship between topography and character of enrichment. The discussion will, of necessity, involve the consideration of factors on which but little information is at present available, but will serve to indicate that, in the writer's opinion, topographic conditions have had a prime bearing on the formation of the iron ores; that enrichment by limonite is found at depths that in places are considerably in excess of that of the present water table; and that such enrichment in hitherto unworked ore-bodies may reasonably be considered to go to similar relative depths.

From Matheson Brook to Martin Brook the south face of the mountains is much steeper and more rugged than elsewhere. Cumberland Brook crosses the ore zone at about 520 feet above sea-level, and Martin Brook at about 550 feet.

Between Martin Brook and Great Village River, the south face of the mountains smooths out a bit, and rocky cliffs are absent Cook Brook does not make much of an indentation in the mountain block. In the vicinity of Great Village River, however, the face of the mountains locally becomes quite rocky and steep - the river cutting a deep gorge across the ore zone at about 350 feet above sea-level. The west bank of this river is much steeper and higher than the east bank, having about a 30 per cent grade for 1,000 feet from the river.

Great Village and Rockland Rivers are too close together to have any pronounced highland between them, but along the line of the ore zone the interstream area rises in places to almost 200 feet above the rivers.

Between Rockland and Folly Rivers, the slope of the south mountain face is considerably lower than to the west, and in places is cultivated all the way to the relatively flat top of the upland. Saltspring, West McElman, and McElman Brooks cut fairly deep gorges, the last named having the deepest, crossing the ore zone 300 feet above sea-level. The gorge cut by Folly River is, however, remarkable for its very steep walls, more so on the east than on the west, although the elevation of the river where it crosses the line of ore is not very different from that of McElman Brook.

From Folly River to Pine Brook, the south face of the mountains has about the lowest slope in the entire district. In this section alone, the Pennsylvanian conglomerates occur at elevations almost as high as those of the rocks of the mountains themselves. Slack, Gory, and Weatherbe Brooks flow from the mountains through very shallow gorges, or no gorges at all. Pine Brook, however, occupies a very deep and narrow gorge, with particularly steep walls on the east.

East of Pine Brook the slopes of the mountain face increase considerably to Debert River, where the south mountain slopes are almost as rugged as they are in the West Mines section.

The deepest enrichment was encountered in the West Mines section, between Cumberland and Martin Brooks, and particularly in the immediate proximity of these brooks. In this section the relief was more pronounced for a long distance than in any other, though precipitous slopes are lacking. In these workings, apparently wherever ankerite was encountered above the limit of downward enrichment it could be classed as ore.

At Old Mountain mines, although the slopes of the south face of the mountain are slightly less than in the West Mines section, yet the precipitous west bank of Great Village River is much steeper than any valley slope at West Mines. Here the conditions of enrichment are different from those of West Mines. Bodies of carbonate outcropping on the precipitous slope and on the flatter ground near the edge of the slope are in places not enriched at all, and were quarried as ankerite. Good, enriched ore was obtained farther back from the precipitous slopes, but the depth of enrichment is not known as mining was not carried to the bottom of the enriched zone.

At East Mines the zone of enrichment was determined to have a shallower depth than in any other section of the district. Also some carbonate bodies were not enriched and were quarried as ankerite. Here the topography is flatter than elsewhere on the south side of the mountains. It is of interest to recall that when operations closed at East Mines a railway was being constructed to a hitherto unoperated part at the west end of the section, and a short distance from the steep slope down to Folly River. It may be assumed that the railway was not being constructed without some ore having been discovered, even though its exact location cannot be determined today. The topographical conditions in this new section would be strikingly similar to those at Old Mountain mines, insofar as the gorge of the river is concerned.

East of Pine Brook, the steep brook valley sides have slopes again similar to those at Old Mountain mines. Here again are large bodies of ankerite, on and above the slopes that have undergone very little enrichment. Farther east, in the Peter Totten Meadow section, there has been considerable enrichment in places, but no information exists as to its possible depth. However, in spite of a rather abrupt south face of the mountains south of Peter Totten Meadow, drainage conditions are not quite similar to those at West Mines where the ground rises continuously from the south face of the mountains to the ore zone, whereas from Peter Totten Meadow the ground to the south rises about 75 feet before it begins to slope toward the south face of the mountain.

The relationship between ruggedness of topography and depth of the water table is quite apparent, as is also the relationship between the latter and the depth of secondary enrichment. Apparently, however, a few other factors enter into the enrichment of these ores. Ankerite, or unaltered carbonate, is found, and has been quarried as such, only in places where the water table may be considered to be either exceptionally high or exceptionally low, in other words, where there is very little relief, and where the relief is almost precipitous. The deepest zones of enrichment were encountered where the relief, although considerable, was not excessive. The reasons for these phenomena are self-evident. To obtain enrichment by deposition of oxides from iron-bearing solutions requires not only a circulation of those solutions, but a moderately slow circulation. A speeding-up of the rate of circulation would result in the solutions passing through the carbonate rock without deposition. These factors should have an important bearing on any search for new enriched ore-bodies, and will be discussed later.

