The Lode Gold Deposits of Canada

by

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INTRODUCTION

INTRODUCTION

Considering the importance of gold at the present time, and the wide search that is being made for new sources, it was considered that a compilation bring together the deposits of the Dominion would be desirable.

In the preparation of this work, the information regarding the deposits, has been taken from the Reports and Memoirs of the Geological Survey of Canada, and the Report of the Minister of Mines of the various provinces.

In some cases the latest reports available were for the year 1929, so that information concerning production and producing properties will not be strictly up to present date.

An attempt has been made to bring together under one cover the more important areas and mines, and to form some idea of the future of Canada as a gold producer; therefore only the producing areas and mines have been dealt with.

The provinces have been treated separately for purposes of comparison of production, but due to the similarity of the geology and occurrences in Manitoba, Ontario, and Quebec, these provinces have been grouped together under the heading of "Occurrences in the Canadian Shield"

Some conclusions and generalizations have been arrived at, and these will be found under the heading, "Summary and Conclusion".

ACKNOWLEDGMENT

To Dr. S. J. Schofield of the Geological staff of the University of British Columbia, the writer wishes to extend his sincere appreciation for useful suggestions and advice received in the proparation of this work.

THE RELATIVE IMPORTANCE OF THE PROVINCES AS GOLD PRODUCERS

ONTARIO:

The greater proportion of the gold production of Canada comes from the Province of Ontario.

For many years it has been the largest producer in the Dominion, producing each year an increasing percentage of the total amount until in 1930 its output was over 80% of the whole for the Dominion, which is derived mainly from the Porcupine and Kirkland Lake areas.

Until recently the Porcupine has been responsible for 95% to 97% of the total for Ontario, due to activities at the Hollinger Mine. Kirkland Lake Camp however has been steadily increasing its production and in 1931 exceeded the output of the Porcupine district, the Lake Shore Mine being the chief producer.

Ontario has every prospect of increasing her total, since there are good values indicated at lower depths especially in the Kirkland Lake area.

QUEBEC

Although British Columbia for many years has been second to Ontario in importance, and still is in total production, Quebec comes second in the list as a producer of Lode gold.

Quebec has only recently come into prominence as a gold province, the first discoveries being made in 1923.

There are many gold quartz veins occurring in the Rouyn-Harricanaw Region and a small production results from these, but the greatest amount comes from the copper gold ores of Noranda.

BRITISH COLUMBIA

British Columbia since 1925 has decreased in lode production and last year lost one of its most important producers when the Nickel Plate Mine closed down, due to exhaustion of its ore bodies.

MINER Sept 1931 P.8

The Premier Mine which has been the mainstay of the industry

B.C. Minister of Mines Report 1930

in the province has also shown a decrease in reserves and grade of ores for the last two years; and it seems possible that another important source will soon be worked out. However, recent development in the Bridge River area show promising results, and an increased production from this district is assured. Add to this the increased production of the Union and Reno mines of the Franklin and Salmo districts respectively, and it is expected that the total production will not show a material decrease.

MANITOBA

In 1928 Manitoba started serious production of gold from the Central Manitoba Mine. This brought the province into fourth place as a gold producer of the Dominion. Since that time developments at the San Antonio and Gem Lake Mines have indicated mineable quantities of ore and an increase in the total output of the province is almost certain.

NOVA SCOTIA

The only other province in Canada which produces gold from lode-mining is Nova Scotia.

The gold areas of this province have been known since 1857 and stretch along the eastern coast of the province for a distance of 275 miles. The degree of activity has varied from time to time but since the turn of the century, interest has been lacking and consequently production has been low.

At the present time, however, some of the old properties are

being reconditioned with a view to working them. This will probably bring about a slight increase of production, but it is hardly likely that any great output will be obtained.

ALBERTA and SASKATCHEWAN

As yet in these two provinces no lode gold deposits have been found.

Prospects of finding gold in Saskatchewan are not entirely absent, as its Northern reaches are underlain by theCanadian Shield. It is in this shield that the gold deposits of Ontario, Manitoba and Quebec occur.

Canada in Comparison with other countries

Since the discovery of the gold deposits at Porcupine and Kirkland Lake, Canada has been one of the leading gold producers of the world.

Until recently, she has been third in world production with South Africa first and United States second. Due to the expansion and increase from Ontario, Canada has gradually risen in total production and in 1930 exceeded that of the United States for the first time.

Canada Year Book 1931 P. 356

During 1931 Canada again increased her total output and at the present time is second only to South Africa. With further increases in sight Canada should easily maintain her present position as a producer of gold.

Minerals Associated with Gold

Pyrite and arsenopyrite occur in the majority of the deposits and are often the most abundant minerals present.

Sphalerite generally occurs in small amounts and is sometimes used as an indicator of gold values as at the Premier Mine in B. C.

Of the other sulphides galena and chalcopyrite are invariably present in varying amount.

In Nova Scotia there is one deposit of auriferous stibnite which is worked at the West Gore Mine.

Gold Fields of Nova Scotia 1929 P. 42

The gold generally occurs in the free state but some deposits have an abundance of tellurides. The tellurides of gold which occur are calaverite, sylvanite and petzite.

Calaverite and petzite occur at Kirkland Lake and sylvanite and petzite at Porcupine. Sylvanite is the economic mineral at Premier. In the Nickel Plate Mine[1] at Hedley B. C. the gold occurs associated with arsenopyrite but there is no definite relation between the two minerals.

G.S.C. Memoir No 2 Camsell P.135

In those mines in which the gold is associated with pyrite there is not one case in which there is a definite relation between the two minerals.

Equal amount of pyrite may assay anything from zero to $100 per ton. On the Powell and Chadbourne claims in Quebec a relation was found between the gold content and grain of pyrite; the gold being inverseley proportional to the grain of pyrite. The gangue minerals associated with gold deposits are invariably, quartz and calcite. Sometimes the quartz shows a pegmatitic character as at Porcupine.

Porcupine Gold Area O.D.M Report 1924 P.41

Relation of Gold Deposits to the Type of Igneous Rocks

From a study of the many gold mines of Canada, one is struck with the close association of the deposits with acid rocks.

W. G. Miller suggested that the gold ores of Porcupine were likely the results of granitic intrusions and that the immense quantity of quartz had been derived as a differentiation product from the magma. Where the quartz has been crushed, the grains show an interlocking character such as is seen in granite.

A pegmatitic character of the quartz is shown by the presence of feldspar at Hollinger Mine.

The relation of quartz veins to pegmatite, aplite and granite has been noted by several writers.

C. K. Van Hise in the Black Hills of South Dakota noted the

Principles of North American Pre-Cambrian Geology
U S.G S 16th Annual Report

gradual transition from intrusive granite through pegmatite dykes, and a decreasing amount of feldspar to quartz veins remote from the granite.

J. E. Spurr in "The Geology of the Yukon Gold District, Alaska"

Bull U S G S 1896

refers to a set of younger quartz veins on 40 Mile Creek and says, "They often contain a little feldspar and sometimes by an increase in the amount of this mineral pass into a variety of fine pegmatite. This in time seems to be transitional into a course aplite which is very abundant."

Lindgren in speaking of the Gold Deposits of Daklonega Ga. says that

The Gold Deposits of Dahlonegg Ga. U S G S Bul. No.293

"they are entirely similar to other auriferous quartz veins of California and Australia and that in all these it seems a probable

hypothesis that the gold was contained in the granitic magma and was separated from it during the cooling process and carried to the veins in the form of magmatic water.

W. G. Miller and C. W. Knight give a similar origin for the gold deposits at Deloro Mine and adjacent properties in S. E. Ontario

The Pre Cambrian Geology of South Eastern Ontario

O D M. Vol xxll P.P. 1915

De Launay in "The World's Gold" refers to the relation of gold to granitic rocks. At Berezovsk in the Urals there occur certain veins of microgranite which contain thin veins of auriferous quartz.

Summery and Conclusion

A The gold deposits of Canada are found to occur in four areas.

1. Along the eastern contact of the Coast Range Batholith -- British Columbia

2. Along the eastern and southern contact of the West Kootnay Batholith --British Columbia

3. In the Canadian Shield

4. Along the east coast of Nova Scotia

B Each area is characterized by the presence of granitic intrusives of Batholithic size.

C The solutions which caused the gold deposits represent the more acidic emanations during the cooling stages of the Batholiths.

D That the intrusions which brought the gold bearing solutions are of four ages.

1. Coast Range Batholith----------Jurassic

2. West Kootnay Batholith----------Jurassic and Miocene

3. Canadian Shield----------Pre-Cambrian----Algoman

4. Nova Scotia----------Devonian

E That the deposits in the Canadian Shield are all found along the areas of Major synclines.

It is quite probable that the deposits of this region were formerly of much wider extent but have since been eroded away on the anticlines, while those in the synclines have been preserved.

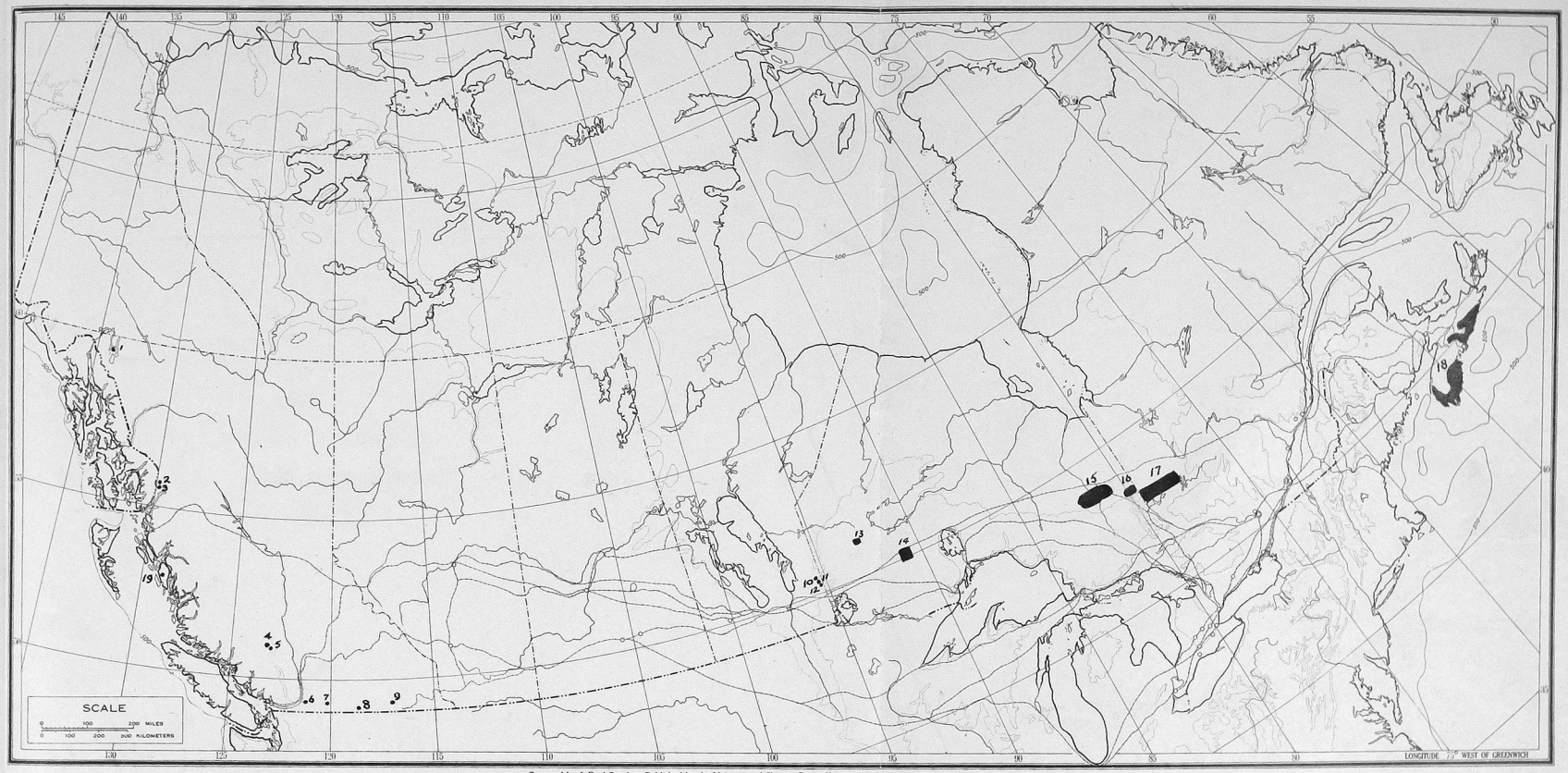
F That the gold occurs for the most part in the free state with tellurides present in monor quantities.

G That the present tendency is for the total production of Canada to increase rather than decrease.

PLATE I

Map Showing Producing Gold Mines and Areas in Canada.

GOODE'S SERIES OF BASE MAPS AND GRAPHS. CANADA ON THE CONIC PROJECTION NO. 111



1. Engineer
2. Big Missouri
3. Premier
4. Pioneer
5. Lorne
6. Emancipation
7. Nickel Plate
8. Union
9. Reno
10. Central Manitoba
11. San Antonio
12. Gem Lake
13. Woman Lake Area
14. Sturgeon Lake Area
15. Porcupine Area
16. Kirkland Lake Area
17. Rouyn-Harricanaw Region
18. Nova Scotia Gold Area
19. Surf Inlet

PART II

OCCURRENCES IN BRITISH COLUMBIA

British Columbia

Introduction

In the early history of the province British Columbia was noted for her rich placer deposits. The deposits are characteristic in that they are short lived, and while they are wonderfully rich for a short period of time, it is the lode mines that form the backbone of the industry.

The lode gold mines of B. C. occur in definite trends throughout the province. From the Atlin district in the North they are scattered along the Eastern side of the Coast Range Batholith as far south as the Coquehalla area.

In the interior of B. C. they occur on the South and East of the Kootnay Batholith in the Osyoos and Lardeau, Grand Forks, Umir and Nelson districts.

For the past five years the lode production has been between three and four million dollars and it is quite likely that this production will be kept up in the future.

History

Prior to 1893 the total gold output of B. C. came from Placer workings. However, during this year lode mines produced 1170 ounces, coming from the Trail Creek, Osyoos and Golden Camps.

In 1897 the Nelson camp added appreciably to the total lode production.

The year 1901 saw the Boundary Rossland camps begin operations. These were gold copper properties from which the gold was abstracted by smelting.

The Nickel Plate Mine at Hedley, which was being prospected in 1897 started milling in 1904. This became one of the steadiest producing mines of the province and closed down in 1931 after approximately 30 years of production.

In 1913 Lode gold production reached its peak with a total of over 5½ million dollars.

During the war years there was a sharp decline in output with Boundary and Rossland producing about 93% of the total.

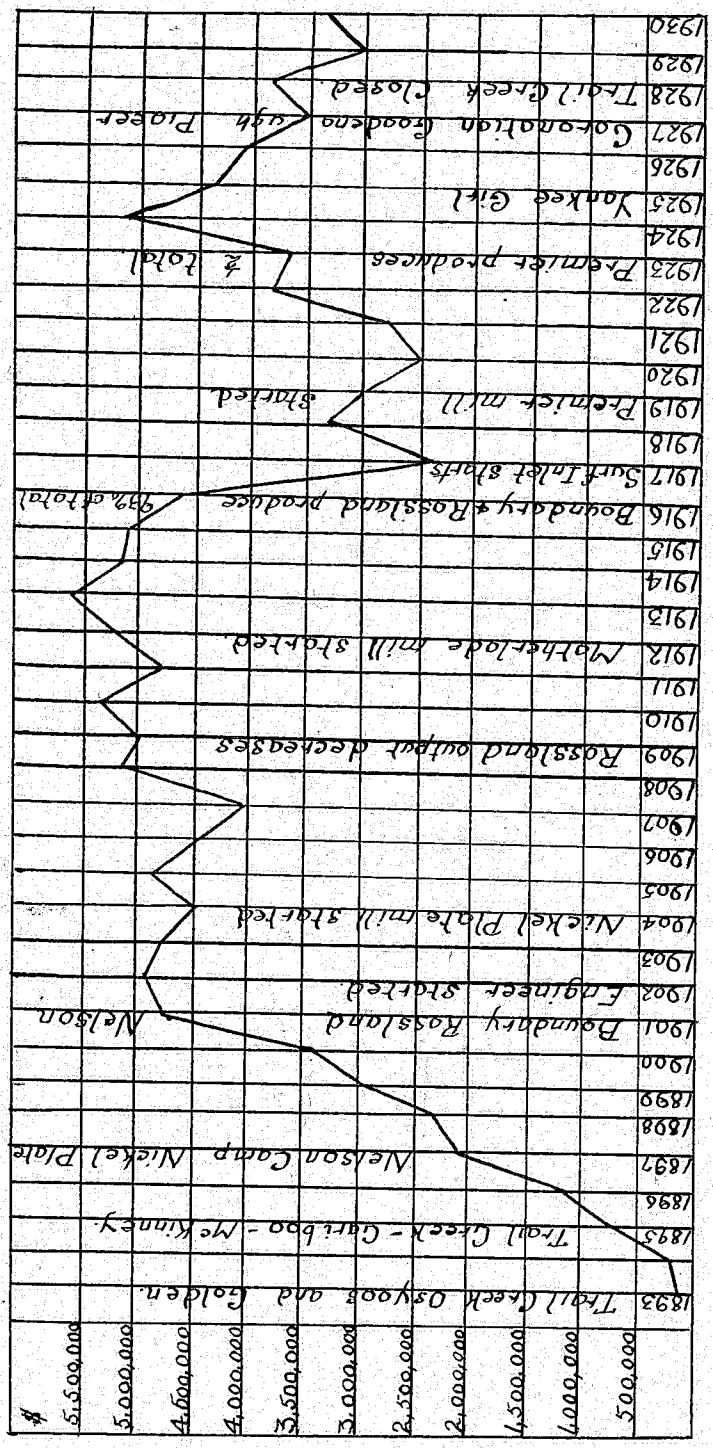
Surf Inlet reached the producing stage in 1917, and continued production for ten years, during which time it produced $8,000,000 worth of gold. The most important feature since the war lies in the development of the Premier mine. This started milling in 1919 and has been still the largest yearly producer of gold in the province.

Since 1927 much interest has been taken in the Bridge River area, where the Lorne and Pioneer Properties occur. The Pioneer Mine has been producing on an increased scale for the last two years and the Lorne at present is constructing a mill.

Two other new producers are Union, in the Grand Fork district and Reno in the Salmo area. The recent depression has caused a further interest to be taken in gold-mining and many prospects are now being worked.

The Chief Sources of Gold in B. C. at the present time are:

1. Premier
2. Pioneer
3. Reno
4. Union
5. Lorne
6. Big Missouri
7. As a by-product from the copper ores of Anyox and Britania


PRODUCTION of LODE-GOLD in BRITISH COLUMBIA to 1930
$
5,500,000
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
1893 Trail Creek Osyoos and Golden.
1895 Trail Creek - Cariboo - McKinney.
1896
1897 Nelson Camp Nickel Plate
1898
1899
1900
1901 Boundary Rossland Nelson
1902 Engineer started
1903
1904 Nickel Plate mill started
1905
1906
1907
1908
1909 Rossland output decreases
1910
1911
1912 Marhatlade mill started.
1913
1914
1915
1916 Boundary & Rossland produce 75% of total
1917 Surf Inlet shuts
1918
1919 Premier mill shuted.
1920
1921
1922
1923 Premier produces ¼ total
1924
1925 Yankee Girl
1926
1927 Consolidation Goodeno - Lyle Pioneer
1928 Trail Creek closed
1929
1930

Age of the Gold Deposits

A sketch of the geoligical history of British Columbia, shows that there was a continuous deposition of sediments until Middle Jurassic time. Following this there was uplift and folding which in Upper Jurassic times culminated with the intrusion of the Coast Range and Selkirk Batholiths.

These batholiths caused considerable metamorphosis of the older sediments and brought with them mineralizing solutions which have caused the larger proportion of the ore deposits.

S. J. Schofield gives the metallogenia epochs of B. C. as follows:

S. J. Schofield Ore Deposits of British Columbia G. S. C. Memoir 132 P. 68

Deposits depending upon eruption of Igneous rocks.