It may be apropos to refer here to the prevalence of botryoidal limonite, or bottle ore, in that section known as West Mines. This type of ore, which was found almost entirely as a cavity filling, and was restricted in occurrence, in quantity at any rate, to this section, was deposited when iron-bearing solutions seeped into open spaces. Such openings in the carbonate rock would postulate earlier solution processes, which may be construed to indicate that these were active over a deep vertical range. Such an explanation would suggest an exceptionally low water table in this section, and this is in keeping with the exceptionally low levels of enrichment encountered. The prevalence of this mineral at or near the surface might, therefore, be considered as an indication that a considerable zone of enrichment exists at that locality. Botryoidal limonite, however, is not known to be plentiful elsewhere.

Mineralogy of the Ores. It is proposed to limit discussion under this heading to those ores collected in place by the writer, and whose relationships are definitely known. This limits the number of specimens for study to those collected in the Pine Brook-Totten Brook section. A suite of specimens collected there was analyzed by the Bureau of Mines, Ottawa, and it is proposed from these analyzes to compute the mineralogical composition of each specimen. The analyses are given below:

	I %	II %	III %	IV %	V %	VI %	VII %	VIII %
Insoluble	4.56	1.74	1.94	00.16	0.11	0.18	0.39	0.32
Fe	10.05	10.77	13.33	12.72	57.35	23.60	13.75	35.09
CaO	27.99	29.10	22.46	30.21	0.50	33.58	29.00	15.29
MgO	12.01	12.02	9.03	11.01	0.36	0.80	9.80	1.86
CO_2	41.74	41.80	40.84	41.88	3.98	26.72	39.14	34.22

I - Massive carbonate on crest of high bank Pine Brook; II - Massive carbonate 900 feet east of Pine Brook; III - Carbonate in open-cut 1,000 feet east of Pine Brook; IV - Carbonate stained red with hematite, open-cut 1,000 feet east of Pine Brook; V - Dark brown or black ore from open-cut, Peter Totten Meadow; VI - Red ore, open-cut Peter Totten Meadow; VII - Carbonate from north side of V and VI; VIII - Black and specular ore, dump of open-cut, Peter Totten Meadow.

In reducing the above data to a mineralogical composition, several assumptions were made, which may be considered to be largely true. It was assumed that calcium and magnesium existed only as the carbonate, and that the balance of the CO_2 left after computing $CaCO_3$ and $MgCO_3$ belonged to an iron carbonate molecule. The computation thus far, with one exception to be mentioned later, left all the CO_2 used up and with a surplus of iron that was assumed to be either limonite or hematite according to the nature of the material. In the former case water, which was not determined in the original analysis, had to be computed to satisfy the limonite. In all cases empirical formulae were used. The results are as follows:

	I %	II %	III %	IV %	V %	VI %	VII %	VIII %
$CaCO_3$	49.8	51.9	40.0	53.9	.9	60.0	51.7	27.3
$MgCO_3$	25.2	25.2	18.9	22.1	.7	1.7	20.6	3.9
$FeCO_3$	17.7	17.9	----	15.8	8.5	nil	14.8	52.7
Insoluble	4.5	1.7	1.9	0.2	0.1	0.2	0.4	0.3
Limonite	2.5	3.7	----	8.5	89.1	----	11.0	16.2
Hematite	----	----	----	----	----	33.7	----	----
Total	99.6	100.4	----	100.5	99.3	95.6	98.5	100.4

In analysis No. III there was not sufficient iron to satisfy the CO_2 remaining after $CaCO_3$ and $MgCO_3$ were computed. It was evident that some other metal existed in this specimen, as some limonite was visible in the sample. A spectrographic analysis showed this particular sample to be high in manganese, which probably existed as the carbonate, freeing some iron to exist as limonite.

In analysis No. VI, it was assumed that all the iron oxide was present as hematite. The low total of 95.6 shows that this was not so, and that some of the iron oxide was limonite, which with the extra water it would require would have brought the total up nearer to 100 per cent.

Analyses Nos. I, II, III, IV, and VII were made of rocks that were essentially the carbonate with some added limonite. Excluding No. III, the results of which were unsatisfactory because of an unknown amount of manganese, the mineralogical computation of the other four analyses are striking in the similarity of proportions between the carbonates of iron, magnesium, and calcium. Reducing these percentages to molecular proportions, the carbonate present in these rocks would appear to conform closely to the formula $4CaCO_3.MgCO_3.FeCO_3$. True ankerite has the formula $2CaCO_3.MgCO_3.FeCO_3$, and, therefore, these carbonates should be more correctly termed ferruginous dolomites; but as ankerite is a term of long standing in the Londonderry field, and particularly as these proportion have been worked out on the carbonates of only a small area of the district, the term ankerite will be retained for the compound carbonates.