Recent.

Pleistocene

Pliocene----------Mercury ores. Kamloops

Miocene----------Copper ore. Boundary District

Oligocene----------Copper ores. Sunlock property

Eocene----------Lead ores. Monarch Field Hazelton

Cretaceous----------

Jurassic----------Copper ores- Anyox, Britannia, Rossland
Marble Bay, Copper Mountain

Silver Lead ores---Salmon River, Alice Arm,
Monarch Mine, Slocan, Ainesworth

Gold ores--------Bridge River, Coquihalla

Nickel Plate, Salmon River

Iron Ores ----------Magnetites Vancouver Island

Platinium----------Tulameen

Carboniferous

Devonian

Silurian

Ordivician

Cambrian

Beltian----------Copper ores--------East Kootnay, Purcell, Sills

Shuswap

The foregoing table shows that the majority of gold deposits in B. C. belong to the Jurassic period of mineralization.

Work by Gunning in the Lardean area showed, however, gold quartz

G S C Memoir 161 P. 20

veins to be associated with the Kuskanax granite of probable Miocene Age.

Drysdale, showed in the Rossland district that there were two periods

Drysdale C. W. G. S. C. Mem. 77 P. 85-93

of mineralization, the first being the copper ores belonging to the Jurassic. These copper ores he found to be brecciated and cemented together again by the gold, thus proving the later age of the gold. He places the age of the gold mineralization as Miocene.

Thus ages of the gold deposits may be grouped then as follows:

1. Pre-Cambrian----------Purcell Sills unimportant
2. Jurassic----------Salmon River nickel plate
   Bridge River Coquihalla
   very important
3. Miocene----------Lardean veins and Rossland
   Copper ores Relatively unimportant at present

Description of Areas and Mines

Salmon River Area

Situation:

The Salmon River Area is situated at the head of the Portland Canal and includes the Premier and Big Missouri gold mines. As the Portland Canal cuts right through the Coast Range Batholith the area is situated adjacent to the eastern contact of the batholith.

General Geology

The rocks outcropping in the area are all Jurassic in age but are covered in places by patches of Pleistocene glacial delteris.

The oldest exposed rocks are the red and green tuffs of the Bear River formation which cover the larger part of the area and contain the ore deposits.

The epoch of the Bear River formation was followed by one of sedimentation in which was laid down the Salmon River and Nass River series. The Salmon River series consists of a few feet of conglomerate which separates the tuff of the Bear River formation and the slates of the Nass formation.

The following is a table of formations that occur in the area.

G S C Memoirs 132 P. 10 Schofield and Hanson

Quaternary	Pliestocene and Recent	Gravels, sands and Glacial drift
	Unconformity	
Mesozoic	Jurassic	Lamprophyre dykes
		Intrusive contact
		Quartz dioride dykes
		Intrusive contact

	Coast Range Granodiorite Batholith
	Intrusive contact
	Mass formation: Slates
Salmon River formation	Conglomerates
Bear River formation	Agglomerates and tuffs

Following the period of sedimentation there was uplift and folding which was followed by intense igneous activity, consisting of the intrusion of the Premier Porphyry and the Coast Range Batholith with its later phases.

The Premier porphyry according to Schofield and Hanson[1]

1. S. J. Schofield and G. Hanson G.S.C. Memoir 132 p.21

was intruded before the period of folding in the form of sills along the bedding planes of the Bear River formation. After the intrusion of the Batholith igneous activity continued until late in the Jurassic, and shows itself in the many dikes both acidic and basic which cut all the formations in the area.

Mineralization

Mineralization of the area is intense and consists chiefly of galena, sphalerite, pyrite, chalcopyrite and gold, in a quartz gangue. This mineralization was probably associated with the closing stages of the Coast Range Batholith.

S. J. Schofield Proc Canadian Mining Institute 1918 p.202

The majority of the properties are worked for their silver content but the most important mine in the district although started as a silver property has been one of the greatest producers of gold in the province.

In the oxidized zone silver values have been concentrated by secondary enrichment, and it is now generally assumed that the rich values in the upper workings of the Premier Mine were due to this cause.

Future of the District

During the past few years the output and grade of ore at the Premier have both been lower and it is expected that the mine will soon be worked out.

The other gold mines in the area are as yet only in the development stage and nothing definite is known of the size of their bodies.

However there is one promising feature of the district and that is the fact that all the deposits have some gold content although it may be small. This fact should be a stimulus to gold prospecting and it would not be a surprise if other large deposits of gold were found.

On the whole then, it would seem as though the immediate future would see a decrease in the gold output; but, though the area may never reach as high a production as it has had in the past, there is reason to believe that it will in the future still contribute appreciably to the total output of the provinces.

Description of Properties

Premier Mine

Premier Mine is situated about eleven miles north of Stewart, at the head of the Portland Canal.

The workings are on the Western slope of the Bear River Ridge on

Cascade Creek just north of the B. C. Alaska boundary.

The property has been known since 1914, and during the years to 1919, several companies explored the ground. In the fall of 1919 the American Smelting and Refining Company acquired an interest and followed out a plan of development, which brought the mine into production in 1920. Since that time the property has been the largest producer of gold in the province. However, during the last two or three years, production has fallen off, due to a lower grade of ore and a lower tonnage. Unless new reserves of ore are found it is expected that the mine will soon be worked out.

Geology

The geology of the mine consists of the green andesitic tuff of the Bear River formation At the mine this rock is usually called greenstone. The tuff is fine grained in texture and is intruded by masses of the quartz porphyry known as Premier porphyry. In 1920 Schofield and Hanson classed this porphyry as sills.

Both the greenstone and the porphyry have been highly sheared and are cut by two sets of dykes--An older light colored quartz diorite or granodioride type and a younger lamprophyre.

Burton classes these dykes as pre-mineral in age but Schofield

W. D. Burton--Ore Deposition at Premier Mine E. C. Geology Sept. 1926 P. 53.

and Hanson believe them to be post ore.

S. J. Schofield and G. Hanson Memoir 132 P. 53

Both the tuffs and the porphyry have been greatly altered by shearing stresses producing much chlorite and sericite. Further alteration has been brought about by intense silification and in spots is almost white in color.

This silification was caused by the ore bearing solutions. Values have been found both in the greenstone and the porphyry but it is the porphyry in which the main values occur, those in the greenstone being quite low.

This might be explained by the fact that the porphyry being the more brittle rock fractured to a greater extent while the tuff tended to flow under the applied pressure. The porphyry then would form the best channel along which the ore bearing solutions could migrate.

The veins are of the replacement type and occur in fracture zones developed along the tuff porphyry contact.

W. D. Burton: Ore Deposition at Premier Mine. Economic Geology Sept 1926 P. 587

The ore occurs along two main shear zones known as the North East Zone and the North West Zone. The fracturing is concentrated along the contact between the porphyry mass and the greenstone. The main or North East are zone strikers N 50° E, while the North West zone strikes N 40° W. The North West zone is not as well defined as the North East, but where it joins the main zone, mineralization is intense.

At the junction of the two ore zones the sulphide body is very wide due to the permeability of the depth, and the sulphide body becomes narrower and lower in grade.

Mineralization

The ore is composed mainly of heavy sulphides with pyrite being by far the most abundant.

The gangue is chiefly quartz, Adularia, with some Calcite and Albite, Galena, Chalcopyrite and a goodly amount of Sphalerite occur.

The presence of sphalerite in places is a fair indication of gold values.

Fracturing continued during deposition of the ore with the major movements occuring early in the process.

Tetrahedrite is found in massive form in the upper 650 feet.

Electrum occurs throughout the whole deposit and almost any specimen, after careful examination will show the presence of this alloy. This alloy is probably responsible for the gold although some free gold has been noted

V. Delmage Can. Min. Journal Vol 41 No.22 1920 P. 454

Argentite, Polybasite and Pyrargyrite occur but are present chiefly in the upper workings. Native silver occurs along fractures in the vein.

After their survey in 1920 Schofield and Hanson attributed the high silver values to concentration by secondary enrichment and stated that they would diminish with depth.

The values occurred only along fractures in the primary ore and were not in the solid vein material.

Both ruby silver and native silver occur in the upper levels, but the presence of high silver values below the third level is quite rare.

There seems to be little doubt that the ore bearing solutions responsible for the deposit, emanated as a final phase of the Coast Range Batholith.

At several places, virtually on the contact of the batholith, occur veinlets of pyrrhotite, sphalerite, pyrite, galena, chalcopyrite, carrying low gold and silver values.

The occurences appear to be genetically connected with the batholith as to origin, and the natural inference is, that the zone

of pyrite galena--zincblende veins found so widely distributed within a distance of three miles east of the contact is of similar origin.

Burton says that a rough zoning is indicated, beginning with

W. D. Burton: Ore Deposition at Premier Mine Economic Geology Sept 1926

P. 601

pyrrhotite veinlets coming through veinlets of chalcopyrite, pyrite, galena, and zincblende finally culminating witht the Premier deposit.

The mine has been developed down to the sixth level, where only one stope is working.

During the past year some footwall and hanging wall stringers were mined out. Outside of these the prospects of finding new ore bodies do not appear very bright. The output of the mill and the grade of ore have been decreasing for several years and unless some new bodies are found the end of the mine is in sight.

Big Missouri Group

Another mine in the Salmon River area which produced gold during 1931, is the Big Missouri.

A few tons of concentrates were shipped to the Trail Smelter from the small test mill on the property.

The property is situated about 5 miles north of Premier, on Harris Creek. The claims cover both flanks and the summit of what is known as Big Missouri Ridge.

The property is controlled by the Consolidated Minining and Smelting Co. which has done a great deal of development work. A crosscutt tunnel was driven through the ridge from east to west for a distance of approximately 2000 feet and a small amount of stoping has been done.

The tunnel is in green sheared tuffs of the Bear River formation.

No porphyry occurs in the tunnel itself but just south and east of it there are several outcrops.

The tuffs have been cut by several generations of quartz veins and have been actively impregnated by pyrite, galena, and sphalerite.

The latest invasion of quartz, which occurs as small gash veins, carries good values in free gold.

It is on these veins that the stoping has been done. The veins are not continuous and are hard to follow. They strike approximately due north and south but as yet their extent has not been determined.

Mining operations were suspended in September 1931, but development by diamond drill was continued in order to make a complete test of the possibilities of the property.

The Salmon Gold Group

The Salmon Gold Group of claims is situated on the West side of Summit Lake about 10 miles north of Big Missouri. This property has shown consistant gold values in the neighborhood of $20 per ton.

J. T. Mandy B. C. Minister of Mines Report 1930 P. 114

The gold is contained in a large body of pyrrhotite which is close to a granodiorite intrusion.

During the summer of 1931 an option was taken on the property by the Premier company and diamond drilling was started. Results of the drilling are not obtainable but were sufficiently encouraging to justify further work in 1932.

Bridge River Area.

Situation

At the present time attention is being focused on the Bridge River district due to the activities of the Pioneer and Lorne Gold Mines.

The Bridge River area is situated Northwest of Lillooet on the P. G. E. Rly. The area lies between latitudes 50°40' and 51°05' and longitudes 122° and 123° W.

The most important part of the area is that along Cadwallader Creek on which the Lorne and Pioneer Gold mines are situated.

The area is situated on the Eastern contact of the Coast Range Batholith and contains some of the rugged coast district and some of the interior plateau.

General Geology

The oldiest rocks occurring are palaeozoic sediments of Pennsylvanian and Permian age known as the Bridge River series.

These occupy about 75% of the area and are well developed in the valley of the Bridge River. Above these come a series of Triassic volcanics.

W. S. McCann:--The Bridge River Area G. S. C. Memoir 150 P. 22

These in turn are overlain unconformably by a series of Upper Triassic sediments consisting of Conglomerate sandstone, crystalline limestone and dolomite, known as the Cadwallader series. Upper Jurassic time is one of importance in the area for during this period there was intruded an angite diorite stock with which the gold bearing veins are believed to be genetically connected.

This stock, is overlain unconformably by the Eldorado[1] series

1. Bateman Geological Survey Sum Report 1912

of thin bedded sediments. This series is of Lower Cretacious Age and is intruded by a mass of quartz diorite. This quartz diorite mass is classed as post-Lower Cretacious and is known as the Bendor quartz diorite.

It has the form of a small batholith and is well developed in the Bendor Mountains[2] where it cuts both the Bridge River and Cadwallader

series. In the Northern part of the area it is seen as wedge-shaped masses cutting the Eldorado series.

Of approximately the same age, and cutting the stock are a series of light colored porphyry dykes which consist chiefly of pure albite. They are closely associated with the quartz veins and occupy the same fissures.

The Oligocene was another period of volcanic and igneous activity, which first laid down a layer of tuff and lava resting in places on lignite bearing sediments. Following this there was an intrusion of a light colored porphyry known as the Rexmount porphyry. At approximately the same time were intruded diorite porphyry dykes with which are associated some antimony deposits. The age of these dykes is not definitely known but they are later than the Bendor diorite which is cut by them.

The Quaternary period consists chiefly of the deposition of glacial and stream gravels with a little volcanic ash, the last to be laid down.

Economic Geology

The most important formation in the area as regards gold deposits is the Augite diorite stock.

According to McCann this stock was probably intruded at the close of Upper Jurassic time and may be genetically related to early movements of the Coast Range Batholith. This is evidenced by the fact that the stock cuts the Cadwallader series of Upper Triassic age and is overlain by Lower Cretacious sediments of the Eldorado series.

The stock being a homogeneous mass of brittle rock lent itself

easily to deformation by stresses. The stresses showed themselves in two systems of fissures normal to one another. One strikes North East and the other North West.

These fissures have been filled with hydro-thermal solutions which caused the gold quartz veins.

The solutions caused considerable alteration of the wall rock but the gold values are contained only within the veins.

The gold quartz veins are relatively absent in the sourrounding sediments.

This is probably due to the more brittle nature of the stock which would fracture under the applied stresses, while the sediments would tend to close the fracture by flowage.

Mineralization

The gangue of the veins consists mainly of quartz and calcite with small amounts of sericite, siderite and dolomite.

The metallic minerals present are telluride, arsenopyrite, pyrite chalcopyrite, stibnite, galena, sphalerite, tetrahedrite and fine gold.

In places the gold is sufficiently concentrated in the free state, so as to be seen with the naked eye. It also occurs in finely divided particles associated with and of the following minerals; pyrite, arsenopyrite chalcopyrite, telluride, and stibnite. All these minerals are considered as indicators of gold values No values have been found in the wall rock.

Pinching and Swelling

Fractures caused by dynamic stresses are usually curved or warped instead of straight. This has been the case in the augite diorite stock and as a result the veins which filled these fissures are inclined to

pinch and swell.[1] The pinching of a vein to a mere stringer does not

1. G.S.C. Memoirs 130 P. 59

mean the end of the vein but further development generally shows that the vein widens up again.

Post-ore faults

Post ore faulting has caused a pronounced sheeting or ribbon effect in the veins. The sheets or bands are parallel to the walls and are separated by their thin films of gouge and sulphides. In places where slikensided surface occur, thin films of gold ore are present.

Persistence of Veins and Ore with Depth

At the time McCann wrote his report only a depth of 300 feet had been reached. He says, however,"[1] It is reasonably certain that the fissures extend to great depths as long as they stay in the diorite, and that the quartz and other minerals with which they are filled were deposited under almost uniform conditions, within the limits of possible mining operations.

1. Memoir 130 P. 60

At the end of 1930, development on the Pioneer had proceeded to the 1000ft. level, and values to this depth were very consistent, averaging $14 to $15 per ton with some assays from ribboned quartz being as high as $80 per ton.

B. C. Minister of Mines Report 1930 P. 200

The veins did not diminish as depth was reached and varied between three and five feet.

This development substantiates McCann's prediction and indicates good possibilities of finding ore at still greater depths.

Origin of the Vein Solutions

The solutions from which the veinsmaterials were precipitated

are believed to be genitically related to the augite diorite and to be the latest phase of differentiation of the parent magma from which the diorite originated.

Age of the Veins

There must have been a sufficient lapse of time for the diorite to solidify before the intrusion of the veins occurred.

The length of time would depend on the amount of covering.

However it is considered that the diorite cooled soon after intrusion. As the veins are the latest differentiate of the parent magma they would therefore be of the same general age as the diorite but slightly younger.

Future of the District

As stated before tha gold quartz veins have been found to any extent only in the augite diorite stock and are relatively rare in the surrounding sediments.

Recent development at the Pioneer has shown continuity of the veins and ore values to a depth of 1000feet[1] with good indications of further continuity.

1. B. C. Minister of Mines Report 1930 P. 200

The future of the district as a gold producer is extremely promising.

The veins occur in parallel systems usually no great distance apart, thus making development by cross -cutting rather easy.

The close proximity of the veins, and the substantiation of their depth, together with their known length, would indicate that any mine in this area would continue to produce for a lengthy period.

Description of Properties

The Pioneer Mine

The Pioneer Mine is an old mine, having been known since 1897. Considerable development work had been done up to 1926, but no serious production had been carried on.

In the succeeding years to 1929, the mine was acquired by the Pioneer Gold Mines of B. C.

Development was carried to further depths and serious production was started in 1930 when the mill was run entirely on ore supplied from the mine workings.

The mine is situated on Cadwallader Creek, about four miles above its junction with Hurley Creek.

Geology

The property is at the eastern extremity of the diorite mass which at this point has a width of about 300feet.

The surrounding rocks are sediments of the Cadwallader series and it is not likely that the veins continue into them, due to their incompetent nature.

To the end of 1930 development had been carried to the 100 ft. level with consistant values being obtained.

All the development has been in ore with average values of $14 to $15 per ton.

B. C. Minister of Mines Report 1930 P. 201

Two veins have been developed which cut one another at a very acute angle.

The veins show pronounced ribbon structures and are easily cleaved along the sheeting planes.

These planes are coated with finely divided sulphides and sometimes films of gold.

Faulting of the veins is apparent in the upper levels, but is not so evident in the lower levels. Fault conditions are not serious and the veins are generally picked up again within a few feet.

Oxidation caused concentration of the gold in the upper 100 ft. of the vein and many high grade samples were taken out. However the average tenor of the ore as stated above is $14 to $15 per ton.

The gold is found in the free state in close association with the arsenopyrite, in which it is included as a fine mechanical mixture.

The production of the mine during 1930 was $285,961, but preparations for increased production during 1931 were being made.

The outlook of this mine is very good, and results of development work indicate an extended life of the property.

Lorne Mine

Lorne Mine is situated on Cadwallader Creek just below the Pioneer.

It also has been known since 1897, but has been worked only in a desultory manner and no production of consequence has resulted.

In April 1931 the property was taken over by the Bralco Development and Investment Company.[1]

1. B. C. Minister of Mines Report 1930 P. 202

This company started developments and construction of a small test mill which is expected to be completed early in 1932.