Analysis No. VIII was made of a rock termed black and specular ore. Actually, although mostly black, it is not a true black ore, as the primary fabric of carbonate remains. The rock is essentially carbonate cut by stringers of specularite, and with limonite deposited throughout the carbonate. This mineral assemblage is then replaced on a small scale by a white carbonate that contains little, if any, iron, and probably is close to calcite. The analytical results show that the calcium carbonate content is about half, and the iron carbonate about three times, as great as those of the normal carbonate. Some of the calcium carbonate can, no doubt, be accounted for by the secondary, iron-low carbonate that replaces the somewhat enriched carbonate, thus reducing still further the amount of calcium carbonate in the original carbonate of the rock. This would place the original carbonate in the siderite class, and if so, it is the only occurrence of which the writer is definitely aware. Unfortunately, rock of this type could not be located in situ, but it was quite plentiful on the dump. It might be mentioned that the sample was composed of small pieces from a large number of fragments, and is more truly representative than would be one or two large pieces.

<u>Theories of Origin.</u> Throughout the foregoing discussion it has been assumed that the enrichment of the ores took place by supergene processes, a theory of origin that the writer believes is unassailable in the light of surface examination, and data on subsurface features derived from the study of reports by earlier writers. However, it is only fair to point out possible errors in the observations of investigators who may thus have overlooked features that might favour a theory of enrichment by hydrothermal processes.

If enrichment had taken place through the agency of hot water solutions from below, we should expect the following features to be apparent in the ore-bodies: (a) no parallelity (even in the roughest degree) between the bottom of the zone of enrichment and the surface of the ground; (b) a gradual decrease in degree of hydration of the iron oxides in depth; (c) the occurrence of iron oxide deposits beyond the limits of the carbonate bodies, if enrichment had occurred subsequent to the introduction of the carbonate bodies; and (d) the persistence of the iron oxide ores to any depth to which the carbonate bodies extend, if enrichment had been contemporaneous with the formation of these bodies.

Regarding parallelity between the bottom of the enriched zone and the surface of the ground (a) it is true that in only one section, West Mines, was mining carried to any considerable depth and to the bottom of the enriched zone, and even here Woodman notes that over a short part of the belt east of Cumberland Brook, ore was exposed in the bottom workings. True, in this section, the apparent bottom of the enriched zone is definitely parallel with the surface of the ground, being much deeper in absolute elevation near Cumberland and Martin Brooks than in the interstream area, but a proponent of a hydrothermal origin for the ores might claim that such relationships were unique for this section, due to local causes not necessarily holding in other parts of the district, and that had deep mining been carried on elsewhere, such relationships would not have been found. It might also be claimed that the zone of enrichment, like that at Flin Flon, which is also hydrothermal in origin, dipped steeply for a short distance, and then raked off at a low angle for some distance before again plunging steeply, and that the miners missed entirely the flat-lying continuation of the ore and believed they had reached its bottom. It is impossible, of course, without first-hand information from underground, to completely refute such a claim. The section, however, was the most thoroughly mined part of the district, and the miners were employed largely on a contract basis, by which they were paid only for ore that they delivered at the portal. They were very adept at following any lead of ore, but they may have been equally hesitant about going far into what they believed was barren carbonate.

No mention has yet been made of the fact that the bottom of the enriched zone was also encountered at East mines, and that there, also, the bottom was parallel, roughly, with the surface of the ground. The workings at East mines were relatively shallow, unenriched carbonate being encountered closer to the surface than in other sections, and because of this, it may be claimed that they were not worked sufficiently to yield positive data regarding the distribution of ore. Again, this might possibly be true, but the workings, although not continuous to any great depth, were quite extensive laterally, and it seems probable that downward extensions of the ore would probably have been found.

Regarding the degree of hydration of the oxide ore, and its decrease at depth (b), very little can be offered to disprove it. In none of the many analyses quoted by Woodman is a figure given for combined water. In deposits of iron oxides formed by hydrothermal processes, as the temperature at time of formation increased with depth the deposited oxide would be expected to change from limonite to goethite to hematite. Paint ore and bottle ore, being strictly surface manifestations, should be excluded from any consideration of such changes. Woodman refers to the brown and black ores as limonite only, but whether he arrived at that designation by analysis or by inspection is not known. Also he makes no differentiation in degree of hydration between ores near the surface and those at the deepest depths attained. The writer, whose examination of ores was limited to those occurring at the surface, found limonite and a mixture of limonite and hematite in adjacent bodies at Peter Totten Meadow. The possibility must be admitted that Woodman's nomenclature was based largely upon inspection of the ores and may be in error, and that ores from the deepest workings are less hydrated than those occurring nearer the surface. Pending, however, the discovery of more conclusive evidence for a hydrothermal theory, his classification should be accepted.

The succeeding two features of hydrothermal deposition, (c) and (d), are more or less related, being reciprocals of each other, and will be discussed together. With the exception of specularite, which is rather common in parts of Cobequid Mountains as a fissure filling in sedimentary and volcanic rocks, and the Derry hematite, which probably is hydrothermal in origin, no bodies of iron oxides are known to exist except within the carbonate bodies. However, again the evidence is negative, and a lack of known occurrences cannot be taken as proof that none exists. Further, a remote possibility exists that miners missed downward extensions of the zone of enrichment at West mines.

There are undoubtedly loopholes in a theory of supergene enrichment, but all postulate a large number of coincidental factors at variance with relationships observed by the writer and previous investigators. Acceptance of a hydrothermal theory of origin for the ores could have very little effect in promoting interest in the locality; it would affect only the life of the district, once operations were commenced. Underground work of any extent should without doubt settle this question conclusively.