Geology

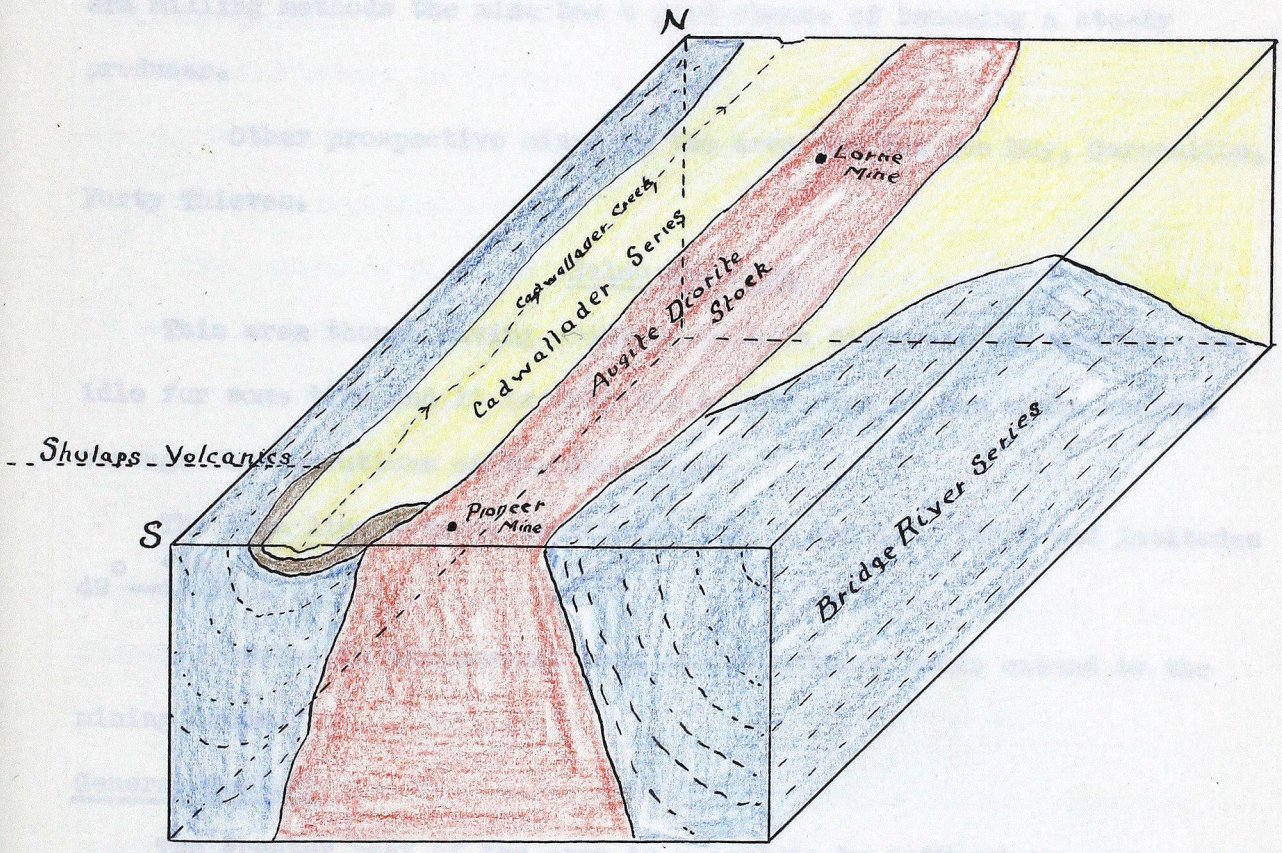
All the workings of the mine are within the diorite stock which is cut by the albite porphyry dykes. These dykes appear to have been planes of weakness along which fissures formed later, to be filled with quartz.

Ten veins and a few small stringers are exposed on the property of which the King, Wedge, Shaft and Woodchuck are the more important.

Plate III

Block Diagram Bridge River

Gold Occurrence



The veins vary in strike and dip, and have a width averaging from 22" to about 5 ft.

The King vein has been the most productive and has a width varying from 4--6 ft.

Values from the vein have averaged about $17 per ton by amalgamation, which is a recovery of about 60%.

With proper and careful development and the installation of modern milling methods the mine has a good chance of becoming a steady producer.

Other prospective mines in the area are the Ida May, Coronation, Forty Thieves.

Salmo Map Area

This area though having produced gold at different periods has been idle for some time and it is only since 1929 that it has again started through the operations of the Reno Mine.

The Area lies between longitudes 117° W and 117° 15" W and latitudes 49°--49° 15".

Salmo is the nearest town and from there roads extend to the mining camps.

General Geology

The greater part of the area is underlain by sedimentary rocks which have been intruded by masses of the Nelson batholith.

J. F. Walker, Mineral Occurrences in the Salmo Map Area G.S.C. Sum Rept 1928

The sediments include the Summit and Pend d' Oreille series of Daly[1] which are the same rocks mapped as the Lower Selkirk and Nickonolith

1. R. A. Daly G.S.C. Memoir No. 38

by Brock and Mc Connell[2]

2. West Kootnay Sheet

The sedimentary series consists of grits and quartzites followed by schists and has been folded into anticlines and synclines with northerly strikes. From east to west across the area there is a series of three synclines each followed by an anticline.

The lower part of the sedimentary series is exposed on the east and the upper on the west.

Mineral Deposits

The gold occurs in fissure veins which are found along the central quartzite anticline. Some deposits occur to the east, while to the west some sulphide deposits carry gold.

The centre of gold activity may be considered to be the junction of the Wolf and Sheep creeks which is about ten miles from Salmo.

The gold bearing fissure veins cut the quartzite and schists and have a strike of N. 60° E to east.

The fissures have been displaced somewhat by faulting and in all cases the south wall moved west with respect to the north wall. These fissures have been filled with gouge and quartz and vary in width from almost nothing to twenty feet.

The mineralization consists of pyrite with a little galena and sphalerite.

In all the veins except the Queen, the primary ore has been found to be too low grade to work but oxidation has concentrated the values in the upper parts of the veins.

The oxidized zone may extend down as far as 500ft. The veins are more or less confined to the harder quartzite and argillaceous rocks, the fissure being tight and unfavourable for ore deposition in the schists.

Description of Properties

Reno Gold Mine Ltd.

This mine is situated at the head of Fawn Creek, a tributary of Sheep Creek and is approximately fifteen miles from Salmo by a motor road.

Two veins occur on the property but development up to the Autumn of 1929 had proved only one vein, the Reno, to carry commercial values.

The vein cuts a series of quartzites, argillaceous quartzites and siliceous argillites.

The vein has been explored over a vertical distance of approximately 450 ft.

In the lowest level known as No. 4 the bottom of the oxidized zone has not been reached, but the presence of galena indicates a change and the primary ore may be expected at any depth.

[1] Developments during 1930 on the No. 3 and No.4 levels, struck the primary sulphide ore.

1. Minister of Mines Report B.C. 1930 P.274

This ore carried gold in sufficient quantities for it to be mined at a profit. The finding of profitable gold values in the primary ore, an exception to the rule of the district opens up possibilities of considerable tonnage below the zone of oxidation and extend the life of the mine to a considerable degree.

There is a 25 ton cyanide mill, at the mine which gives a recovery of 95% to 97%.

The production for 1930 was $162,259 and total production of the mine to Dec. 1930 was $199,798.

Queen Mine

This mine is situated on Wolfe Creek just above its junction with

Sheep Creek. It was the chief producer of the district having produced steadily from 1902-1916 but since then has been idle.

It was from the Queen vein that the steady production occurred and this vein was the only one known at that time, which contained sufficient gold values in the primary ore to make mining profitable.

The geological features correspond in general to those of the area, with the veins cutting the argillaceous and quartzite rocks.

The mine has been idle since 1916, but during 1930 a company known as "The Queen Mines Ltd.", was formed, to recondition the property with a view of bringing it to production again.

Grand Forks District

The Union Mine

The Union Mine is situated in what is known as the Franklin Mining Camp about 45 miles North of Grand Forks, in the Grand Forks Mining Division.

The mine has been in the development stage for sometime. In 1927 the property was taken over by the Hecla Mining Company of Idaho and development continued which brought it into steady production in 1929.

The mine operated continuously throughout 1930 and produced 1,104 tons of concentrates. Operations continued through 1931 and at the present time the outlook of the mine is encouraging.

The geology of the camp was reported on by C. W. Drysdale in 1915.

C. W. Drysdale G.S.C. Memoir 56 1915

At that time little work had been done on the property and no estimate could be made of the size of the ore deposit. Since then little has been written on the camp and as a result literature is scarce.

The rocks of the mine belong to the Franklin group of carboniferous age and are altered augite porphyrites generally known in the region as

greenstone.

The veins are referred to Jurassic time and were formed along shear zones having a strike of S.80° W.

Ymir Section

Goodenough

The Goodenough gold mine is situated on the north eastern side of Ymir Creek about 4½ miles distant from Ymir.

The property is owned by H. Jackson and A. McDonald of Ymir.

Production was started in 1927 and development has continued since that time. The rocks in the vicinity of the mine are schists of the Pend d' Oreille series which are intruded by lenses of the Nelson granite.

The ore consists of gold bearing pyrite, sphalerite and argentiferous galena, with the chief values in gold.

There are two veins on the property which occur along shear zones. These have not been developed to any great depth but recent indications suggest the possibility of values on lower levels.

During 1930, the ore shipped amounted to 1141 tons which brings the total production up to 4717 tons.

The average tenor of the ore in gold would approximate $18 per ton.

B. C. Minister of Mines Report 1930 P. 269

Hedley District

The Nickel Plate Mine

Nickel Plate mountain is which the mine occurs is situated in the Osyoos Mining Division at the town of Hedley.

The mine has been one of the greatest producers of gold in the province and came after an activity of thirty years to an end in Sept.1931

Exhaustion of the ore reserves was forseen and in 1928 H. S. Bostock[1] made a survey of the geology resources of the property.

H. S. Bostock:--Geology and Ore Deposits of Nickel Plate Mt. Hedley B.C.

G.S.C. Summary Report 1929 Pr A.

Investigation failed to locate new ore bodies of any importance in the surrounding district. The mine continued to produce during 1930 and part of 1931, and an intensive diamond drilling campaign was instituted.

This also failed to produce any ore bodies of importance and the mine closed in Sept. 1931

Nickel Plate mountain consists of a series of westerly dipping sediments of Triassic Age which are intruded by numerous sills, dykes, and masses of diorite and gobbro.

The ore deposit is described as being of the contact metamorphic type with the ore consisting of gold bearing arsenopyrite in a gangue of metamorphic silicate.

G.S.C. Summary Report 1929 Part A. P. 227

Minerals associated with the ore are garnet epidote, and diopside. These indicate the formation of the ore in the deeper vein zone under high, temperature and pressure.

The ore deposits according to Camsell were formed at the same time

C. Camsell G.S.C. Memoir No.2 "Hedley Mining District"

as the intrusion of the gabbro diorite sills, and dykes.

Atlin District

Engineer Mine

W. E. Cockfield G.S.C. Summary Report 1930 Pr. A P.11

The Engineer Mine is situated on Tagish Lake approximately twelve miles south of Golden Gate, where the route to Atlin turns east.

The property is an old one having been first started in 1902. Nothing much has been done but the property has frequently aroused interest due to its spectacular gold values.

A few years ago an attempt was made to mine the deposit on an ambitious scale. Most of the money however was spent in camp improvement and some on mine development.

Unfortunately the high grade veins did not contain sufficient tonnage to warrant the expenditure and the venture proved a failure.

Since that time a small crew has been working at the property and development has indicated a large body of very low grade ore.

In 1930 the property was closed down due to financial difficulties, but it is expected that further work will be done in the near future.

Geology

The rocks in the vicinity of the mine consist of sediments of the Lebarge series of Jurassic Age. These are cut by a stock of granodiorite which forms Engineer Mountain.

Two silicious zones or "Hubs" of quartz occur near the centre of the property and it was thought that these carried the ore but later development proved them not to be commercial.

Cutting both the sediments and the granodiorite is a shear zone which has a general northeast strike. The veins on the property seem to be given off from the "Hubs" as might be expected. The relation of the veins to the shear zone is not quite clear as none have been traced into it.

The veins have not proved themselves to contain mineable values, but the shear zone holds some promise of providing the necessary tonnage to make the mine a success.

The zone has an indicated length of about 4000 feet and may be much longer.

As the shear zone was probably the main channel for the circulating o ore solution there is a good possibility of ore concentration within the shear zone.

Values already abtained are encouraging and further work on the zone would be justified. The gold occurs in the free state but closely associated with arsenopyrite.

Surf Inlet

V. Dolmage G.S.C. Summary Report 1921 Part A

This property is situated on the western side of Princess Royal Island about seven miles from the head of Surf Inlet.

From 1916-1926 the mine was operated by the Belmont Surf Inlet Co. and during that time yielded $8,000,000.

B.C. Minister of Mines Report 1930 P. 70

The property was lately purchased by J.B.Woodward of Vancouver, and Noah H. Timmins who intended to reopen the mine in conjunction with adjoining properties during 1931.

The ore deposit consists of large quartz veins in a shear zone which cuts the quartz diorite of the batholith, and a small roof pendant.

The mineralization of gold bearing pyrite with accompanying copper minerals such as chalcopyrite, bornite, chalcocite and covellite.

Coquihalla Area

Emancipation Mine

C.E.Cairnes G.S.C. Memoir 139

A few prospects occur in the Coquihalla area but so far only the Emancipation Mine has shown much promise.

The ore occurs in quartz veins which cut across the Ladner slates

and Cache Creek greenstones of Upper Jurassic and Carboniferous Age respectively.

The highest values are found in what is known as the Dyke Vein. This vein has a gangue of quartz and calcite, the quartz being turbid with inclusions of country rock and with concentrations of sulphides.

The most prominent mineral is arsenopyrite and the gold was found to occur in small distinct particles associated with it.

The source of the mineral solutions is referred to a diorite intrusion of probable Upper Jurassic Age.

PART III

OCCURRENCES IN THE CANADIAN SHIELD

Chapter I

Introduction

General Statement

The pre-Cambrian Shield of Canada is the largest exposed area of pre-cambrian rocks on the North American continent and may be treated both physiagraphically and geologically as a unit.

It surrounds the Hudson Bay on the east ,south, and west in the form of a huge horseshoe and has an area of approximately 1,800,000[1] square

1. W. G. Young Geology and Economic Minerals of Canada 1926

miles covering large parts of Quebec, Ontario, Manitoba and Saskatchewan. In the north where it stretches along Hudson Strait and the Artic Ocean for 200 miles it has it's widest extent. Stretching south it narrows and finally vanishes south of Lake Superior in the United States.

Its boundaries are characterized by large bodies of water and 25% of the area is underlain by water making the canoe the ideal means of transportation.

The shield has suffered from long periods of erosion and is now in an advanced stage of peneplanation. As a result of this peneplanation the shield exhibits no great relief, the greatest difference in elevation being not more than 200-300feet.

The rocks of the shield represent the earliest eras in the geological scale of time. Due to widespread ignous intrusion these rocks are very much folded and highly metamorphosed. Erosion in due course has stripped the covering from the granite in many places and this rock now occupies by far the larger areas of the shield.

Logan was the first man to do any work on these rocks and his conclusions still stand with but few alterations. Many men have been in the field and many

Many men have been in the field and many classifications have been attempted but none of them differ very much from Loyons original work

Geology

The present accepted classification is Canada is as follows.

As given by R. W. Brock

Keewanawan	
Animikian	
Intrusive(Algoman))	Red granite cutting everything up to the Hailyburian
Hailyburian	Basic lamprophyre dykes
Temiskamian	Sediments conglomerate and quartzites highly disturbed but not metamorphosed
Intrusive Laurentian Granite and Gneiss	mostly grey and gneissoid
Grenville sediments	highly metamorphosed
Keewatin Igneous complex	highly metamorphosed

Description of Formations:

Keewatin

The Keewatin igneous complex consists of both acid and basic lava flows now metamorphosed to phyllites and schists. When alteration has not been so great the lavas show a characteristic pillow and ropy structure. In many places they are accompanied by agglomerates tuffs and

some sediments. The series is very highly folded and contorted due to intrusions of granite.

The term Keewatin was originally applied by A.C. Lawson in 1885 to a series of Hornblende schists and volcanic agglomerates in the Lake of the Woods district. The term was adopted in the Lake Superior region and there applied to altered volcanics younger than Temiskaming. The term came to be used in the same sense when other areas were studied even though there were gaps which could not be bridged by correlation.

Intensive study has proved the wide areal extent and continuity of those altered volcanics throughout many thousands of square miles of Quebec and Ontario and has thoroughly established the name Keewatin.

The term Keewatin is now used to designate the assemblage of ancient lavas and associated sediments in northern Ontario and Quebec as these have been proved areally continuous.

The Rouyn--Harricanaw Region, Quebec G.S.C. Memoir 166 P. 52

Grenville series

Occuring in southeastern Ontario is a series of grey limestones greywacki and interbedded bands of chert and jusper which contain iron. This series overlies the Keewatin but has been disturbed and metamorphosed to such a degree that many of the original features have been obliterated. Logan gave this series of rocks the name of Grenville.

Laurentian

After the deposition of the Grenville sediments there was evidently an uplift of mountain building proportions which was followed by the intrusion of an enormous amount of granite. Logan called this granite Laurentian. This granite which is light grey in color has not been found to carry any mineralization. This lack of mineralization may be

due to the deep erosion to which the granite has been subjected in which case any deposits resulting from the intrusion would be dissipated.

Temiskaming

In the Cobalt district there is found overlying the Keewatin unconformably a series of conglomerates quartzites and slates which are highly disturbed but little metamorphosed. This same series has been found in many parts of the shield exhibiting the same age relations to the Keewatin.

W. G. Miller who was the first to study these rocks called them the Temiskaming series after the lake near which they occur.

Hailyburian

The Hailyburian period is represented by a series of basic and lamprophyre dykes which cut the Temiskaming sediments.

Algoman

Following the intrusion of the basic dykes there was a great upwelling of a red or pink granite which is found cutting everything to the Hailyburian. This granite is very widespread and is believed to be responsible for the gold mineralization. From the granite mass there followed later more acid differentiates to form a great mass of quartz veins and replacement deposits. The quartz veins carry gold and are responsible for gold deposits of Ontario, Quebec and Manitoba.

Animikie and Keweenawan

Following the intrusion of the Algonian granite there was a long period of erosion before the deposition of the Animikie and Keweenawan sediments and lava flows. The Animikie is characterized by the presence of an iron formation while the Keweenawan is characterized by many flows of basaltic lava, some of which contain native copper.

Fissure Systems of the Canadian Shield

In looking over the strikes of the gold bearing veins of the Canadian Shield one notices the fact that the majority have a general similarity of trend.

The veins of the producing mines in Manitoba strike with the trend of the sediments so these will not be considered.

A list of the strike of the veins of various producing mines will tend to bring out the point.

Due to the irregular fracturing of rock masses some of the veins may vary but in general the strike is N.E. or N.W.

In the Porcupine district the trends of the Pearl Lake vein system on which most of the mines occur is N.30° to N. 70° E.

In the Kirkland Lake district the mines are stretched out along a vein system which strikes N. 65° E.

In the Boston Skeed gold copper area the Barry Hollinger vein has a strike of N.57° E. The general trend of the shear zones and fissures of this area are Northeast and Southwest.

In Quebec the same is noticeable in the Rouyn Area. According to Cooke there are five sets of veins the first two being complementary.

1. N. 30° -- 40° W.
2. N. 40° E.
3. North and South
4. N. 75° E. to N. 80° E.
5. N. 45° -- 55° W.

From the foregoing list it is seen that the majority of veins here also have a Northeast or Northwest trend.

Again in this region the major fault along Davidson Creek has a strike of N. 40° E.

There are also two natural sets of dykes which strike

1. N. 50° — 60° E.

2. N. 20° W.

This would suggest that the fissures in the shield were due to regional stresses which acted probably after the period of folding, and were due to tension caused by a relaxation of pressure, after the folding and granite intrusion.

Age of the Gold Deposits

In Ontario[1] the gold deposits that are found in numerous localities of the province from the Quebec to the Manitoba boundary are in many cases at least genetically connected with granites to which the name Algoman is applied.

1. W.G. Miller and C.W. Knight

Metallogenic epochs of the Pre-Cambrian of Ontario,

Ontario Bureau of Mines 1915 P. 245

The gold occurs in quartz veins being associated usually with pyrite but the ore carries considerable arsenopyrite.

The gold deposits are found chiefly in the Keewatin schists but a few occur in the Temiskaming clastic rocks.

In Quebec the occurrences are very similar and are generally related to intrusions of the Algoman period.

In Manitoba the gold occurs in several localities in the pre-cambrian, but the rocks have not been definitely correlated and thus have different names. The chief areas are at Beresford and Rice Lakes

J.F. Wright-- The gold, copper-nickel and tin deposits

of Southeast Manitoba G.S.C. Summary Report 1929 Pt.B.

Here the rocks are given the names of the localities in which they occur. However their properties are very similar to the Keewatin and Temiskaming series in the east.

Young[1] in his map of Canada colors these areas similar to those which contain the Temiskaming and Keewatin series in the east.

1. Young:- Geology and Economic minerals of Canada 1926

It seems there that throughout the Canadian Shield gold occurs in the Temiskaming and Keewatin series; the solutions which brought the gold mineralization coming from the Algoman granitic intrusion or phases thereof.

Structure of Deposits

A survey of the general structure of the deposits show that all occur along the axes of major synclines. This seems reasonable when the long period of erosion that the shield has undergone is taken into account. During this period the anticlines would be eroded away first while those lying in the synclines would be more or less protected.