RESULTS OF DETAILED WORK IN THE PINE BROOK-TOTTEN BROOK AREA

In 1943 it was decided that work of a detailed nature should be carried out on some section of the Londonderry district that might be considered to have future economic possibilities. That section lying between Pine and Totten Brooks was chosen because: (a) large bodies of ankerite were known to exist there; (b) occurrences of enriched ore were known; (c) there were no underground workings to jeopardize any future workings; and (d) the operators of the Londonderry mines were carrying on a prospecting program in the section when work closed down.

Outline of Work

A transit line was run from Pine Brook, following as closely as possible the line of carbonate bodies, to Totten Brook, and eastward some 2,000 feet from the latter brook to the first of two small lakes draining into Debert River. On this control line a plane-table map was constructed on a scale of 200 feet to the inch, with 5 foot contours. The area mapped by plane-table is about 800 feet wide and 6,400 feet long, and wood roads, outcrops, prospect workings, and streams were located by stadia.

While this work was in progress, Professor A. E. Flynn of the Nova Scotia Technical College very kindly ran a series of observations across the possible ore zones with a Hotchkiss Superdip Magnetometer. For this purpose six lines were cut out at right angles to the supposed trend of the ore, and stakes were driven at 50-foot intervals on these lines. Three lines crossed known occurrences of ankerite (one occurrence carrying enrichment of ore grade), and three lines were run across sections where the presence and location of carbonate bodies were unknown. It was hoped to obtain information from the observations on the known occurrences that could be applied to those sections where no data was at hand, and thus further the knowledge of their extent. Such, however, was not possible.

Description of Section

Work was started from Pine Brook which, where crossed by the iron carbonate bodies, hugs the east side of a valley 150 to 200 feet wide. Rock is exposed plentifully in the brook bottom, but not continuously, and is composed mostly of volcanic rocks of intermediate composition, with some sedimentary rocks cut by a small, fine-grained, intrusive body. Dykes and stringers of ankerite are plentiful, but probably do not exceed a foot or so in width. There is no sign of a body or bodies of ankerite of any size crossing the brook, but, as mentioned previously in this report, there are gaps in the completed rock section ample to allow such bodies to cross should they exist.

The east bank of Pine Brook is quite steep, and in one or two places almost precipitous for 600 feet east of the brook where the elevation is 185 feet above it. Four hundred and fifty feet east of the brook, and 115 feet above it, is a short prospect adit driven into ankerite. On the hill above the adit, 550 feet east of the brook, is a rounded exposure of ankerite with numerous very narrow seams of specularite through it. North and south, this exposure has an unobstructed width of 16 feet, but nearby small exposures indicate that the width of solid ankerite may be as great as 30 feet. No non-carbonates are exposed here. East and west the exposure has a length of 40 feet, and extends eastward almost to the top of the steep slope. Fifty feet east of this exposure, and on a slight down grade, is another small exposure of ankerite. The slight down grade is followed to the east by a short flat, and then by an up grade until an elevation 225 feet above Pine Brook is attained at a small prospect open-cut 1,000 feet east of the brook. Scattered outcrops of ankerite are found between the top of the first rise and the open-cut. In the cutting, ankerite is exposed for a width of 70 feet, no other rock being present. On the west side of the knoll into which the cut is made, scattered outcrops, only of ankerite, show that the possible width of carbonate may be 120 feet.

To the east of the knoll into which the open-cut is driven, and 25 feet lower in elevation, is a swamp about 150 feet wide, on the east side of which is a hill of drift about 30 feet high. This drift-covered terrain extends eastward in slightly rolling country for 1,200 feet, although a small knob of volcanic rock sticks through the mantle 700 feet east of the swamp.

Two thousand three hundred feet east of Pine Brook this flat, rolling country gives way, with a rather steep drop, into the western end of a long swampy depression lying about 175 feet higher than Pine Brook, and known locally as Peter Totten Meadow. This depression, insofar as its flat, swampy characteristics extend, is about 2,200 feet long, east and west, and varies in width from 100 to 400 feet. Near the eastern end it is crossed by Totten Brook, which forms a small pond in the meadow, but enters and leaves the meadow by steep-walled gorges.

The north side of the meadow rises steeply, but not precipitously, and was rising less steeply at the northern edge of the mapped area some 400 feet north of the meadow where the elevation was about 100 feet above the meadow floor. The south side of the meadow is in places precipitous, being bounded by a rocky ridge 75 to 90 feet high, which extends west to the western end of the meadow. Fletcher called the rocks in this ridge intrusive, and they may be in part of that origin, but in some places definite characteristics of volcanic rocks were observed. Totten Brook flows from the meadow through a narrow gorge in this ridge, and from the top of the ridge a few hundred feet south of the meadow the country slopes uniformly to the south.

For 2,200 feet east of the outlet of Totten Brook from Peter Totten Meadow, this ridge maintains its high, rocky characteristics and a narrow depression 200 to 400 feet wide lies on the north of it. This depression is none the less marked because the divide between Totten Brook and Debert River lies in it only 1,000 feet east of Totten Brook. In this depression, and 1,600 feet east of Totten Brook, is a small circular lake 300 feet in diameter, and about 1,000 feet east of this lake, in the same depression, is another slightly larger lake. These lakes, together with the pond where Totten Brook crosses the meadow, suggest, very strongly, sink-hole lakes in their general appearance, although they are all choked to a shallow depth with vegetation. The two easterly lakes drain into Debert River, and on aerial photographs the depression in which they lie may be traced considerably to the east of the eastern lake, although the plane-table work was carried only to the western one.

About 700 feet east of the western end of Peter Totten Meadow a small brook enters the meadow from the north. On the east bank of this stream considerable trenching was done at some time. No rock is exposed, but pieces of ankerite may be found in the rubble.

Six hundred and fifty feet east of this brook, and 700 feet west of where Totten Brook enters the meadow, is a small open-cut some 30 feet deep cut into the rather steep north bank of the meadow. A section of rock about 70 feet wide, north and south, is exposed here, the only rock seen being carbonates or their oxide enrichments. On the west side of the cut, and poorly exposed due to slumping of the walls of the cut, are two bands of oxide enrichment in juxtaposition. The southern band is a dark brown limonite (analysis No. V, previously given), and to the north of it is a bright red hematite and limonite enrichment of carbonate (analysis No. VI). The total widths of these bands are not determinable; both widths are, however, not less than 7 feet.

Magnetometric Work

As mentioned, six series of observations were made on north-south lines using a Hotchkiss Superdip Magnetometer. In principle this instrument consists of a magnetic needle on a horizontal axis, to which axis is also attached an auxiliary arm, the angle between which and the magnetic needle may be adjusted. The auxiliary arm, being acted upon only by gravity, may be adjusted relative to the needle so as to completely nullify the effect of the earth's magnetism, in which case, and only at that station where this adjustment was made, the magnetic needle will come to rest anywhere within the circle. In practice the angle between the auxiliary arm and the needle is changed a small amount from this exact position so that the effect of the earth's magnetism is almost, but not quite, nullified. The result is that extremely small variations in the earth's magnetism give very large differences in readings of the needle. It was hoped that a large variation over a short distance would be encountered on going from country rock to carbonate rock or vice versa, or that the country rock and carbonate rock would give uniform, but differing, readings over their extent. There seemed to be some basis for the first hope, inasmuch as large variations had been obtained by Professor Flynn at the contacts of limestone and other rocks, but very little basis for the second as no magnetic minerals were known in either rock group. The results although inconclusive were interesting, and will be outlined below, describing first those lines run across known occurrences of carbonate.

Line No. 1 was run across the first large outcrop of carbonates east of Pine Brook, and near the brow of the steep bank up from the brook. Carbonates are exposed over a width of nearly 30 feet, of which 15 feet is bare rock. The readings on the outcrop, and to 25 feet north of the outcrop, are quite high, followed suddenly 75 feet north of the outcrop by an extremely low reading. North of this low reading the subsequent readings become higher and higher, until 300 feet north of the outcrop they are about the same as those on the exposure itself. South of the outcrop readings are very steady and much the same as those on the bedrock, except for one, 200 feet south that is a little higher than the others, followed farther south by others that are the same. With no other observations on known occurrences of carbonates, one might be excused for assuming that the north contact of the carbonates with the country rock gave a decidedly low reading, and that the carbonate body here extended 75 feet farther north than was exposed. Directly opposite results, however, were obtained on line No. 2, which was run about 80 feet west of the prospect open-cut located 1,000 feet east of Pine Brook. Outcrops of carbonates are scattered for 120 feet along this line south of its zero point opposite the north end of the open-cut. The nearest outcrop of country rock is on the line 275 feet south of zero. The readings taken on the line north of zero were quite uniform and quite high. South of zero, however, in the known carbonate zone, the readings immediately dropped to extremely low and continued so for 200 feet, with the exception of one relatively high reading 175 feet south. Readings 225 feet and farther south were again quite uniform and relatively high, although not quite as high as those north of zero. It can be seen, then, that using only this line as a criterion, one might assume that the carbonate bodies gave uniformly low readings, and that the carbonate body extended farther south than exposures indicated, with a possible band of country rock in it. Such assumptions cannot be made, however, in the presence of the results from line No. 1.

Line No. 5 was run across the prospect open-cut on the north side of Peter Totten Meadow, the zero point being 150 feet south of the carbonate exposures on the south side of the cut. The readings across the known carbonates were the highest obtained on the line, dropping slightly on proceeding to the north of the cut. To the south of the cut the readings take a considerable drop on the edge of the swampy ground of the meadow proper, then rise a bit, dropping at the zero point of the line to an equivalent of the first low point, then rising very slowly while proceeding south across the meadow, finally rising abruptly when the south side of the meadow is reached. The results from this third line across known exposures appear to have nothing in common with the results from the first two. The carbonate does not give a uniform low set of readings as in line No. 2, nor does there appear to be a decided low on the north side of the carbonate as in line No. 1. There is, however, a wide zone of uniform low readings, which extends completely across the meadow, and there is also an isolated low reading, which in this case is on the south of the known carbonate instead of on its north as in line No. 1.