Type of Deposits

All the deposits of the shield show the presence of tourmaline and other high temperature minerals except Kirkland Lake. The mineralization here resembles that of an intermediate temperature deposit more than that of a high temperature.

Lindgren[1] classifies these deposits as "Hypothermal", belonging to the deep vein zone with a probable temperature at time of formation varying between 300 ^{o}C and 500 ^{o}C.

1. Waldemar Lindgren:- Mineral Deposits 1928 P. 747

Summary and Conclusions

1. The gold bearing deposits lie along the axes of major synclines. These synclines strike approximately east and west and are occupied by Temiskaming and Keewatin sediments.

2. The deposits formed in fissures faults and shear zones along the synclines.

3. The majority of the veins have a North East or North West strike.

4. The deposits are lenticular in shape.

5. The mineral bearing solutions came from a deep seated source to fill the fractures and shear zones and in doing so caused a certain amount of replacement.

6. That the age of the deposits is Algoman.

7. That the deposits are of the "Hypothermal" type except Kirkland Lake which resembles the "Mesothermal" type.

8. All the veins carry gold in the free state but some tellurides occur as at Kirkland Lake.

9. Quartz is the chief gangue mineral but in places carbonates are present.

10. The mineralization seems to become finer with depth but this does not affect the value of the ore.

Chapter III

Manitoba

Gold Areas in the Province

Gold is widely distributed in the pre-Cambrian area. The more important districts at present are the Rice Lake, Gem Lake, and Central Manitoba but gold occurs also at Elbow Wekusko, Island and Oxford Lakes.

There are three operating mines at present.

1. Central Manitoba Gold Mines
2. Gem Lake Gold Mines
3. San Antonio Gold Mines

The Central Manitoba mine is the chief producer and the San Antonio expect to start production in the near future. In northern Manitoba there are large copper zinc deposits which contain low gold values and these are expected to add appreciably to the total output.

History

Manitoba Department of Natural Resources

Vol I 1928 P. 46 and sec.

Manitoba as a gold producer was rather insignificant until 1928. Previous to this date there was no definite source of supply and the returns came from scattered sources. In 1927 the Central Manitoba Gold Mines started producing and was the only source of gold in the province during that year. In 1928 the mine produced approximately twice as much as the total recorded production up to that time.

The chief sources prior to 1927 were the Mandy Copper Mine which carried some gold values and the Rex Gold Mine on Herb Lake. The Mandy Mine was closed in 1920 and the Rex in 1925. The Central Manitoba Mine has produced steadily during the last four years and at present are producing at the rate of $40,000per month.

C.I.M.M. Bulletin Jan 1932 P. 10

This is at present the chief producer in the province but just recently the Gem Lake mines made their first shipment. The San Antonio Mines are expected to start production shortly.

Beresford-Rice Lakes -English Brook District

These three mines occur in what is known as the Beresford-Rice Lake -English Brook district. This district was described by J.F.Wright in 1929.

J.F.Wright Gold Copper-Nickel and Tin deposits of Southeastern Manitoba G.S.C. Sum. Rept. 1929 Pt. B Pgs. 136-171

Geology

Table of Formations

Diabase

Gold bearing quartz

Pegmatite

Granite and granite gneiss

Granite Porphyry

Gabbro and diorite

Rice Lake Series	Wanipigow Phase	course grained quartzose seds quartzite arkose.
	Beresford Phase	lavas, carbonate and sericite schist interbedded chert tuff, and other pyroclastics, iron formation.
	Manigatogan Phase	fine grained quartzose sediments and derived quartz mica, quartz garnet gneiss and schist.

J.S. De Lury and George E. Cole[1] make the following statement

1. Manitoba Department of Mines and Natural Resources 1928 P.24

"It is reasonably certain on grounds of lithological resemblance and proximity of locality, that the rocks of southeastern Manitoba correspond fairly closely to those of the Lake of the Woods region."

It is in this region that Lawson[1] first identified the Keewatin series of rocks.

1. A.C. Lawson Report on the Geology of the Lake of the Woods region G.S.C. Annual Rept 1885 Pt. CC.

This term has since been widely used to describe similar rocks in all parts of the Canadian Shield.

In 1912 E.S. Moore[1] made a classifacation of the rocks in the Rice Lake District and correlated them with the Temiskaming of Ontario

1. E.S.Moore Region east of the south end of Lake Winnipeg G.S.C. Sum Rept 1912

In a note accompanying a report by Burwash on the geological formation along the Manitoba Ontario Boundary from Winnipeg northward W.G.Miller states,

"The rocks classed as Wanipigow appear to correspond to the Temiskaming series of part of northern Ontario.

The granite intrusion which cuts the Rice Lake series and Wanipigow rocks is believed to be responsible for the gold mineralization and in many ways resembles the Algoman granite."

From the foregoing statements it is reasonable to believe that although the rocks of this area are classified under local names, they represent the same geological happenings as similar rocks in other parts of the Canadian Shield.

Rice Lake Series

G.S.C. Sum. Rept. 1929 Pt.B. P. 158

The lower members of the Rice Lake series consist of both acid and basic lavas which in places show pillow structure. Interbedded with the lavas are beds of chert and tuff. The Wanipigow phase of the Rice Lake series consists of thick beds of quartzose sediments which have a uniform strike and dip over large areas. The dip where found is steep to the North and suggests a synclinal structure for the series.

These beds of the Rice Lake series have all been very much metamorphosed by later intrusions of granite, and phases of the granite.

This granite is believed to be responsible for the gold mineralization.

Character of the gold deposits

Most of the gold quartz veins occur in the Beresford phase of the Rice Lake series along shear zones within the volcanic rocks. The veins are lenticular and stringers of quartz are irregularly scattered through the jointed rock. The most favorable place for deposition is where the rock is more jointed or brecciated than sheared.

The gold mineralization in the Lake of the Woods Area is the result[1] of a granitic intrusion classed as Algoman. This mineralization can be traced, into southeastern Manitoba where the same type has been produced

1. Manitoba Department of Mines and Natural Resources

Vol I 1928 P.22

by a granite which seems to be part of the batholith of this area.

The shearing is found very often along the contacts between different types of rocks, which were probably planes of weakness.

Mineralization

The gold may be in the free state or may be associated with sulphides.

Chalcopyrite and pyrite are most abundant sulphides while pycrhotite sphalerite, galena, tetrahedrite, arsenopyrite and moly bdmite may be present in samll amounts. Gold tellurides are relatively absent.

The free gold may occur as flakes coating a jointerplane or as grains in unfractured quartz. Tourmaline has been recognised in some of the veins indicating formation at high temperatures.

Three types of veins may be said to occur in the district.

1. Large roughly circular bodies of white to grey pegmatic quartz carrying abundant crystals of white and pink feldspar and muscovite. This type is not considered to be worth investigation.

2. Lenticular bodies of fine even grained white quartz containing considerable calcite and ankerite with a scarcity of sulphides.

This type although containing some values has not been productive.

3. Bodies of highly fractured smoky dark grey to black quartz containing some pyrite and chalcopyrite but only small amounts of feldspars and mica.

This type has proved the most productive and constitutes most of the gold ore of the area.

Description of Deposits

Central Manitoba Gold Deposit

G.S.C. Sum Rept 1929 Pt. B. P.140

The property is situated about 3 miles north east of Long Lake and has fine veins of which the Kitchener Eclipse and Tene 6 are the most important.

The veins all except the Tene6 occur in a narrow band of chert and tuff close to the contact of a mass of diabase and gabbro.

The veins are more or less parallel to the contact and have a strike of approximately S 75° - 80° E.

The Tene 6 vein occurs in the gabbro and has a similar strike.

Andesite and basalt border the chert band on the south while the gabbro mass is on the north. All the rocks are cut by dykes of granite porphyry and bodies of this rock are found in the mine workings.

The gabbro diabase body is a medium grained black massive rock with slightly prophyritic phases developed locally, and its contact with the chert bed is in most cases a sharp one.

The chert is a fine grained greenish, grey, black and white laminated rock interlayered with silicious rocks composed of fragments of quartz feldspar and felsetic rock.

In places the chert is highly folded and brecciated and it is along these zones that the Kitchener and Eclipse veins occur. The veins are the latest rocks on the property except for a small discontinuous diabase dyke which cuts the Kitchener vein.

The veins are located along a zone of fracturing and shearing varying from 15 to 250 in width and can be traced over 2 miles in length. In this area many smaller zones of shearing occur. The veins and shear zones are roughly arranged (en echelon) and have a strike of S 75°-80° E with steep dips either North or South.

The Kitchener vein is composed of the dark variety of quartz carrying pyrite chalcopyrite and a lettle pyrrhotite. The gold as shown by tests is chiefly fine particles in the free state The ore lenses average four feet in width.

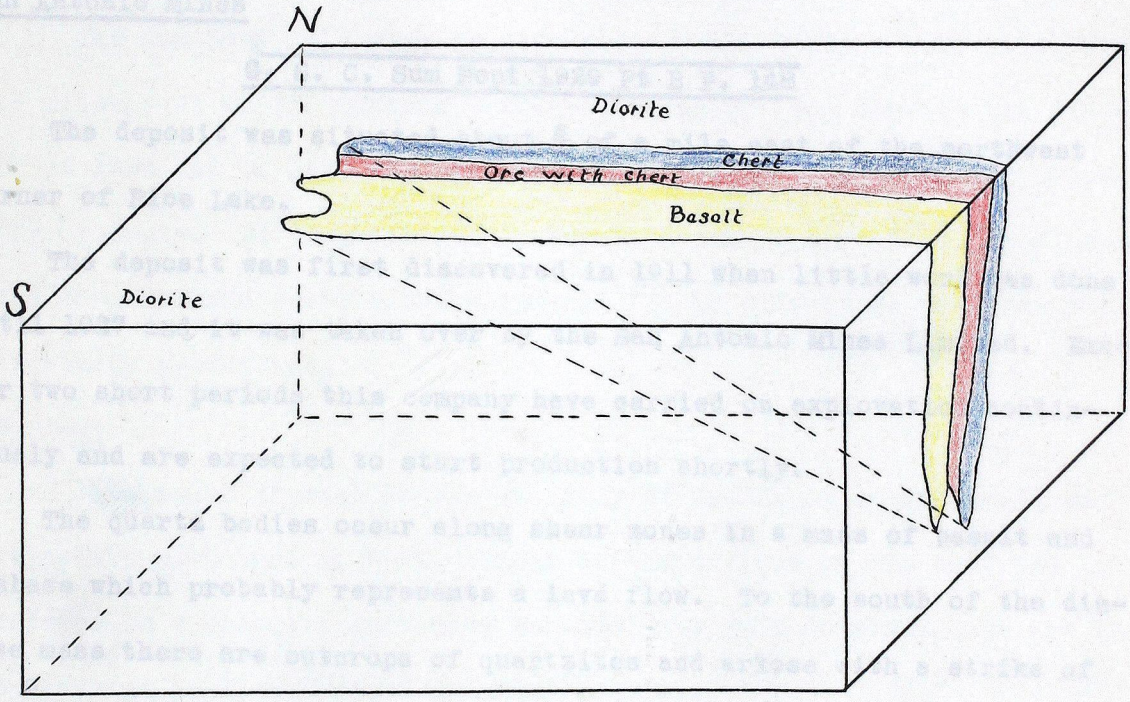
The Eclipse vein varies in length and width on the levels explored and the dip varies from vertical to 75° S. It is similar to the Kitchener in mode of mineralization. The length of the vein is 380 feet on the 200 foot level and 320 feet on the 375 foot level.

The Tene 6 vein in the middle of the gabbro body is lenticular in

Plate IV

Block Diagram Showing Ore

Occurrence at Central Manitoba Mine



shape with a width of 19 feet and length of 200 feet. It is of the dark quartz variety and carries considerable chalcopyrite.

This vein gave values fairly consistantly of $13-20 per ton but the vein was shallow and did not develop a large ore body.

Development work on the Roger and Hope veins proved the ore deposits small and relatively low in gold values and further work on these have not been done.

San Antonio Mines

G. S. C. Sum Rept 1929 Pt B P. 148

The deposit was situated about $\frac{3}{4}$ of a mile east of the northwest corner of Rice Lake.

The deposit was first discovered in 1911 when little work was done until 1927 and it was taken over by the San Antonio Mines Limited. Except for two short periods this company have carried on exploration continuously and are expected to start production shortly.

The quartz bodies occur along shear zones in a mass of basalt and diabase which probably represents a lava flow. To the south of the diabase mass there are outcrops of quartzites and arkose with a strike of S 80° E. North of the diabase occurs a mass of porphyritic quartz diorite.

The veins are rather short, and no long and continuous shear zone occurs on the property. However close to the quartz vein some of the diabase has been altered to a grey carbonate rock by solutions carrying considerable iron and carbon dioxide. This grey carbonate rock carries gold in sufficient quantities to be commercial across narrow width.

Most of the development work has been done on the 600 and 725 foot horizons. Carbonate bodies are found on these horizons. On the 600 foot level a quartz vein 80 feet long has been explored and it carries free gold.

The quartz is of the dark variety and assays indicate a small body of high grade ore.

On the 725 level a northeast trending vein shows values of $12.94 per ton over a length of 329'. It has an average width of 3.8 feet and consists of both light and dark colored quartz containing fine crystaline pyrite close to the foot wall.

Gem Lake Deposit

G.S.C. Sum Pept 1929 Pt B P. 153

The Gem Lake Gold Mine is situated approximately a half mile west of mileage 91 on the Ontario Manitoba boundary. The deposit was discovered in 1926 and in 1927 the Gem Lake Mines Limited was organized to develop the property. Development and exploration has continued and just recently the company made their first shipment. It is planned to keep the property in steady production.

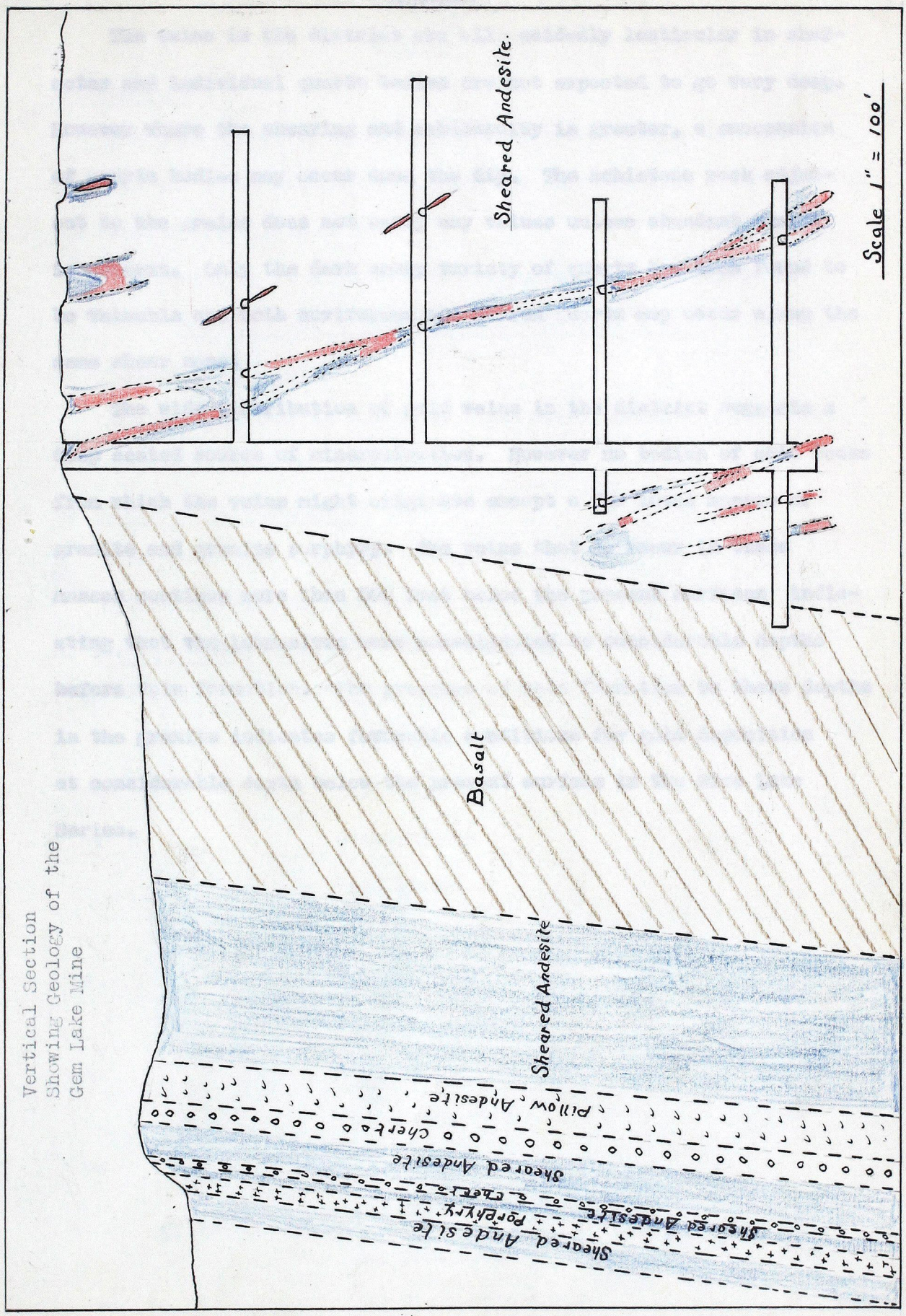
Geology

The rocks exposed in the vicinity of the deposit are basalt and andesitic lava with beds of tuff. Close to the contact of the tuff the lava is altered to a chlorite carbonate schist. The tuff beds and lava are intruded by several small masses of granite porphyry.

The veins occur along a shear zone in a greenish grey schistose lava about 400 feet wide. The strike of the schistosity is about S 75° E, with a dip of N 76°. The band of schistosity may be traced for approximately 1¼ miles but narrows toward the east.

The quartz is localized in stringers, lenses and veins along the shear zones. The average width of the quartz stringers is 2.4 feet over a length of 200 feet. Widths of 8 feet and 12 feet occur with values averaging $8.20 per ton. These veins and lenses are more or less lenticular in character.

Plate V



Vertical Section
Showing Geology of the
Gem Lake Mine

Summary

The veins in the district are all decidedly lenticular in character and individual quartz bodies are not expected to go very deep. However where the shearing and schistocity is greater, a succession of quartz bodies may occur down the dip. The schistose rock adjacent to the grains does not carry any values unless abundant quartz is present. Only the dark smoky variety of quartz has been found to be valuable and both auriferous and barren quartz may occur along the same shear zone.

The wide distribution of gold veins in the district suggests a deep seated source of mineralization. However no bodies of acid rocks from which the veins might originate except a few local masses of granite and granite porphyry. The veins that do occur in these masses continue more than 500 feet below the present surfaces indicating that the intrusives were consolidated to considerable depths before vein formation. The presence of vein formation to these depths in the granite indicates favorable conditions for gold deposition at considerable depth below the present surface in the Rice Lake Series.

Chapter III

Ontario

Introduction

The gold districts of Ontario are scattered widely throughout the province but it is from the Porcupine and Kirkland Lake districts that the bulk of production comes.

The following is a list of the producing mines during 1929.

Ontario Dept of Mines Report 1930 Part I P. 8

1. Porcupine District

   Hollinger, Ankerite Coniaurum, Dome March, McIntyre, Porcupine United, Vipond, W. Dome Lake.

2. Kirkland Lake District

   Barry Hollinger, Kirkland Lake, Lake Shore Sylvanite, Teck Hughes, Wright Hargreaves.

3. North Western Ontario

   a. Woman Lake
      (1) Bathhurst
      (2) Bojo

   b. Michipicoten
      (1) Cooper
      (2) Parkhill

   c. Sturgeon Lake
      (1) St. Anthony

   d. Red Lake
      (1) Howey Mine

   e. Miscellaneous
      (1) Wabigoon Contrast Bay
      (2) Gold Rock
      (3) Big Turtle River

History

Ontario as a gold producer goes back to the year 1892 when 5710 tons were treated by the Sight companies operating in the Lake of the Woods field. As early as 1866 gold was discovered in Madoc T.P. by a man named Powell[1] but no production resulted.

1. Report of Royal Commission, Mineral Resources of Ontario 1890 P. 27

Production increased until 1899 when it was 27,594 ounces. Many mines were started during the years between 1892 and 1899 but the bad habit of putting all finances into a mill before a payable ore body was proved was prevelent. This together with bad management caused a decline until 1909 when Porcupine was discovered.

The developemnt of properties in this area was carried out by experienced men with sound financial backing, with the result that huge ore bodies were opened up and production increased rapidly. Developments here carried on through 1910 and 1911 and 1912 really ushers Ontario in as a gold producer. The production for 1912 amounted to over $2,000,000 with Porcupine producing 81.8%. In 1913 Kirkland Lake entered the field as a producer and has increased almost steadily from the first. These two camps have been producing approximately 98% of the total for the province since 1914[2]. Porcupine during the

2. Ontario Department of Mines Report 1930 PartI P. 7

years from 1913 to 1927 produced the bulk of the gold but Kirkland has been increasing its output steadily and this year exceeded Porcupine for the first time.

The war years had their effect upon the industry in the province. Wages and the cost of production went up enormously, which is a serious handicap to a product which has a stable value. However the two large camps continued to produce although in 1918 there was a slight

decrease.

The after war years brought labor troubles which interfered with operations and it was not until 1921 and 1922 that the industry got back on its feet.

The depression of 1921-22 caused gold to be a much sought after metal, as it is today, due to the fact that its selling price is always stable. New interest was taken in the industry and production speeded up to such an extent that new sources of electric power were needed. The shortage of power caused a decrease in 1923 During the following year several new mines were opened up in the Porcupine and Kirkland Lake areas. These added considerably to the output which in this year reached over one million fine ounces.

From 1925 to the present, Kirkland Lake has been increasing steadily but Porcupine has decreased to a small extent. The total output of the province shows an increase yearly, except for 1929.

The year 1929 showed an increase of 43,834 ounces over 1928, due to the expansion of the Kirkland Lake mines.

Porcupine showed a slight decrease due to a lower grade at Hollinger.

Much interest was taken by prospectors in Northwestern Ontario and several promising areas were opened up including Red, and Woman Lakes, Michipicoten and Sturgeon Lake.

This year saw an universal decline in stocks and bonds which ushered in a period of depression, and prices of base metals declined to a very low mark.

As in 1922 gold became the sought after mineral. This speeded up production and created new interest in gold prospecting which showed

itself in an increase for 1930. 1931 shows the largest production eve.

1. Bulletin C I M M Jan 1932 P.10

reached by Ontario with an increase of nearly $8,000,000[1] over 1930

This increase is due to a larte increased production from Kirkland Lake area of which Lake Shore Mine is the most important.

Porcupine Gold Area

The geology and the ore deposits of the Porcupine area have been studied closely by A.G.Burrows of the Ontario Department of Mines who has published several reports on the district.

Ontario Department of Mines Report 1911 Pt II

Ontario Department of Mines Report 1915 Pt III

Ontario Department of Mines Report 1924 Pt II

These reports are similar in character with each subsequent publication giving a more detailed report of the underground workings.

It is from these reports that the information on the Porcupine area has been taken.

History

The Porcupine gold area was first discovered in 1909 when gold was found tobbe present in quartz veins in the vicinity of Pearl Lake, Tisdale township. It is here that most of the mines occur.

The area is situated in northeast Ontario north of the height of land from which the water drains north into James Bay.

Some of the earliest discoveries have grown to be the greatest mines. Among these are the Hollinger, McIntyre and Dome mines which today are among the greatest producers of gold in Canada.

For many years Porcupine has been the largest producing field in Canada and in 1925 reached its peak, producing over 81% of the total for Ontario with an economic value of over $24,500,00.

Geology

The geology of the district is pre-cambrian in character consisting of Keewatin and Timiskaming series which are cut by the Algoman and post Algoman intrusives

Table of formations

Ontario Department of Mines 1924 Pt II P.12

Pliestocene	Glacial and Recent	Boulder clay stratified clay, clay sand gravel and peat.
Pre-Cambrian	Keweenawan	Olivine Diabase
	Post Algoman	Quartz Diabase
	Algoman	Granite, Quartz Porphyry
	Hailyburian	Serpentine
	Timiskaming	Conglomerate greywacki slate and quartzite
	Keewatin	A complex of basic to acid lava flows

The Keewatin and Timiskaming series lie in a syncline whose axis strikes approximately east and west. The veins in the district belong to the Pearl Lake system which has a northeast trend.

Algoman Quartz Porphyry

The most important intrusive in the district is a quartz porphyry of Algoman age which occurs in the form of stocks and more rarely as dykes.

One of these stocks partly underlies Pearl Lake and extends southwest to the Hollinger.

The structure of the intrusive masses is important in that its altitude has an effect upon the ore shoots. The porphyry intrusions at the Hollinger and McIntyre mines rakes about 55° to the east while similar conditions are found elsewhere.

The outlines of the porphyry masses are not regular but contain jagged structures particularly on the ends underneath and above. This condition would be expected if the intrusion took place in previously schisted or sheared ground. This is well illustrated at the Hollinger and McIntyre mines . Apophyses extend for considerable distances below the parent stock.

The attitude of the porphyry masses as now seen is probably that which existed at the time of intrusion. The intrusion of the porphyry has further altered the surrounding rocks increasing the amount of schistocity and forming shear zones favorable for the location of gold deposits.

The porphyry is a hypabyssal type of rock intermediate between the deep seated plutonic and surface volcanics. Its proximity to the gold deposits with which it is related indicates that it was intruded into the upper portion of the earth crust where the formation of the fractures was possible. Various stocks of the porphyry have been exposed by erosion while others may occur in the vicinity below the present surface erosion not having been carried far enough to expose them.

Gold deposits in western Ontario were generally found in quartz veins in the Keewatin schist or in the granite adjacent to the schist.

Consequently the granite was considered by some, to have a genetic

connection with the gold deposits.

In eastern Ontario the gold mines were in proximity to granite areas. No typical granite occurs in the immediate vicinity of the gold deposits at Porcupine but outcrops in the region round about.

Type of Deposit

Lindgren[1] classes the gold deposits of Ontario as high temperature or hypothermal due to presence of such minerals as tournaline and pyrrhotite. These two minerals occur at the Dome mine.

1. Lindgren Mineral Deposits 1928 P.747

Character of the deposits consist of quartz and mineralized schist in varying proportions, being either linear or in irregular masses. They may be either classes as veins or lode or lode systems. They are not the filling of open fissures such as are connected with veins near the surface and they do not show the crustification or banded character of the filling of open fissures. The quartz has been injected under heavy pressure and is pegmatitic in character.

L. L. C. Graton[1] in describing the Southern Appalachian gold district says:

1. L.C.Graton-Gold and Tin deposits of the Southern Appalachians U.S.G.S. Bulletin No.293

"It is even possible that the vein forming solutions representing the final product of the emanations from a granite magma were injected under heavy pressure into the surrounding rocks along lines of weakness, and so like pegmatite dykes made spaces for themselves by opening their own fissures."

This mode of formation would readily explain the irregularity of the quartz masses in the Porcupine deposits.

Veins on the Hollinger , McIntyre and other properties are linear for several hundred feet and very irregular in detail. Where the quartz veins are numerous and closely spaced the whole of the intervening rock mass may carry much pyrite. Veinlets of quartz cut across the schist while others, frequently the larger masses run with it. A rough banding often results from parallel strips of schist in the quartz.

Some fracturing was present at the beginning of ore deposition but the deposits were the result of enlargement by metasomatic replacement. The quartz which brought the mineralization silicified the surrounding schist rock. The alteration of the rock is well shown along separate quartz veins which extend into the wall rock.

The primary quartz in the deposits has been much fractured. Granulation is frequent along the margins of the quartz grains and such minerals as calcite, sericite, and chlorite are frequently observed in the crushed areas. Metallic sulphides and gold are often prominent with the minerals in the fracture plans. A favorable location for the concentration of ore minerals is also along the contact of quartz and schist. Fragments of the country rock enclosed in the quartz show a concentration of gold either in or around them.

Where cracks have been produced in the quartz vein and later filled with minerals from solution secondary quartz can be distinguished from primary quartz only with difficulty. Due to this it is not always possible when examining such a vein to say whether the visible gold occurs in the earlier or later quartz.

The fracturing of the quartz may occur along lines more or less parallel to the wall or the vein, giving a streaky appearance. The seams along which the specimen breaks are often very minute showing

such minerals as carbonate,sercite, chlorite, pyrite gold and sometimes tourmaline.

Mineralogy of the Ore Deposits

Many minerals both metallic and non-metallic occur but gold is the most important economically with pyrite and pyrrhotite important in order of abundance. Silver and copper occur in the native state and some of the silver is combined with the gold. The native copper is a rare constituent.

The gold occurs predominantly in the native state and rarely as telurides. It is sometimes visible but it is generally invisible in the pyrite and other sulphides. Gold occurs in the free state in that some of it will amalglmate but that which occurs ultimately with the sulphides must be separated by cyanidation, and consequently most of the plants use this process for recoveringtthe precious metal. At the Dome mine a combination of both amalgamation and cyanidation is used due to the presence of silver as an alloy. The gold as a whole is about 850 fine and in rich specimens shows a rich yellow color.

Pyrite is the chief sulphide present and is generally well crystallized in the form of cubes which may be modified by the octabedre or pyritobedron. Microscopic examination of auriferous pyrite from the Hollinger mine failed to show any gold included in the pyrite crystals.

However, H. S. Robinson reports having observed flakes of gold in pyrite crystals which have not been crushed. Disseminated pyrite which is auriferous cannot be distinguished from auriferous pyrite except by assay.

Galena and zincblende occur as well as chalcopyrite in fractures in the quartz. Portions of the veins carrying these minerals are

likely to contain high gold values. Arsenopyrite occurs at the Hollinger and Dome mines while molybdenite has been observed in the West Dome Lake mines.

Many other minerals also occur but those mentioned above the the most important.

Description of Properties

Hollinger Mine

Ontario Dept of Mines Rept 1924 Pt. II P. 154

Situated in the south west portion of Tisdale T.P. , and with the main portion of the property lying to the southwest of Pearl Lake.

Outcrops of veins have been found on all claims except one and nearly all the veins have a general North East-South West strike. The main vein system strikes from N30° to N 70° E.

Both Keewatin lavas and Algoman intrusive quartz porphyry are present. The Keewatin rocks are highly altered and even the more massive or blocky portions do not retain their original composition.

The porphyry occurs in several separate stocks and as far as mining has been able to show, these do not join on depth.

The longer axes of the stocks strike N 70° E and the pitch is easterly. The porphyry although carrying veins has not proved an important ore bearer. While the veins are quite linear for the several hundred feet they are often connected and show a chainlike arrangement.

In detail a vein is frequently composed of a number of lenses which are arranged echelon.

The composition of a vein is generally a proportion of quartz irregularly distributed with pyritized schist.

The veins vary in width and average about nine feet but some have been worked over a width of forty feet and widths of fifteen feet are common.

The Hollinger is the greatest producer of gold on the continent and compares favorably with the mines on the Rand of South Africa.

In 1929 it produced 455,093 fine ounces of gold valued at $9,407,627. This is a decrease from the preceeding year due to a lower grade or ore and a decrease in quantity milled.

A summary of the ore reserves shows that there were at the end of 1929

Ontario Dept of Mines Rept 1930 Pt. I P.103

775,245 tons of ore over $10 and averaging $11.83 with an estimated gross value of $9,147,028. In veins $10-$8 there were 2,637266 tons averaging $8.88 per ton and having a gross value of $24,896,223. Veins from $8-$6 show 461,237 tons averaging $7,34 and having a gross value of $3,387,383.

This gives a total ore reserve with probable ore under six dollars and surface outcrops of 6,360,021 tons averaging $7.52 with a gross value of $47,819,398.

The output of the mine during 1929 was over 1,500,000 tons.

This shows then that if no durther reserves are found, at the present rate of production the known reserves would be worked out in approximately five years.

McIntyre Mine

Ontario Dept of Mines Rept 1924 Pt. II P. 60

The McIntyre Mine is situated at Schumalker on the opposite side of Pearl Lake to the Hollinger and is the next largest producer in the district. During 1929 it produced a total of 206,621 fine ounces

Geology

The geology is very similar to the Hollinger but the main vein is badly faulted in the upper reaches. The main vein lies on the north side of Pearl Lake north of the porphyry. This vein has been one of the greatest producers of the area. It is badly faulted above the 400 level but below which it is fairly regular.

Character of the ore.

The ore occurs along a persistent fracture striking N 60° E and dip 67° N. The ore is of the replacement type consisting of silicified and pyritous lava with some vein quartz. The vein averages seven feet in width.

Development

Development on the property depends on the structural relations of the Pearl Lake porphyry stock with the Keewatin Lavas.

The porphyry has a strong easterly pitch and as depth is attained in the mine the Keewatin schist predominates, underlying the ground behind the porphyry. The zone behind the porphyry is favorable for the occurence of ore shoots and this area has been developed from the lower levels.

In 1929 development had reached the 3,875 level where there were 3,781 tons of $4.50 ore mined.

The capacity of the mill had increased yearly up to March 31,1930 when it was 550,495 tons for the year.

Vipond

Ontario Dept of Mines Rept. 1924 Pt. II P. 64

This mine is situated to the southeast of the Hollinger and the veins have the general northeast-southwest strike of the Pearl Lake system. In 1916 the North Thompson mine was amalgamated with the Vipond and in

the following two years all the ore milled came from the North Thompson. Further work on this property developed an ore reserve in 1924 amounting to $5,000,000.

Geology

The rock in this vein system is Keewatin schist. No porphyry occurs on the property but a large mass outcrops to the west which has a marked easterly dip. Carbonaceous material occurs in some of the wall roc rock giving it a dull black color. The wall rock often carries pyrite in a banded arrangement. Pyrite occurs abundantly sometimes in well developed cubes and again in large coarsely crystallized masses. Chalcopyrite, Sphalerite and galena are common.

Visible gold is profusely scattered in some parts of the veins. Quartz is the chief gangue mineral but carbonate also occurs in this capacity.

Some lustrous graphite occurs and in places visible gold has been seen with this material. Both gold and graphite have been slickensided by movements in the vein and it has been suggested that the lustrous graphitic material has been derived from the dull carbonaceous material by intense slipping of layer on layer. The gold with the graphitic material may be accounted for as possibly of a later period than the graphite and to have been precipitated from solution by it. Various origins for the carbon have been suggested by A. Dorfman and J. McIntosh Bell and include, reduction from carbonates precipitation from soluble carbides or the decomposition of hydro-carbons.

In 1929 Vipond produced 39,569.25 fine ounces. Since 1927 the mine has managed to extend its ore reserves to keep pace with its production.

Dome Mine

Ontario Dept of Mines Rept 1924 Pt.II P. 72

The Dome Mine is situated in the Southeast part of Tisdale township and in 1924 contained 440 acres.

The geology is more complex than in the other properties near Pearl Lake in that it brings in the Timiskaming series.

The major feature consists of an asyminetrical anticlinal followed by a synclinal trough on its south side. In the anticline the Keewatin rocks outcrop to the west and pitch N 60° E at 40° under the Timiskaming sediments. To the North the contact inclines gently northward while on the south sied it is almost vertical and the sediments in the syncline are carried to great depth. The south side of the syncline is intruded by a mass of quartz porphyry. The top of the pitching Keewatin in the anticline is called the crest line and it is along this partly in the Keewatin but mostly in the overlying sediments and in the deep trough to the south that most of the great ore bodies of the Dome occur. A few deposits occur entirely in the Keewatin and two have been stoped from the the porphyry.

The ore shoots are large irregular lenses which are very wide in proportion to their length varying from 15'-150' in width and 600' in length.

They consist of mineralized schist, sediments, volcanics, with a proportion of vein quartz. The quartz is irregularly distributed in the schist and while occuring in large masses in some of the deposits the percentage is generally from 10%-15%. The most favorable rocks are the Timiskaming greywacke and conglomerate which in parts is covered by an impermeable layer of slate. Some of the best ore has been obtained from just below the slates which are encountered at different

levels as the workings extend eastward.

The ore from different stopes varies greatly in appearance. The conglomeratic character shown by pebbles is easily recognizable in some of the sedimentary ore, but the ore is often simply a dark grey schist spotted with iron pyrites and cut by vague veinlets of quartz. Replacement is recognized in bands of greywacke in which the pyrite follows the rock banding.

The pyrite is the chief sulphide present and is nearly 5% of the ore mines. Pyrrhotite is common while arsenopyrite, chalcopyrite and shalerite also occur. Quartz is the chief gangue mineral but tourmaline is abundant in some stopes indication high temperatures. Tourmalerization has been carried along the quartz vein dikes.

Since 1926 the reserves have been gradually increased until in at the end of 1929 they were 1,300,000 tons. Production was approximately 550,000 tons per year but during 1929 dropped to 480,900.

Coniaurum

Coniaurum Mines Limited were a company formed in 1924 to take over the properties of the Newray and Goldale companies. The properties are situated in the township of Tisdale and adjoins that of the McIntyre on the east.

The rocks on the Goldale part are varieties of Keewatin schist with several small stocks of porphyry. The ore is a pyritized black basaltic schist with irregular masses and veinlets of fractured quartz.

A 500 ton mill was erected in 1928 and in that year it produced 16,634.49 fine ounces.

However the narrowness of the veins coupled with minor faults caused a further diminuition of ore than was expected and the company

met with financial difficulties.

In 1929 a new company was formed and production increased more than 2½ times being 30,640.66 fine ounces.

West Dome Lake

This property is a consolidation of the West Dome and Dome Lake mines. Production has been chiefly from the Dome Lake portion. The principal vein of the Dome Lake property follows a consistant fracture traceable across the north part of the property in an east west direction. Along the outcrop of the vein there is fragmental material representing a flow top in which the vein has been formed.

The vein is a mixture of carbonate and quartz of medium grey color with finely divided pyrite,visible gold occasionally being present . The proportion of quartz and carbonate varies in different parts of the vein which averages 2-3 in width. The pitch length of the ore shoot is greater than its length along the drift.

Prior to 1929 production had been small but in January of that year the mill was turned over and a total of 35, 142 tons was milled. Unfortunately the mine was closed down in January 1930 pending a reorganization of the company.

March Gold Mines

The March Gold Mines are located centrally in the north portion of Deloro Township.

Developemnt work was started in 1923 and the geology showed several massive porphyry dykes intruding a highly schistose band of rhyolite bounded on the north side by basic chlorite-carbonate schist. Further development was done late in 1924 and construction of a mill was started in 1926 and completed,but little concentrates

were produced.

1928 was the first year that the mine had any appreciable production being 6,459.58 fine ounces. In 1929 this was almost doubled although the tonnage did not increase at the same rate thus showing a higher grade of ore milled.

Two other potential producers from this area are the Ankerite and Porcupine United. These produced in 1929 3,458 fine ounces and 2,133 fine ounces respectively.

The Ankerite closed down in 1930 and production from this source ceased but the Porcupine United is still operating.

Future of the District

The production of gold from Porcupine in the future may show a decline unless new mines are opened or new reserves are found in the existing mines.

Since 1925 Hollinger has gradually decreased in production due to a lower grade or ore. Since 1926 the reserves of this mine have been gradually decreasing being in that year 7,779,234 tons of $8.52 ore while in 1929 they were 6,360,021 tons of $7.49 ore.

Dome and McIntyre mines have ample reserves and McIntyre have increased theirs during the past few years. Production from these sources should at least be steady and it may increase.

These are the principal producers in the district and it is from them th that the bulk of output comes. A decrease in the production of the smaller mines would not affect the total production to any great extent.

Kirkland Lake Gold Area

Introduction

This area first attracted attention as a gold area in 1913. Since that time developemnt and production have had a more or less steady progress.

Early reports of the area are contained in the Ontario Bureau of Mines Reports for 1914.

The Kirkland Lake and Swastika Gold Areas

Ontario Bureau of Mines 1914 Pgs.1-32

This report was written by A. G. Burrows, and P. E. Hopkins who wrote a second report in 1920[1] giving a more detailed account of the ore deposits and geology.