The other three lines were run across sections in which the presence or absence of carbonates was unknown, and from them it was hoped that information might be obtained. The zero point of line No. 3 was located on an outcrop of volcanic rock 1,700 feet east of Pine Brook, and nearly in the middle of a drift-covered belt lying between Peter Totten Meadow and the exposures described near Pine Brook. Fifty feet north of the zero point is an extremely low reading, in fact the lowest reading obtained anywhere. This low reading is bounded by readings at the zero point, at 25 feet north, at 75 feet north, and at 100 feet north by average readings. Readings at 150 feet north and 200 feet north are a little lower, but by no means as low as that just mentioned. Readings at 250 feet, 300 feet, and 350 feet north are quite uniform and relatively high. South of the zero point the readings get quite high at 100 feet south, drop a bit at 200 feet south, and get a bit higher at 300 feet south, the southern part of the line yielding no series of uniform readings. The extremely low reading is of considerable interest, and will be discussed later.

Line No. 4 was run across Peter Totten Meadow 350 feet east of its western extremity, the zero point being on the wood road following its south side. The lowest readings observed along this line were recorded at the zero point, increasing abruptly to the south where volcanic rocks are exposed on the southern ridge of the meadow, and less abruptly to the north where they reach a maximum 25 feet north of the zero point, then dropping again slightly at 50 feet north to a reading that remains remarkably constant to the north side of the meadow. North of the meadow, and 200 feet north of zero point, the readings slowly get higher, but even at 450 feet north of zero they are not as high as the reading obtained 50 feet south of zero. Here again the outstanding feature is a sharp and narrow low reading, and like that obtained on line No. 3 the low is immediately north of an outcrop of volcanic rock.

Line No. 6 is run across the depression trending eastward from Peter Totten Meadow towards two small lakes draining into Debert River, the zero point being on a wood road following the depression, and 500 feet east of Totten Brook. For 100 feet north and 100 feet south of the zero point the readings are quite uniform, and rather low. Going south these conditions are followed at 200 feet south by a more pronounced low reading, which is followed at 250 feet south by the most outstandingly high reading obtained in the series. This extremely high reading is followed at 300 feet, 350 feet, 400 feet, and 450 feet south of zero by consecutively lower readings, but it is only south of 400 feet that readings are as low as those north of the zero point. Outcrops of volcanic rocks occur near this line and at 300 feet south of zero, there being no other exposures known. Although the outstanding feature of this line is the extremely high reading 250 feet south of zero, yet the low preceding it at 200 feet south of zero should not be overlooked, particulary as its relative lowness is due in no small measure to the high reading next to it. This low reading, like those on lines Nos. 3 and 4, was observed a short distance to the north of known exposures of volcanic rocks.

From the readings obtained along those lines crossing known carbonate bodies, it is impossible to forecast whether the other three lines crossed similar bodies. That lines Nos. 3, 4, and 6 (and possibly No. 1 north of the carbonate) did cross some pronounced structure, whether it be a fault, a contact, or some other structural form, might, however, be safely assumed. It cannot be assumed, however, that the narrow zones of low readings obtained on these lines indicate the same structure, or even similar structures. The lines are too widely spaced for such an assumption to be valid. Should diamond drilling ever be undertaken in this section, however, the drilling of some of the holes should be preceded by magnetometric surveys along the line of those holes so that some information may be obtained as to the meaning of these low readings.

ORE POSSIBILITIES OF THE DISTRICT

It is proposed here to discuss in rotation from west to east the various sections of the district, and the possibilities that can be said to exist in each of there being undeveloped orebodies. The paucity of information in certain sections will be apparent, and opinions expressed for those sections should be treated with the reservation that they may be changed by any additional information, however slight.

Matheson Brook to Cumberland Brook

In this section very little prospecting was ever done, although a few slumped pits are visible on the flat mountain top between the two brooks. Mining was, of course, carried on in that part of the section available to levels driven from Cumberland Brook. In 1942 two parties did considerable work in four limited localities, and possibly had an equivalent amount of work been more generally distributed, information of a more definite character might have been uncovered.

Woodman reports that the zone of possible ore is wider in this section than in any other. By this he probably means that float and stringers have been located over a greater north-south distance here than in other parts of the district. He does not mention the occurrence of bodies of mineable size other than those that were actually mined, and no such bodies are apparent in the excellent section exposed on Matheson Brook, although on this brook, as on others, the section is not so complete as to exclude the possibility of their existing. On the flat mountain top, both east and west of Matheson Brook, outcrops are extremely scarce, and over large areas completely lacking, but the drift mantle is thin wherever prospecting operations have been carried out.

No reason is known why carbonate bodies could not exist in this section, and if their presence were proved, the topography, particularly on the Matheson Brook side, is such as is considered favourable for deep zones of enrichment.

West Mines Section

Regardless of whether or not carbonate bodies still exist in this section, it would be considered very inadvisable that they be developed. Mining has been carried on in this section to such an extent that any future underground work must be extremely hazardous. It is also believed that the section was mined practically to completion, at least insofar as enriched deposits go.