1. Ontario Dept of Mines 1920 Pt.4

A still further detailed report was published by the same authors in 1925 in the Ontario Bureau of Mines Report for that year.

With a further demand for more information E. W. Todd studied the field in 1928 and combined his own findings with those of former reports and published them in a separate volume of the Ontario Department of Mines.

Ontario Department of Mines 1928 Pt. II

It is from these reports that the following information has been taken.

History

As early as 1906 during the boom days of Cobalt many claims were staked for gold around Swastika and northeasterly to what is known as Kirkland Lake. Many of these claims reverted to the Crown and it was not until 1911 that gold was first discovered by W. H. Wright on what is now part of the Wright Hargreaves property. This with the progress being

made in the Porcupine, interest was rekindled and by the end of the year all the ground had been staked. Prospecting and developemtn work continued and in 1915 Tough Oaks operated a cyanide mill. This was practically the only producer till 1917 when Tecke Hughs commenced operations.

1918-19-20-21 saw great development bringing into production the Lake Shore, Kirkland Lake and Wright Heargraves in the order named. In 1919 Tough Oaks closed down and did not reopen until 1923 when it was amalgamated with the Burnside Mine.

Production fluctuated somewhat at the start but has increased yearly since 1919 and last year eclipsed production from the Porcupine for the first time.

In 1927 a new producer Sylvanite came into the field and has added appreciably to the total production.

General Geology:-

The most extensive formation in the area is the Keewatin but in the camp itself the productive veins occur in the Temiskaming which lies in a narrow syncline in the Keewatin basement.

The intrusions in the area are considered to be offshoots of the Algoman grantie of which there are extensive exposures to the south and south west.

Table of formations

Ontario Bureau of Mines Rept 1928 Pt.II P.14

Quaternary Glacial and Recent	sand gravel and swamp
Pre-Cambrian Algoman	Diabase dikes: Serpentine Lamprophyre dikes, Syenite porphyry. Red syenite, Basic Syenite Hornblende and Biotite granite

Temiskamian ---------- Volcanic tuff, Volcanic flows

---------- Conglomerate, Rusty Carbonate

Keewatin---------- ---------- Pillow lava, altered diabase

----------green schists rusty carbonate

---------- Iron formation and tuff.

Description of Formations

Keewatin

These rocks do not occur aduacent to the ore zone and are therefore of no particular economic interest in the camp itself. They outcrop to the north and southwest and have the same characteristics here as in other parts of the Canadian Shield.

Temiskamian

The series here consists of conformeable beds of conglomerate, greywacki tuff and lava flows occupying a synclinal trough which extends eastward into the province of Quebec. They have a strike varying from E30° N to E 30° S. The change in strike is probably due to a large boss of granite and syenite which outcrops in the south part of Lebel township. The tuff and consolidated volcanic ash extend across Teck township in persistent bands and makes up a considerable portion of the total thickness of the series. A section made from north to south across the syncline suggests the following sequence of rocks.

1. Basal conglomerate and greywacke
2. Volcanic sediments
3. Conglomerate and greywacke
4. Volcanic sediments
5. Conglomerate and greywacke

The oldest member of the Temiskamian series in the producing section is a thick deposit of sediments which appear to be water lain volcanic ash. The color of the tuff (ash) varies between dark grey and red. On the whole, the tuff is fine grained in texture and bedding planes are redily discernible. Seasonal banding and cross bedding are shown to a marked degree in certain places and a study of these indicates that the tops of the tuff beds face southeast.

In the vicinity of Kirkland Lake the tuff is overlain by a coarse conglomerate which passes upward into a greywacke phase containing beds of conglomerate. Bordering the tuff the conglomerate is, as a rule extremely coarse, some of the boulders being as much as two feet in diameter. The thickness of the coarse conglomerate overlying the tuff at one place was measured to be 370 of coarse material with occasaional beds of sandy greywacke.

The greater proportion of the sedimentary series in Teck township consists of the grey sandy greywacke phase containing narrow bands of conglomerate.

There are no igneous rocks of volcanic origin within the area immediately surrounding the producing mines. However, eastward in Lebel township occur bands of lava consisting chiefly of a red to grey trachyte. Various structures characteristic of volcanic rocks occur and interbedded with the flows are beds of reddish stratified tuff identical with the tuff at Kirkland Lake.

The origin of the tuff at Kirkland Lake and the lava flows just described are probably identical and if the easterly continuation of the tuff bands in Teke township were mapped in detail they would be found to lie in the same stratigraphic horizons as the volcanic rocks in Lebel

Where there is a contact between the tuff and coarse conglomerate the change is extremely abrupt and in places evidences of disconformity exist although the strike of the beds in the two formations from the contract is parallel. Boulders of tuff have been found in the conglomerate and in places the conglomerate truncates the tuff suggesting that the latter was slightly eroded before the deposition of the former.

Algoman

The invasion of the granite of this period caused much faulting and folding in the Temiskaming sediments and Keewatin lavas and tilted them at high angles into closed folds extending in a northeasterly direction.

Accompanying the folding of the older rocks, lines of weakness were developed along which offshoots from the granite mass were injected. Continued pressure produced large faults even in the offshoots themselves and thus made openings for deep seated solutions to enter and form ore bodies.

In the producing section the intrusive rocks are all of the offshoot type. Various syenitic phases, which were differentiated in order of increasing acidity make up the greater part of the intrusives.

Plutonic rocks in large masses outcrop on the south margin of the Temiskamian belt from the middle of Teck township eastward to Gauthier township. The distance of the productive veins from the closest of these outcrops is one and a quarter miles.

The intrusive rocks of Kirkland Lake itself consists of various phases of the Algoman invasion.

The first phase is represented by a basic syenite resembling certain lamprophyres in composition. This is followed by a more acid phase high in potash which is turn is cut by a syenite porphyry high in soda.

The final phase was again a basic one represented by lamprophyre and diabase dykes which cut the syenites in the case of the diabase at least before the end of the period of ore deposition.

Structure

That the Temiskaming and Keewatin series at Kirkland Lake lie in a syncline has been suggested by Burrows and Hopkins.

A.G.Burrows and P.E.Hopkins: The Kirkland Lake Area

Ontario Dept of Mines Annual Rept 1925 Pt.4 Pgs.10-11

The axis of the syncline has a general east-west strike.

The folding which brought about the syncline caused a line of structural weakness roughly parallel to the strike of the sediments. Along this line of weakness differentiates, probably coming from the granite mass were intruded.

While there must have been faulting during the intrusion it is the post intrusive faults which are of most importance since it is along some of these that the ore bearing veins occur.

The veins in the producing section are bodies of secondary minerals filling fractures in and partly replacing the country rock along a faulted zone which has been called the "Main break"[1] of the camp.

1. Ontario Dept of Mines Report 1928 Pt II P.45

The principal faults follow remarkably straight lines striking about N 65° E and along this line the producing mines are stretched out for about two miles. There are two main faults in the area, a north vein fault and a south vein fault.

North Vein Fault

The north vein fault has the best ore associated with it. Properties along this fault are parts of the Kirkland Lake, Lake Shore, Teck Hughes

and Wright Hargreaves. The south side of this fault has been moved up with respect to the north side a distance of at least 800'.

South Vein Fault

The south vein fault is not so important but affects the Lake Shore and Teck Hughes properties. The fault seems to diminish on the Teck Hughes property when it strikes a mass of basic rock The displacement here is upward on the south side of from 500'-800'.

Relation of Veins to Faults

The productive veins lie along the faults mentioned above and cut across all the rock formations. The importance of the faults is readily seen. They provided openings into which the solutions could penetrate in sufficient quantity to form ore bodies of commercial size. Generally where the movements have been greatest and the wall rock is highly brecciated, the veins are strongest.

The type of rock in which the fault occurs is also important in the formation of ore deposits. Brittle rocks such as porphyry and acid syenite give a brecciated area around the fault while tough plastic rocks such as the sediments give a tight fracture which is not suitable for ore deposition.

Post Ore Faulting

Post ore faults are important features and occur in two distinct systems. The most prominent is a series of "cross Faults" which strike approximately north and south and the other is a series of "flat Faults" encountered in the veins.

The cross faults are important in mining operations in that part of the district from the Wright-Hargreaves eastward.

The flat faults occur in both the North and South veins. Their effect

is to shift the vein horizontally with a small displacement. This displacement is encountered in stoping the vein and causes it to be pulled apart leaving a gap.

The cross faults appear to have originated from tangential strain acting under tension caused by a push to the northward of the granite mass in Lebel Township.

General Character of the Veins

In the area there are three zones all more or less parallel but only the central zone isiimportant as far as production is concerned. The vein system extends from east to west a distance of 14,400 in the vicinity of Kirkland Lake. Commercial ore shoots have been found at intervals along 13,000 of this distance along which is extended the six producing mines.

The Central Zone

The veins of the central zone are closely related to the fault movements and have the same trend. Thecharacter of the fissures is important in controlling ore formation as well as replacement.

The Main veins are regular in dip and strike and follow faults of largest replacement. In general veins consist of sheared and brecciated rocks partially replaced by secondary minerals. Irregular masses of quartz fill the openings through the crushed rock in the veins and the gold accompanied by the tellurides and sulphides occur in streakes and minute fractures in the masses of the secondary minerals. As a rule the veins are strongest where displacement has been greatest providing the wall rock is favorable. Occasionally the ore extends across the vein but more frequently it is found only along one of the boundaries or along some of the minor fissures crossing between the walls.

The larger movements are generally marked by seams of gouge which in the ore shoots appears to have been replaced somewhat by ore forming minerals. The largest masses of quartz and the richest ore are found to lie adjacent to the main planes of movements where the rock was fractured to the greatest extent.

Around the main faults there are minor parallel branching fissures which carry gold values. Many of these are of no importance but in some close to the main fault fissuring has been of sufficient magnitude to allow for ore deposition. Examples of these occur on the Teck Hughes, Lake Shore and Wright Hargreaves.

Age of Veins and Source of Ore.

Since the faults which formed the openings for the deposition of the ore cut the older sediments and the earlier phases of the Algoman intrusion the veins are necessarily younger in age. However they probably represent a final active phase of Algoman granite which continued long after the earlier phases had become inert.

The diabase dykes in the area seem to be the closest to the veins in the point of time and age. This is a departure from the normal view that gold deposits are genetically related to a more acid type of intrusive. The wource of the ore appears to have been an underlying mass of granite.

Since all rocks traversed by the veins contain ore shoots there is no relation between the ores and the rocks but the stated before the type of fracture produced is very important.

General Character of the Ores.

The material mined consists of altered country rock with small amounts of quartz and other vein materials. The values are invariably

associated with the quartz without the presence of which the values are negligable. Due to there being two ages of quartz the earlier of which is barren it is sometimes found without any values.

Carbonates of calcium, magnesium and iron occur in the ore, either replacing the ferromagnesium minerals in the country rock or as small veinlets through rock in and around the veins. The high grade dark streaks generally contain some carbonates along with the later qquartz and metallic minerals.

Calcite is often seen in the gouge seams with borite and occassionally carrying bunches of coarse galena and chalcopyrite. This association of minerals suggests deposition at low temperatures. Pyrite is the most abundant mineral in and around the veins and is disseminated through the country rock. In restricted dark colored parts of the veins occur visible quantities of tellurides and chalcopyrite. These dark colored streakes are usually high grade and molybdenite and sometimes graphite occur in thin films on slickensided surfaces, usually where the values are high. The rich shoots are characterized by the presence of the black streaks denoting good values. The black streaks range in width from several inches to mere films in which no individual mineral can be recognised without the microscope. Under the microscope it is seen that the dark color while partly due to the fine grained sulphides is to a large extent caused by the presence of chlorite. This chlorite was probably derived from the ferromagnesian minerals in the rocks and redeposited along the veins and probably aiding precipitation of the ore minerals.

Mineralogy of the ores

The gold is found combined with tellurium to a certain extent but it is believed that the majority of it is in the native condition.

Tellurides of lead and mercury occur but these carry no chemically combined gold. The tellurides of gold, calverite and petzite are rare in occurrence but form a considerable part of the gold from the Wright Hargreave, Syvenite, and Tough Oaks Burnside. The percentage of gold which is native varies on different properties. Samples taken on the Lake Shore showed 84.3% native gold while the Teck Hughes showed 38.4%.

Minute particles of gold are sometimes found embedded in crystals of pyrite but there is no definite relation between the two minerals. In ordinary vein material a section containing a uniform quantity of pyrite may have wide variations of gold values.

Much of the native gold is extremely fine especially in the lower levels of the Teck, Hughes and Kirkland Lake mines.

The native gold appears to have been deposited slightly later than the sulphides and tellurides and is frequently seen deposited upon and intermingled with chalcopyrite.

The occurence of tellurides are one of the most characteristic features of the ores of Kirkland Lake. These minerals are found in the high grade sections of the producing mines. Altaite or lead telluride as well as mercury telluride occur but do not carry any gold.

Calaverite occurs and is next in abundance to altaite but is never found in sufficiently large or pure quantities for chemical analysis.

Another telluride of gold petzite $(au\ ag)_2\ Te$ also occurs and is more noticeable in the mines toward the east. The occurrence of the tellurides and their distribution varies in different parts of the ore zone the reason for such not being clearly understood.

Of the sulphides pyrite is the most abundant and occurs in well formed cubes being more noticeable adjacent to the ore bodies where it

has been formed by the action of sulphide solutions upon ferromagnesian minerals.

Chalcopyrite occurs in small amounts and is generally a good indicator of values particularly in the high sections of the veins.

Galena and sphalerite are comparatively rare but some galena is found with the lead telluride.

Molybdenite has been found on slickensided surfaces.

Pyrrhotite occurs only in Teck Hughes mine. Other minerals which occur in small amounts are hematite, graphite and selenium.

The minerals of the veins suggest formation of the ore at intermediate temperature and pressure. They do not contain any of the minerals characteristic of high temperature deposits, such as tourmaline, pyroxene, biotite or garnet, and in this respect differ from the deposits at Porcupine.

The character of the veins indicates formation by open space filling along narrow brecciated zones.[1] This phenomena in itself is indicative of intermediate pressure.

1. E.W.Todd Ontario Dept of Mines Report 1928 Pt II P.91

Summary of events leading up to and following deposition of the ore

1. Pressure associated with the intrusion of a batholith of Algoman granite produced folding in the older rocks along an east west line.

2. Lines of weakness were developed approximately parallel to the folding.

3. Differentiates from the deep seated granite magma were injected along the lines of weakness.

4. A release of pressure applied from southwest to northeast produced a series of overthrust faults trending in an easterly direction.

5. Deposition of ore along the faults by deep seated mineral solutions. In places faulting and ore deposition were contemporaneous.

6. Production of a series of north south tension faults which are subsequent to the ore.

7. Erosion which has extended for long periods of time.

8. Glaciation during Pleistocene times which left a thin mantle of till over the area.

9. Further erosion.

Persistence of Veins with depth

The major factors controlling the ore deposition are"1." The size and extent of the fissuring caused by fault movements preceeding ore deposition. "2." Character of the rocks bordering the fissure zones.

The first factor depends on the amount of displacement caused by the faulting. This has been estimated as approximately 2000 in the Western and Central parts of the main vein. The likelihood of structures resulting from such movements disappearing at a shallow depth is remote; thus the possibility of favorable structures for ore deposition at greater depths is good.

As regards the second factor the rock character has changed littl

with depth and the geology of the 1000 level in the eastern end of the camp is comparable with that of the surface.

This comparison when extended to the whole camp indicates where developemnt has been carried further the same relationships hold.

Since the ores are or the intermediate temperature type there should occur, as mining proceeds downward, a gradual change to a higher type of deposit bringing about a lowering of the grade of ore when this condition is reached.

Description of Properties

Kirkland Lake Mine

Ontario Bureau of Mines Rept 1928 Pt II P. 93

Kirkland Lake Mine is situated on the western end of the ore zone along the main fault.

The rocks on the surface consist of tuff conglomerate lamprophyric syenite and porphyry. The dark lamprophyric rock is most abundant in the mine workings. The most important rock from an economic standpoint is a red syenite with which the ore shoots are associated. This rock does not outcrop on the surface but is encountered in the workings. The mass is considered to be faulted, the upper part being found on the north side of the vein at the 1850 level and the lower part persists on the north wall to the bottom of the mine.

The ore shoots are found in the faulted zone which dips about 85° S and is not affected by post ore faults.

The red syenite seems to be an indicator of the commercial ore shoots as these occur where the syenite forms one of the walls.

This gives two producing horizons one between the 300 and 1100 levels and the other from 1850 downward. As the syenite forms one of the walls of the vein to the bottom of the mine there is very good ore

shoots

to expect commercial ore shoots at still further depths.

The shoots pitch to the west which is a local feature caused by the pitch of the syenite masses with which they are associated.

The ore consists of minor amounts of quartz with carbonatized wall rock. In the upper levels gold and tellurides are frequently visible with the pyrite. Below the 1800' level there is a change and the gold and tellurides are rarely seen. Here the mineralization is very fine and pyrite which seems to be more abundant with depth is the only mineral recognizable.

Spectacular patches of ore have been found which closely resemble the high grade streaks of the upper levels. In patches the quartz is dark and contains coarse gold with which is associated tellurides of lead and gold. Chalcopyrite and pyrite also occur. At a depth close to 3000' the mineralization of the vein is similar to that in the higher levels. This gives excellent possibilities of profitable mining operations at lower depths.

The managers report of the mine for 1924 shows that a horizontal drill hole on the 3225' level struck a mass of porphyry. Also on the 3600' level this porphyry mass was found to be wider. This mass of red porphyry is thought to be a downward continuation of a westerly pitching mass which outcrops about $\frac{3}{4}$ of a mile to the east.

In most of the mines to the east of the Kirkland Lake property the ore is associated with a red porphyry and not a syenite.

A drill hole in the newly encountered porphyry crossed three gold bearing veins within a width of 60 feet. From the similarity of the conditions with high grade bodies of other mines associated with the porphyry, it is expected that further development at lower levels will

produce large ore bodies.

Although as yet the mine has not been one of the more important producers of the area, recent developments predict an increase in production in the future.

Teck Hughes Gold Mines Limited

Ontario Dept of Mines Report 1928 Pt II P.98

This property is one of the larger producers of the area and in 1929 produced 293,774 fine ounces.

The property is situated on the west side of Kirkland Lake and extends about three quarters of a mile north and the same distance south of the ore zone.

The geology of the property is similar to that of the Kirkland Lake mine but the red syenite which increases eastward is more abundant. There is also a greater proportion of porphyry present.

Evidence of faulting in the main vein is seen in the displacement of a diabase dike. This displacement shows a vertical movement of approximately 2000' and a horizontal one of 550°.

The igneous rocks consist of various phases of syenite both acid and basic which have been intruded by smaller masses of porphyry. The syenite and the porphyry are very hard to distinguish underground.

An important feature of the underground workings is a large diabase dike, which occurs both north and south of the veins.

The dip is about 75° W but flattens at lower depths. The average width of the north lower section of the dike is about 85 feet and the south about 70feet.

On this property faulting prior to ore deposition caused wider fracturing than is the average for the camp. This probably resulted

from the more brittle character of the syenite and porphyry. The width of the fractured zone east of the diabase dike is about 150 feet. A spreading of the fracturing which is pronounced from the 10th to the 18th levels is still quite marked in the lower horizons but diminushes towards the west.

The major movement down to the 9th level shows itself in a single plane but below this spreads into several planes. The movement has displaced the diabase dike in a similar manner and as the dike is approached the main fractures become ore bearing.

This structure indicates favorable conditions for large ore bodies below the 10th level where the ground was opened to a greater degree by the major movements.

From the 17th to the 19th level inclusive occurs a lean streak in the ore due perhaps to a narrowing of the fractures which here are fairly tight. This lean streak is roughly circular in outline, but beyond the borders of this circle splendid results have been obtained.

The relation between the diabase dike and the ore bodies is an important one. The main fractures always displace the dike and commercial ore may occur in them up to the margins of the dike and in some places beyone this. There is usuadly a distance of about 200' between the displaced ends of the dike. In this region the values are generally low and are obtained from narrow stringers which lie between the blocks of diabase and other wall rocks.

Several different types of ore occur which are more or less distinct.