Old Mountain Section

Although considerable mining has been done in this section, it was limited to a zone that did not extend far below the flat top of the mountain, and that the lowest workings of any extent were still over 100 feet above the bottom of Great Village River. No. 3 level (the lowest level of any extent) was entered in September 1938 by J. C. Sproule of the Geological Survey. He observed ore of different widths on several faces, the ore varying from black and brown to paint.[1] The presence of such ore might be taken as an

---

[1]Sproule, J. C.: Geol. Surv., Canada, Information from notes taken in 1938.

indication that the bottom of enrichment had not been reached, and indeed such would be expected from an examination of the topography there. It is doubtful, however, if these points would be stressed were it not for the fact that the workings could, if interest were taken, be entered relatively cheaply and the exact character and disposition of the ore examined in detail.

Great Village River to Folly River

Very little is known of the potentialities of this section. Prospecting has been confined to a few short levels and a number of shallow pits, and the results of this work are not recorded. Outcrops, except in stream bottoms, are extremely scarce or even lacking. However, indications of carbonates are found in all the traversing streams except Saltspring Brook, and might possibly have been missed on that stream. Topographically the section could be considered to be unfavourable for deep enrichment should carbonate bodies be present, and taken as a whole this is probably true. In one part of the section, however, due to local characteristics, conditions for such processes may be considered to be much more favourable than they are in the remainder. The ridge separating McElman Brook from Folly River is $\frac{3}{4}$ mile wide, and although the south front of the mountains between these streams is devoid of appreciable relief, yet these streams have cut such deep valleys through the mountains that the east-west relief along this narrow block is comparable to that in those sections of deep enrichment. Prospect pits west of No. 4 highway, and about 1,200 feet north of the bridge over the railway, have, according to Sproule (1938), ankerite piles on their dumps, which would indicate the presence of carbonate bodies. Such a position is almost exactly in the line joining carbonate indications on McElman Brook with the southernmost similar indications on Folly River.

Folly River to Pine Brook

Included in this section are the East mines, and the ore possibilities of that section are not discussed for reasons put forward in the case of West mines, namely, that unrecorded underground work has been carried on to an extent that would render any future work extremely hazardous. To the west and to the east of the East mines lie two sections, on the east bank of Folly River and on the west bank of Pine Brook, that merit some attention.

About $\frac{1}{2}$ mile of undeveloped country lies between the western workings of East mines and Folly River. The east bank of this stream is appreciably steeper and more rugged than the west bank, and the general relief of this section is comparable with that of Old Mountain mines facing Great Village River. Disregarding the low relief to the south of East mines, and which is found also to the south of this part of the section, the east-west relief is considered ample to give rise to a relatively deep zone of enrichment, subject of course to the limitations of such a zone at West Mountain in that the steeper parts of the slopes were underlain by practically unaltered ankerite.

As was mentioned previously, a narrow-gauge railway to this part of the section was under construction when operations ceased. This is of interest, particularly as there are no records of development work, indicating that some ore or indications of ore must have been found there.

Between the eastern end of the East mines workings and Pine Brook is about ½ mile of rolling country followed by a steep declivity into the brook valley. Outcrops are scarce or lacking, both on the top and on the gorge sides. No signs of prospecting have been observed. The remarks about the east side of Folly River would also apply here, with the exception that there are no signs of the operators in the district having found or tried to find ore in this part.

Pine Brook to East of Totten Brook

Near the crest of the east bank of Pine Brook, and 550 feet from the brook, ankerite is exposed for a clear width of 16 feet, and a somewhat obstructed width of at least 30 feet. One thousand feet east of the brook, the ankerite has a clear width of 70 feet, and a width indicated by isolated exposures of at least 120 feet. In neither case is the bounding country rock exposed at these limits, but in the latter case such an outcrop occurs 120 feet to the south of the southernmost outcrop of ankerite. In addition to these two main exposures, a sufficient number of small ones are found between them to indicate that the carbonate may be continuous. In the brook bottom below the first exposure is a zone of considerable width showing ankerite stringers cutting the country rock, but no massive carbonate is found, although it may still exist there.

Using only the narrower positive width of 16 feet, assuming a possible depth of 200 feet, making proper allowances for the slope of the bank toward the brook, and using a figure of 11 cubic feet per ton for ankerite, it would appear that there may be 220,000 tons of ankerite within 1,000 feet east of Pine Brook. The conservatism of the figures used in the computation is apparent. Of this body of ankerite, the amount, if any, that has undergone enrichment to ore grade cannot be estimated. Based on experiences elsewhere in the district, one could almost safely assume that enrichments would not be lacking. That the ankerite exposed on the steep slopes would not be enriched is to be expected from observations made at Old Mountain, where similar topographical conditions hold. It might, however, be expected that enrichment would have taken place at the open-cut 1,000 feet east of the brook, and indeed the iron content of the carbonate is here slightly, but only slightly, higher than at the top of the steep slope. These points can only be decided by exploration.

Between the prospect open-cut 1,000 feet east of Pine Brook, and that on Peter Totten Meadow, 2,500 feet to the east of it, there are no exposures of carbonate, although such rock may be safely assumed to exist at a point where some trenching was done 600 feet west of the latter point. However, it seems highly improbable that the country between two clear exposures of carbonate, each 70 feet wide, should be entirely lacking in such rock when the trends of the bodies are known to be toward each other. In the opinion of the writer, it may be safely assumed that carbonate bodies do exist in this intervening country.

As mentioned, enrichments that might constitute ore are found in the meadow workings. No estimate can be made of the extent of this enrichment. Its presence, however, indicates that conditions favourable to enrichment were present, and no reason exists for supposing that such enrichment should be limited only to the place where it was found.

A description has been given of a linear topographical depression extending from the west end of Peter Totten Meadow to some thousands of feet east of it. Magnetic variations were found on the south side of this depression on two lines of observations, and at a point on another line west of the depression but in line with it. Observations on one line across the depression gave no such variation. This depression may be due: (a) to a normal fault with a downthrow on the north, and not sufficiently old to have its surface expression yet removed; (b) to a belt of harder rocks on the southern, steeper side (Fletcher maps an intrusive belt on the south side of the meadow); or (c) to a belt of softer rocks underlying the depression that have been eroded or dissolved, leaving lower ground. That the depression may be due to a fault must not be discounted. Such an origin may account for the magnetic variations along the south side of the depression. These variations could be as easily explained by the third alternative, however. Although the main faulting along the south side of Cobequid Mountains occurred prior to the deposition of the Pennsylvanian sediments, yet some faulting has occurred in places along that line, and presumably in lines parallel to it, since their deposition. Such faulting could presumably have occurred at a date sufficiently recent to permit the surface expressions of the fault to still remain. Against such a theory, however, is the fact that although the south side of the depression is undoubtedly steeper and rockier, yet normal glacial action, by sweeping clear the north-facing ridge and depositing material on the south-facing ridge, might account for such conditions.

There is no essential difference in the rocks north and south of the depression. Rocks believed to be of volcanic origin have been found on both sides, and although fine-grained intrusive rocks may occur on both sides, such are not considered plentiful enough or sufficiently resistant to account for the depression. The note above on glacial action would also apply here, and it is possible that were the north slope stripped of debris, there would be no essential difference in the steepness of the two sides.

The above considerations lead, by process of elimination, to the possibility that the depression is caused by the erosion or solution of softer beds or bodies. Such rock, particularly if solution is considered as a means of erosion, would be carbonate. Against this theory may be mentioned that although in general the carbonate bodies exhibit the erosional features of limestone and to a lesser extent of gypsum, yet such pronounced topographic expression has not been heretofore found on a carbonate body or bodies. The writer considers that determination of the character of the rocks underlying this depression should be one of the first demands made on any exploration program in the section.

Uses of Ankerite

It was mentioned earlier in this report that during operations at Londonderry, ankerite was quarried as such, and charged into the furnaces in the place of limestone. The magnesium content was not considered detrimental, and using the ankerite had the advantage of adding such iron as was present in the carbonate to the iron in the melt.

In computing the charge for a blast furnace, magnesium is added to calcium, the total being treated as calcium. This takes care of a magnesium content up to from 5 to 10 per cent of the limestone. The Londonderry ankerites vary considerably in their magnesium content, but in the Pine Brook-Totten Brook section did not go above 12 per cent magnesium. Whether such an amount of magnesium would be detrimental to furnace procedure could be determined only be experiment. And even if such a content should be considered detrimental, the disadvantages of using such rock as a flux should be weighed against the advantages of adding some almost phosphorus-free iron to the melt.

RECOMMENDATIONS

In discussing the ore possibilities of the region, it was apparent that at a number of localities limited deposits of iron ore might reasonably be expected to exist. In only one of these, the Pine Brook-Totten Brook section, does it appear reasonable that if carbonates do exist they are in rather large quantities. The amount of enrichment to be encountered in any unexplored carbonate body cannot be estimated in advance.

The writer would recommend that the Pine Brook-Totten Brook section be considered as a source of furnace flux, from which some iron will be obtained, with the hope and reasonable expectation that enriched bodies of unknown size will be encountered during its development. The most reasonable method of exploration, both in time and money, would be a diamond-drilling program along the supposed carbonate belt.

REFERENCES

Fletcher, Hugh: Geol. Surv., Canada, Ann. Rept. 1892, vol. V, pt. P.

Gilpin, E., Jr.: The Iron Ores of Nova Scotia; Trans. Can. Soc. of Civil Eng., vol. V, 1891.

Lindeman, E., and Bolton, L. L.: Iron Ore Occurrences in Canada; Mines Branch, Dept. of Mines, Canada, Pub. No. 217, vol. 11, pp. 169-174 (1917).

N. S. Dept. of Mines: Ann. Repts. for 1874, 1875, 1877, 1884, 1904, 1905, and 1907.

Woodman, J. E.: The Iron Ore Deposits of Nova Scotia; Mines Branch, Dept. of Mines, Canada, Rept. No. 20 (1909).