One adjacent to the diabase dike consists of a dense dark material which usually contains a high percentage of pyrite. In this case there

is no definite ratio between the gold and the pyrite a high grade type of ore occuring in the lower levels consists of a very fine grained dark silicified porphyry. The mineralization is in minute particles and under the microscope whows pyrite with finely divided gold and tellurides.

A common type in the mine is one which has a gangue of black quartz and follows the more regular fracture planes. Occasionally this type shows coarse gold and tellurides but as a rule the mineralization is very fine.

As depth is attained there seems to be a change in the mineralization. In the higher levels coarse gold and tellurides are often seen but are less common at lower depths. This does not affect the value of the ore. Pyrite however seems to increase with depth and the mineralization becomes finer. These changes are probably due to the increase in temperature and pressure at the time of ore deposition, which occurred in the 2000 of depth that the veins have been traced.

Lake Shore Mines Limited

Ontario Dept of Mines 1928 Pt II P. 172

This property occupies a central position around the proved part of the ore zone.

Approximately half of the property is under the south arm of Kirkland Lake. In 1929 it was the largest producer of gold in the district with a total of 293,586 fine ounces.

Geology

The rocks exposed on the surface are similar to those on the Teck Hughes property but some differences occur. The mass of lamprophyric

syenite which extends eastward from the Kirkland Lake property is here cut by a greater number of dikes. To the east Surface showing indicate an increase in the number of porphyry dikes, but do not show the presence of a large mass of the porphyry which is covered by the lake.

Two distinct types of rock structure are indicated. One in which the veins are entirely enclosed in porphyry the other where they are in mixture of porphyry and various phases of the syenite.

Sediments occur in small patches or strips included in the igneous rocks in the western part of the mine down to the 600 level.

The geology is the same down to the 1000 horizon and what work has been done below this indicates a further continuation of the same conditions.

Veins

There are two productive veins on the property, which extend through it approximately parallel to each other at a distance of 375' apart. These two veins are known as the north vein and the south vein.

The north vein is part of the main break of the camp and corresponds to the productive veins in the Teck Hughes. The part of the vein explored up to the present indicates a single well defined, highly productive vein with less fracturing than at Teck Hughes.

The south vein lies in a smaller fault than the north vein and has a vertical displacement of about 800

The grade of ore is lower than that of the main break but some rich streaks occur which fill subsidary fractures in the crushed material around the fault plane.

The veins are displaced by the cross faults and flat faults which were mentioned in the section of ore structure. These are definitely

later than the ore but as yet have not proved difficult in mining the veins.

The type of ore mined is the general run of the camp. However, above the 1000' level there occurs, perhaps more frequently then in other properties, the coarse gold and tellurides.

A change in the ore is noticeable below 1400' level with the mineralization becoming very fine similar to the condition experienced on the Teck-Hughes.

Ore lenses in the north vein have been encountered over lengths of 1500' and 1600' on the 1000' horizon. Below this , ore of similar grade and widths is being encountered.

The south vein is not so good but ore zones up to 800' in length have been worked. Here the grade is lower than in the north vein but is as high as $8 a ton.

Wright Hargreaves Mines Limited

Ontario Dept of Mines Rept 1928 Pt II P.125

This property is situatedoon the main ore zone of the camp at the Northeast end of Kirkland Lake. It was on these claims that the original discovery of gold was made in 1911, but it was not until 1921 that the mine entered the field as a prominent producer. For a period of five years it was the greatest producer in the district, until 1926 when it was exceeded by the Lake Shore.

Geology

The lithology of the mine is simpler than those to the west, consisting chiefly of a large mass of porphyry with inclusions of conglomerate. In the northwestern part of the property a mass of sediments consisting of greywacke with narrow pebbly beds, is cut by a lamprophyre

dike. These masses of sediments and lamprophyre are not cut by the main veins which lie within the mass of porphyry. The porphyry does not change much with depth and is generally a deep red color which changes to a lighter color adjacent to the veins.

There are two main productive veins on this property which are an easterly continuation of those on the Lake Shore, but here they are 520' apart. The general dip of the veins is vertical but they are affected slightly by post vein faults.

The relations between the veins is very similar to that on the Lake Shore property with the north vein being the most productive. However here the veins are enclosed entirely within the porphyry and are not associated with other types of rocks. The veins are affected by the same post ore faults but the "flat faults" are at a lower angle, approximately 35°.

There are several large cross faults which caused considerable displacement of the vein generally in a north direction, the east side of the vein moving north.

In the north vein there is less intense alteration of the surrounding country rock than in the mines to the west. The values are associated with quartz and where the porphyry is not silicified, no values of consequence occur.

The south vein shows more displacement than in the mines to the west, which is probably due to the fault becoming stronger as it proceeds eastward.

The ore appears different from the north vein and consists of highly crushed silicified porphyry with stringers and bunches of white quartz accompanied by an abundance of pyrite. The grade of ore decreases

below the 700 horizon although some high grade stringers have been opened up. This ore consists of a dark slicious gangue containing gold, calverite, chalcopyrite, and pyrite in finely divided particles.

In 1929 due to a shrinkage of the ore reserves production was curtailed until the reserves could be built up again. The development program instituted in this case increased the ore reserves to the extent that the mill could operate at a capacity of 550 tons per day. However, the management felt it unwise to increase production until development fully warranted it.

A statement of the ore reserves at December 31, 1929 is as follows:

Ontario Dept of Mines 1930 Pt I P.

Tons	418,877
Grade	$11.30
Value	4,721,551.53

Sylvanite Gold Mines Limited

Ontario Dept of Mines Rept 1928 Pt II P. 134

This is one of the younger mines of the area having reached the producing stage only in 1927. The property is situated to the north and northeast of the Wright Hargreaves and is on the main vein system of the camp.

The geology is very similar to that of the Wright Hargreaves, the veins being enclosed within the porphyry. However on this property there is a north system of veins in contact with an inclusion of sediments in the prophyry.

The prophyry and sediments are quite similar to those on the Wright Hargreaves. Bands of the sediments have been found to extend downward a distance of 1500 or [illegible] north side of the ore zone while further north

larger bands probably extend deeper.

No basic rocks are seen in the mine workings but syenite and lamprophyre occur in small masses north of the veins to the west.

Here also there are two vein systems, which seem to be an eastward continuation of those on the Lake Shore and Wright Hargreaves, despite the fact that they consist of a number of fractures instead of one definite plane.

The south vein series has two productive veins known as the main and south veins. The main vein dips 75° - 80° South and contains a fine ore shoot. This shoot has a depth of 550' from the 700' horizon and is estimated to be 550' long.

The ore resembles that found in the main break of the western part of the camp, and not that which is found in the south vein of other properties. The mineralization in the rich streaks consists of gold, altaite, coloradoite with pyrite and chalcopyrite.

The second vein of the south system follows a strong structure showing much evidence of movement. The ore in this vein consists of highly crushed and altered porphyry more or less replaced by quartz containing pyrite as the common mineral, but gold and chalcopyrite are seen in minute particles.

North System of Veins

This vein dips to the south at angles between 45° and 80° and consist of narrow and irregular quartz stringers surrounded by porphyry. In places the quartz is extremely high grade showing gold and telluride along the fractures. As these veins are generally narrow and have irregular tendencies they are not likely to produce a large tonnage.

As regards cross faults there is one large one which passes thro

the property. It has a dip of 75° W and an approximate displacement of 150'. The direction of displacement is similar to other faults of this type in the district. Several smaller faults occur, having a displacement of about 50'.

Location of the westerly continuation of the ore beyond the large cross fault is of importance to the mine. It is believed that with further work in this part further bodies of ore will be found.

Tough-Oakes Burnside Gold Mines Limited

Ontario Dept of Mines 1928 Pt II P. 141

The Tough-Oakes property was the first producer in the district but closed down in 1919 from lack of ore. In 1923 it was amalgamated with the Burnside mine and the amalgamation company has been operating ever since.

The property is situated on the most easterly part of the "main break" which has not been traced east of the Tough -Oakes.

Geology

The Sylvanite body of porphyry cutcrops over an area about 700' wide on the west side of the property, east of which it occurs as dikes which disappear, as they progress eastward. Bands of sediments occur both on the north and south sides of the property.

They consist of bands of greywacke with interbedded conglomerate and tuff which extend downward 1350' or more.

Basic intrusions occur but do not affect the Burnside part of the property.

Several post ore faults occur,the most important of which follow a diabase dike having a north west strike. This appears to be one of the strongest in the district but the amount of displacement is doul

ful.

The rocks were evidently extremely shattered in an irregular fashion prior to ore deposition. This irregular shattering has caused the ground to be permeated by small veinlets of quartz in which errotic shoots of high grade ore are of common occurrence. The problem then at the mine is to select from this type of deposit a grade of ore that can be mined with a profit.

Those veins first opened on the Tough-Oaks property are of little importance but there are some vertical fractures which contain small ore shoots. What is termed as the south break at the mine has so far proved unproductive but a continuation of it on the Sylvanite property contains a payable streak.

The best ore in this section was a high grade shoot of good width containing the usual type of Kirkland Lake mineralization. The vein dipped 35° S.E. and bottomed against the diabase dike and fault. The productive parts of the vein consisted of quartz stringers and crushed porphyry containing visible gold and tellurides.

Barry Hollinger Gold Mines Limited

Ontario Bureau of Mines 1929 PtIV Pgs. 86-113

Is situated in Pucand township in the Boston Creek Gold Copper area. The district is about ten miles south of the producing section of Kirkland Lake with which it is associated in compiling the statistics.

The geology of the region is typically precambrian with the intrusive rocks being granite and porphyry which are believed to be associated with the gold mineralization.

The shear zones, fractures and veins all have a general northwest-southeast trend adjacent to the large granite mass which occupies part of the township. Most of the faulting and fracturing throughout the area

has preceeded the ore deposition and in this respect is similar to Kirkland Lake.

The veins are dominantly of the fissure type and in general two kinds of gold bearing veins may be recognized.

1. Those having a gangue of considerable quartz and some calcite containing the following minerals: pyrite, chalcopyrite, molybdenite, galena, gold and telluride.

The Berry Hollinger is of this type.

2. The dominantly sulphide veins with relatively little quartz or calcite as gangue. Pyrite is usually the most abundant with chalcopyrite, specularite and molybdenite.

The mine has been operated intermittently since 1917 but it is only since 1925 that it became a producer of any size. The entire output of the mine up to 1929 had come from one vein which strikes N 57° E and dips 70° SE The highest production was in 1927 when it reached 8,479.61 fine ounces.

The production for 1929 was 7,321.05 fine ounces. The managers report for 1929 shows a reserve of 18000 tons with possibilities of still greater tonnage.

Boston Skead Gold Copper area District of Temiskaming L. V. Bell

Argonaut Mine

Another mine which has been a fairly large producer in the past and which is generally considered to be part of the Kirkland Lake area is the Argonaut. This had a fairly large production between 1924 and 1927 but was closed down on March 31, 1928. During 1929, 478.52 fine ounces were produced from a clean up made of the property.

Northwestern Ontario

During 1929 there was considerable development of gold prospects in northwestern Ontario which opened up several promising areas. Of those

Woman Lake seems to be the most prominent. At Woman Lake occur the Bathurst and Bojo mines.

At Sturgeon Lake is situated the St. Anthony property which during the year produced 115 fine ounces. Other properties in the district are Wabigoon Contact Bay, Gold Rock, and the Big Turtle River Mining Company. During 1929 there was a total of 1,112 fine ounces produced from the section.

Woman Lake Area

The general geology of the Woman Lake area is typically precambrian and predominantly igneous, the Animickian and Keweenawan sediments being absent. Acidic intrusions of different phases of the Algoman are abundant and to these, the gold deposits are believed to be genetically connected. The veins occur in pre algoman rocks which have undergone intrusion by the Algoman dikes prior to the formation of the veins. The disturbances which accompanied the dikes may have formed fractures for the solutions which followed or may have provided a brittle member which fractured during later stresses.

The type of wall rock does not seem to make any difference to the ore deposition as quartz veins, bearing gold values have been found both in acid and basic volcanics.

The mineralogy of the veins is simple many of them containing only a small amount of metallic mineral. Pyrite is the most abundant and occurs both in the quartz and in the wall rock. In some cases arsenopyrite has been found in the same relationship. Gold occurs both as the native metal and as the telluride petzite. The veins are complex in character having an earlier quartz of high temperature which has been replaced by a younger quartz bearing the metallic minerals. The younger quartz shows a fine grained unstrained character and probably crystallized from the colloidal

state from which the gold separated in visible particles.

In this area the Bathurst and Bojo properties were the only ones to produce bullion during the year 1929. This was chiefly from high grade pockets near the surface. Bathurst started operations during the summer of 1928 and have continued a development program since that time.

The Bojo Mining Company Limited took over the Laidly claims in 1928 and have followed an active program of development since that time. In 1929 the company produced 561 ounces from high grade sample streaks.

In the Michipicotin district the Cooper mine was in operation up to March 31, 1930 after which time it was abandoned. In 1929 it produced from high grade samples 298.22 fine ounces.

Sturgeon Lake

Ontario Dept of Mines Report 1930 Pt II

At Sturgeon Lake is situated the property of the St. Anthony Gold Mines Limited. This is an old property in which interest was reawakened in 1928 when considerable diamond drill work was done. The mine was re-opened in 1929 and ore was run through the stamp mill which was on the property. This ore yielded 115 fine ounces of gold.

The geology is again typically precambrian with the mineralization being associated with a mass of Algoman granite.

The main ore body is a north-south fissure vein at the contact between the Keewatin and a dome of granodiorite. A quartz porphyry stock has intruded along this contact and has caused considerable alteration. The quartz veins accompanying this intrusion have also caused alteration. The veins dip slightly to the west and the ore bodies rake to the southwest following the quartz porphyry stock.

The gangue minerals are quartz, calcite and siderite which carry gold, pyrite, chalcopyrite, galena and sphalerite. The galena and shpalerite

seem to be indicators of good gold values.

Sturgeon Lake Gold area--Districts of Kenora and Thunder Bay-A.R.Graham

Chapter IV

Quebec

Location and extent of the Gold bearing area

That part of Quebec in which the gold bearing ores are found is situated in the northwest corner of the province, bordering the Quebec, Ontario Boundary and lying chiefly in the countries of Abitibi and Temiscamingue.

The district extends from the 48th parallel of latitude, north to latitude 48° 45' and from the interprovincial boundary east to longitude 77° 30' W and contains an area approximately 4000 square miles.

History

Prior to 1924 any gold produced, came as a by-product of the lead zinc ores of the eastern townships.

During 1923 much interest was taken in North Western Quebec and development on the Horne and Chadbourne claims gave encouraging results.

The Horne is situated on the northwest corner of the Osisko Lake in Rouyn county and the Chadbourne about one mile southwest of the Horne.

At this time Lake Fortune and Stabell claims looked promising but did not reach the producing stage.

These claims lie in the East extension of the Gold Bearing zone of Ontario which passes through Dasserat, Boischatel and Rouyn counties in Quebec.

During 1925 and 1926 development and assessment work continued without much increase in production. The gold produced, still came as a by-product of the copper, lead and zinc ores of Portneuf county.

In 1926 the O'Brien mine situated in Cadillac township reported $1170 gold production chiefly from high grade pockets found during development.

During this year the straight quartz deposits were overshadowed by the

copper, gold, zinc ores of Rouyn district which came chiefly from the Horne mine.

Development at the Horne mine showed enough ore blocked out, to warrant the erection of a smelter which was started in teh spring of 1926 at the town of Noranda. Smelting operations began in December 1927 and aided materially in increasing production for that year from 3680 ounces in 1926 to 8331 ounces in 1927.

Annual Report Quebec Bureau of Mines 1927 P.56

Part of this increase was due to the Rouyn copper gold ores which are treated at Noranda smelter, and shipped as blister copper from there.

1928 showed a tremendous increase in production, reaching a peak of 60 60,066 ounces which is over seven times that of 1927.

The production came from four sources:-

1. Copper gold zinc ores of Rouyn County.
2. Zinc-lead ores of Portneuf County.
3. Pyrite ores of Eastern Township.
4. Straight gold ores of Western Quebec.

The great increase of this year again came from the increased production of the Rouyn camp.

Quebec Bureau of Mines 1928 Annual Report P.50

In 1929 a production of 90,798 ounces was reached being an increase of 51% over 1928.

Quebec Bureau of Mines Report 1929 P.60

The source was the same as the preceeding year, but straight gold ores were being actively developed and mined.

The Arntfield property shows values of $8 per ton over an 8 foot section while encouraging exploration at the Granada property resulted in

the erection of a 75 ton mill.

It was in this year that the assets of the Horne property were taken over by the Noranda Mines Limited.

The Amulet property recovered a small percentage of gold from their test mill but the 100 ton cyanide mill of the Siscoe Gold Mines which was operating throughout the year added considerably to the total production.

Development was continued on the O'Brian property and the Venus Gold Mine which is now a producer started the installation of heavier mining machinery.

Prospectors during the year indicated the possibility of there being another body of copper gold ore in the North of the province at Chibongamon Lake, but development had not been carried far enough to give any definite information on the area.

During 1930 gold production amounted to 141,747 ounces, coming from the copper, gold, zinc ores of which Noranda is the chief producer, and from the straight gold ores of Western Quebec.

Quebec Bureau of Mines Report 1930 P.17

Up to this year the lead zinc ores of Portneuf County had contributed to the gold production but owing to the depression, and the low price of base metals, operations were suspended and no shipment was made.

Increased activity in the Western Quebec fields aided appreciably in production there being now three producing quartz gold mines:-- Venus, Siscoe, and Granade, the latter reaching the producing stage in August 1930. The history then of Quebec as a gold province shows an increase production each year since 1921, due principally to the

operations of the copper-gold areas of Western Quebec.

General Statement

The gold district of Quebec is an eastward continuation of the gold areas of Ontario and consists in the main of Pre-Cambrian rocks which have been covered by the debris of Pleistocene and post glacial erosion products.

Keewatin lavas and volcanics underlie large areas to the North but South of latitude 48° 15' Temiskaming conglomerate, lavas, and greywackes are predominant.

Cutting both formations are intrusions of quartz-porphyry, quartz-diorite and granodiorite, the granodiorite covering the largest areas and being the most important economically.

The mineralization is found chiefly in the hard brittle lavas and tuffs of the lower Keewatin series.

The outcrops of granodiorite are very widespread, showing that the intrusion was of batholithic proportions.

H. C. Cooke, who has done a great deal of work in this area, shows in his reports of 1925[1] and 1926[2], that the copper-gold ores of Rouyn county are intimately related to this intrusion.

1. H. C. Cooke- Gold and copper deposits of Western Quebec G.S.C. Summary Report 1925 Pt. C Pgs. 28-51

2. Origin of the Copper Ores of Rouyn District, Quebec.G.S.C. Summary Report. 1926 PtC Pgs. 48-55

Characteristics of the Deposits

All deposits with but one or two exceptions are found in shattered and sheared zones produced by faulting which formed clean open fissures into which the ore bearing solutions could find their way.

These faults are of the thrust type with a large horizontal component. This is true of some of the Siscoe Veins, Powell, Horne, and Chadburn claims. The veins formed in the hard tough brittle rocks, which shatter to form clean breaks.

Such rocks are the course grained lavas of Dubuisson township, the granite and granodiorite of Dubuisson and Malartic townships, and the granite, lava and fresh rhyolite of Rouyn T. P.

The softer rocks of the area as the Temiskaming greywackes, thin altered lavas, tuffs, probably flowed under the strain, instead of fracturing, and what fracturing did occur was small. This allowed the solutions to pass through, only in a disconnected way and the type of deposits formed were lode deposits of disconnected lenses and branching stringers scattered over a fairly wide area.

The fault in which the veins occur fall into five sets.

1. Two oldest groups which are probably complementary and have a strike and
2. of N 30-40° W and N40° E.

Martin and St. Germain in Dubuisson County

Powell veins in Rouyn County.

3. Strike N and S in Siscoe County.
4. Strike N 75° - 80° E. A great number of veins including Noranda and Lake Fortune.
5. N 45°-55° W. A few veins including the Chadbourne claim and small fault on the Stabell. The faults are probably the expression of some regional movement late in Pre-Huronian time and caused compression along a Northsouth axis between Dubuisson and Rouyn T.P.

H. C. Cooke[1] states: The chief tendency of mining men and prospectors was to look for ore in the neighborhood of syenite porphyry, due

1. H.C.Cooke:-Some Gold Deposits of Western Quebec G.S.C. Summary Report

to its relationship to the ores in Ontario gold districts.

Ore bodies may be derived from other sources, and evidence shows that the granodiorite masses are an important source of ore bearing solutions in the past. Later evidence has shown that at least some of the ore-bearing solutions are within the time of porphyry intrusion.

Conclusions regarding producing mines

The largest producer of gold in Quebec is the Noranda Mine whose ore is a complex of gold and copper.

This has shown a continuous increase in production of gold from this mine will increase still further.

This is the only really large mine in the area. The others that are producing are of the narrow vein type with small pockets of very rich value.

These mines are not likely to uncover a huge ore body, and mining activities should be concentrated on extracting the rich pockets in the most economical way.

Future Possibilities

The future of Quebec as a large gold producer is indeed very promising.

The proximity of this area and its close geological relationship, to the large gold areas of Ontario are undoubtedly encouraging facts.

The history of this area as a gold producer of any account, extends back only a matter of five or six years and new producers are coming to the front each year.

The areas which have been prospected are those easiest of access and where the overburden and vegetation is not so abundant.

There is every reason to believe that with more intensive and intelligent prospecting new finds of relative importance will be found and these with the increased development and production from the known properties, should materially increase the total yearly production of gold in Quebec.

Geology of the Gold District

The geology of the area is essentially Pre-Cambrian consisting of Keewatin and Temiskaming rocks with a very small area in the south-west portion of the district covered by the Cobalt Series of Huronian Age.

Table of Formations

G.S.C. Memoir 166 P.24

Rouyn- Harricanaw Region, Quebec

Quaternary	Post Glacial	Clay, silts, sands
	Glacial	Boulder clay, Morrainal deposits
Keweenawan	Nippissing diabase	Dikes
Huronian	Cobalt Series	Conglomerate greywackes arkose, argillites

Great Unconformity

Pre Huronian	Intrusives	Basaltic dikes
		Later Gabbro
		Altered Peridotites
		Granitic intrusives
		Quartz diortie(older) (Gabbro)

	Post Temiskaming folds
	Diorite porphyry
	Amphibolite
	Conglomerate greywackes
	lavas
	Temiskaming series

Probable Unconformity

Keewatin series	Basalts andesites dacites rhyolites tuffs and metamorphosed seds.

Description of Formations

Keewatin

The Keewatin series of lavas, both basic and acid intrusives and several bands of metamorphic sediments which have been described by B. S. Buffam.

B. S. W. Buffam Destor area Abitibi county Quebec G.S.C.TSummary Report 1925 PtC Pgs. 82-104

According to him they occur in six bands and are infolded with the older lavas and are considered to mark synclinal areas in the folded Keewatin.

In general the sediments consists of thin beds of volcanic tuff with some slates and phyllites.

The lavas of the Keewatin are generally well preserved and exhibit the characteristic flow and ropy structure.

Temiskaming Series

This series underlies the greater proportion of the southern half of the area and consists mainly of sediments with some volcanics. They may be divided into three bands.

1. The Duparquet band in the north stretching across the middle of Duparquet and Destor T. P.s with a length of ten miles and a width of ½-1 mile.

2. The Cliercy band in the Parese and Bousquet counties.

3. The main or southern band stretching across Abitibi and Tineiscamingue counties varying in width from two to nine miles.

The main band consists of conglomerate and greywacke with a little interbedded lava. The type of pebble in the conglomerate varies from place to place while the greywackes are light grey to dark in color and appear to have been formed from arkoses and impure sands.

The Cliercy band strikes with the general direction of the Keewatin which is N. 60° W. These rocks of this band consist of the erosimal products from the Keewatin.

The Duparquet band of even grained arkose and conglomerate.

Folding in the Area

Both the Keewatin and Temiskaming were effected by forces which flung them into a series of synclines and anticlines. The age of the folding is between the intrusion of the diorite porphyry and syenite porphyry. These are shown in the Keewatin in the neighborhood Dasserat Opasatika and Fortune Lakes.

The folds in the Temiskaming are observed at Opasatika Lake[1] where their axes have a strike of N 70°-80° E with the axes converging to the

east.

Several major faults have been observed:

1. On the west end of Kekeko Lake.

2. A very large one which has displaced the Keewatin-Temiskaming contact at Davidson Creek approximately three miles and has a strike N 40° E.

G.S.C. Memoir 166 P 102

3. Another fault has displaced the Clericy band of seds about 2000 feet.

Igneous Geology

Both formations are intruded by numerous plutonic and hypabyssal rocks. The most important is the large areas of granite which outcrop. This is a typical grey granite and is economically important because of its connection with the copper-gold ores of the district.

Small patches of syenite porphyry outcrop over widely separated areas but generally confined to the Keewatin.

The term "later gabbro"[1] is applied to a large number of dikes younger than the Temiskaming and consisting of both olivine and quartz gabbro.

1. G.S.C. Memoir 166 P. 142

There is a pronounced parallelism between the dikes which are long and straight and have a constant width.

There are two natural sets of dikes which have the following strikes.

1. N 50°-60° E
2. N 20° W

This implies that the fissures were formed by general regional stresses of gentle proportion causing practically no faulting.

Cobalt Series

The Cobalt series outcrops in the southwestern corner of the area in the southwestern corner of the area adjacent to the Ontario boundary.

It has not a very great areal extent in this part and is of little importance as far as ore deposits are concerned. It consists of conglomerates with some greywacke arkose and slate.

Ore Deposits

The gold in Quebec occurs in association with the copper ores of the Rouyn district which are a replacement type and in the straight gold quartz veins. In each case the gold is either in the free state or as a mechanical mixture, no chemical association taking place with any of the sulphides. Its occurrence in the sulphide ores is very erratic and is found in both pyrite and chalcopyrite without any degree of proportionality. It has been suggested that the gold was introduced in a local and erratic fashion after the deposition of the sulphides.

Gold Quartz Veins

The straight gold deposits may be divided into veins and replacement deposits. So far only the Malartic property is of the replacement type. The veins may be classed as follows.

G.S.C. Memoir 166 P. 171

1. High temperature type showing rutile.
2. Quartz chalcopyrite veins.
3. Quartz tourmaline type.
4. Quartz pyrite.
5. Silica replacements.
6. Carbonate replacements.

Great numbers of the high temperature veins occur of which the Granada Rouyn is an example.

The quartz tourmaline are also high temperature and are exemplified in the Siscoe property.

Quartz chalchopyrite is usually highly auriferous and contains the bulk of the gold.

Of the silicious replacement type the Malartic is the only one yet known in the district. The silicification seems to be connected with the intrusion of a small mass of feldspar porphyry.

Some carbonate bodies have been developed and the alteration has formed some fairly good sized bodies of gold bearing material the tenor of which is too low to mine.

Description of Properties

Noranda

G.S.C. Memoir 166 Page 183

The Noranda Mine though primarily a copper property produces the greater proportion of gold in Quebec. It is situated just west of the south end of Osisko Lake in Rouyn township. Three discoveries have been found on the property:- the Powell gold quartz veins, the Chadbourne gold vein and the Horne copper-gold deposit.

The property was first staked in 1920 by E H Horne and a little development work was done. Exploration work continued until 1927 when the mine reached the producing stage and the erection of the smelter was completed. Since then its capacity has been increasing steadily.

Geology

The rocks in the vicinity of the mine are Keewatin consisting of lavas and tuffs. All have been highly metamorphosed by the intrusion of several igneous rocks, such as quartz diorite, syenite, porphyry and later gabbro.

The rocks have been dragfolded over a distance of 1800 feet.

There has also been considerable faulting. North of the fold is a large fault striking N 77° E. Numerous small faults occur generally being

left banded and varying in strike from north to northeast.

The general strike of the ore body is northeast and is independent of the bedding. As the strike of the ore bodies and that of the faulting primarily controlled the ore deposition.

A fault has caused considerable shearing of the lavas in places the shear zones having a general strike of nearly northwest, which is parallel to the fault.

Mineral solutions of quartz and calcite carrying much pyrite have been deposited along the shear zones. Both veins and country rock are heavily pyritized. Ore values in this zone have been very promising and further development should be done.

Samples of the pyrite were taken with special attention being paid to the size of grain and it was found that the gold content varied inversely as the grain of pyrite.[1] The variation in the value of gold probably indicates that it is deposited either in or on the pyrite and is present in the free state.

H.C. Cooke Some Gold deposits of Western Quebec

G.S.C. Summary Report 1923 Pt.CI P 116

The sulphides are composed of pyrite pyrrhotite and chalcopyrite with a little magnetite and sphalerite. Pyrite was deposited first, and from observation on the Aldermac property, it is presumed that it is older than the syenite porphyry.

Chalcopyrite cuts the syenite porphyry and is therefore later.

The ore bearing solutions has altered the country rocks considerably. The lavas are all highly altered being now very much chloritized and having very little original feldspar left. The alteration proceeded in two stages.

1. Replacement of feldspar by quartz sericite and albite.

2. Replacement of silicified rock by chlorite.

The distribution of gold values in the Horn ores is very erratic.

A review of the gold content of the Horne ore bodies shows that the gold is in no way connected with the amount of copper and pyrite present and that it has no affinity for one or the other.

Ore Body	Copper	Iron	Gold
F	very little		$8
B	8%-----10%		$8
A-D	10%----15%		$4-$5
A	same as F		$1-$2
K	10%----15%		$1-$2

The pyrrhotite was separated and found to carry no gold whatever. This leaves only the pyrite and chalcopyrite; but they did not carry any gold when they were deposited. Therefore it is very likely that the gold was introduced into the sulphide in a local and erratic way.

Reserves

Up to December 1929 the estimated blocked out ore reserve was 6,664,000 tons. Of this 3, 426,000 tons was direct smelting ore with an average of $3.29 per ton in gold. Another 3,000,000 tons averaged $3.00 per ton in gold. However since that time the reserves have been added to with gold values as high as $15 per ton but average $3.40.

Powell Vein

G.S.C. Memoir 166 P.256

The Powell vein is situated south east of Héré Lake and is a large

gold bearing quartz vein which cuts through rocks of the Keewatin series which are also intruded by the Powell granite.

The width averages from 3'-6' and the vein has been traced along a strike of N 30° W for a distance of 3600'.

The vein fissure was probably caused by faulting as striae occur along the walls in many places with a dip to the south of angles of 50°-60°. The south sides of the striae have a much steeper dip than the north indicating that the east side moved north and upward, the fault being and overthrust.

The ore bearing solutions probably came from the granite stock, carrying pyrite in a gangue of white quartz and settled in the fissures. The veins are widest and carry highest values close to the granite. This is probably due to the more brittle nature of the rocks close to the granite consequently forming a wider and cleaner break. The Here also the gold values are found to vary inversely as the grain of pyrite.

Venus Gold Mine

L.V.Bell Quebec Bureau of Mines Annual Report 1930 Pt B P. 39

Is situated in Barraute township, Abitibicounty on the Quebec Cochrane branch of the C.N.R. about 25 miles southeast of the town of Amos.

Geology

The rocks in the vicinity belong to the Keewatin series and are overlain by glacial drift.

There are two vein systems on the property which do not form a continuous zone and are markedly different in form of occurrence. They are disignated as the North vein system and South vein system.

The South Vein System

The South system cuts Keewatin lavas which are schistose with the

shear plane striking N 68° W and dipping 55° to 60° N. A second set of shear planes not so well developed strike similar to the main shear system but dip in the opposite direction at 40°-50° S. This corresponds to the attitude of the principal veins.

As there are two sets of shear planes there are also two sets of quartz veins. Only the south dipping veins are of importance. These veins are composed of vitreous quartz and commonly cut accross the planes of shear at an angle. They have a variable dip which gives rise to rolls and flexures.

In the south zone the veins are generally narrow more or less lenticular and parallel. Only four are sufficiently well mineralized to encourage development. They have a general N 70° W strike and dip 50° S.

Mineralization

The veins are reported to carry much pyrite and some tourmaline with very fine gold. The presence of tourmaline indicates the high temperature type of deposit.

On account of the narrowness and lenticular nature of the veins and the fact that the gold is practically restricted to the quartz very rich values would be necessary to provide ore over mining widths.

As these values have not been found indications of developing a commercial ore body in the south system are not very prosperous.

North Vein System

The North vein system has a similar structure to the South vein system but has evidently been shattered to a greater extent as there are in all three sets of shear planes. There are two sets striking N 70° E with a dip 70° N. The rocks are of Keewatin age and are intruded by an acid porphyry which is younger than the shearing, for it is shattered to the same extent as the intruded rock. The system consists of two, more

or less parallel veins which are more like zones as the quartz lenses have little continuity and outcrop in an irregular fashion.

The lenses vary in thickness from 1-3' and have a strike of N 66° - 68° W with low dips such as suggest a synclinal fold. They consist of white vitreous quartz carrying tourmaline suggesting the same type of deposit as the South vein system. The lenses are heavily pyritized but the pyrite is concentrated in a narrow zone close to the wall rock. The gold is concentrated in the pyrite, but is in the free state having been to occur as a film over the pyrite crystals.

This means that any values found will be in the narrow pyrite zone bordering the wall. Further investigation reports that values are found only in restricted portions of the border zone.

Encouraging gold values have been found and development on the north set of veins was continued through 1930. A 25 ton test mill was completed early in 1931.[1]

[1] Quebec Bureau of Mines Annual Report 1930 Pt.A P.97

Siscoe Gold Mine

G.S.C. Memoir 166 P.247

The Siscoe Gold mine is situated on Siscoe Island in De Montigny Lake.

Geology

The southeast part of the Island is underlain by flows and tuffs while in the north, part is covered by a much altered intrusive mass related to the granodiorite mass in the vicinity of De Montigny Lake. Diamond drilling showed a great deal of erosion at the contact due probably to the presence of a shear zone.

All the rocks are cut by granodiorite porphyry dikes coming

probably from the same reservoir as the larger masses.

Veins

The veins are of the quartz tourmaline type carrying free gold and seem to have come from the granodiorite mass.

So far four zones have been discovered namely A, B, C, D, but development up to 1926 had only been carried on at the north end of the island on the D zone.

Veins of the D zone fall into two sets.

1. The older set with a north-south strike.
2. Younger set with an east-west strike.

Veins of the older set do not exceed a foot in width and are composed of quartz with little bunches of tourmaline needles. Little or no sulphide may be present but free gold occurs.

Veins of the second set cut and fault those of the first and are therefore younger. They are generally less than an inch in width and contain more tourmaline then the first type, as well as a larger percentage or pyrite. The principal values are due to the free gold which is closely associated with the tourmaline.

In 1927 development was again started on C zone and the vein underground was reported to have a length of 500 feet and a width of 3½ feet with an average tenor of $20.00 per ton.

Quebec Bureau of Mines Report 1927 Pt.A P.146

Development continued through 1928 and in 1929 a 100 ton cyanide mill started operations. Two new veins were discovered during development work and it is planned to explore them further. During 1930 the mill operated continuously and development work at the mine has showed a prospective increase of production which necessitates an increase in

mill capacity[1] . The presence of

Quebec Bureau of Mines Report 1930 Pt.A P.91

galena or sphalerite generally indicate high grade ore.

The vein solutions have altered the wall rock to a width of 2-3'. In places the dark greywackes have been bleached a light yellow and contain a good percentage of pyrite.

Granada Rouyn

G.S.C. Memoir 166 P.235

Granada Rouyn mine is situated in the southwest corner of Rouyn township.

The claims are underlain by Keewatin lavas in the north and Temiskaming sediments in the south. Both formations are cut by a belt of feldspar porphyry dikes approximately 2000' in width.

Numerous quartz veins carrying gold are found within the belt of dikes. The strike of the zone is N 60° W.

Up to the end of 1929 exploration was confined to what is known as N°2 vein. It consists of numerous quartz cutting the conglomerate of the Temiskaming series. Commonly along the hanging wall there is a larger vein of quartz. Coarse gold is visible in many places and values up to $100 per ton have been found.

The vein material is chiefly white quartz with a little tourmaline and hornblende.

The quartz has been greatly fractured and chlorite with some sericite has been

During 1930 heavier machinery was installed and a 75 ton mill erected. The ore is free milling and the mill is therefore quite simple.

The mill started operating in June 1930 and operated till the end of

the year at a capacity of 60 tons per day with an average value of $14.00 per ton.

Quebec Bureau of Mines Report 1930 Pt.A P.66

Besides the construction of the mill development was carried further on No2 vein and stoping was started at the 500 and 625 levels. Free gold has been observed in several places and high grade values secured.

The problem in this mine seems to be the extracting of the high grade pockets in the most economical way. It is not present but efficient mining of the high grade pocket may pay the operators a liberal reward.

O'Brien Claims:

G.S.C. Memoir 166 P.267

The O'Brien claims are situated in the northwest corner of Cadillac township. The rocks in the vicinity consist of Temiskaming sediments which have been cut by porphyry dikes or sills.

Five veins occur on the property but only two of these are important.

Both veins have a similar strike to the rocks in the vicinity which is practically due east.

The first vein, lies in a band of conglomerate and has a gangue of quartz carrying arsenopyrite and coarse free gold, which is scattered throughout its length. A little pyrrhotite and chalcopyrite also occur. The width of the vein varies from a few inches to 15 feet.

The other vein occurring in the porphyry has a width of 16-24 inches and carries coarse gold along the fissures in the quartz.

In 1927 a rich pocket of ore was found when developing this vein and stoping was started. Continued development of the vein disclosed more rich pockets and further stoping was done and heavier machinery installed.

Part IV

Nova Scotia

Introduction

One of the earliest gold discoveries in the Dominion of Canada was the finding of this precious metal in mineable quantities in the slates and quartzites, bordering on the Atlantic Coast-line of the province of Nova Scotia.

This discovery in 1857, caused no little excitement and many prospectors rushed to the field in the hope of obtaining fabulous wealth.

The ore occurs in quartz veins aggregated on the domes of plunging anticlines and seems to be spread over a very wide area.

For many years little detail work had been done until E.R. Faribault of the Geological Survey of Canada started his investigation from which there was acquired much important information.

In 1929 all available information of Nova Scotia was compiled under one cover by W.Malcolm.

W. Malcolm,"Gold Fields of Nova Scotia" G.S.C. Memoir 156

Area and Extent

The area and extent of the gold bearing formations is approximately 10,250 square miles or about half the area of the province. The extreme length is about 275 miles varying in width from 10 miles in the north to 75 miles in the west.

Its most easterly point is at Canso. From here it extends southward in the form of a triangle, along the south shore of Chedabucto Bay, and westward to the mouth of the Avon River.

Just south of Halifax it is cut by a granite intrusion of fair width, but the formation comes in again at Mahone Bay, where it occupies approximately half of the width of the province.

It is continuous to the extremity of the province, where it extends

across the entire width to St. Mary's Bay.

History

Although the first district was discovered in 1858 at Tangier, no intensive mining was carried on until 1862 and operations have been more or less continuous since that time.

The rush of 1861 produced many new discoveries and numerous new areas were opened up.

The degree of activity has varied to a considerable extent. In the rush of 1861 many people registered claims who had little experience in mining and this, together with costly operating caused a marked decline in the industry.

Following this, larger companies began to work combined holdings.

This revived the industry, and the production in 1867 reached 27,583 ounces.

Speculation, however, caused the production to fall off considerably until in 1874 only 3141 ounces was produced.

Many reasons are given for the decline, the most prominent being

1. Rash expenditures of capital and profits.
2. Very inefficient milling methods.
3. Incompetency of some so called "mine manager".
4. Lack of detailed geological work.

Following this depression mining was carried on by the "tribute system". This kept the industry alive, but prevented the carrying out of any well defined policy of development.

In 1883 and 1884 several successful attempts were made by men of experience to reopen abandoned and idle mines.

Success was due chiefly to better mining and milling processes and

application of strictest economy. So successful were the operations, that low grade bodies were mined with a profit. This period of prosperity continued for a number of years.

In 1893 there was a decided decrease in production to be followed by an increase in 1898.

During these latter years, concentration was placed on the treatment of the tailings.

The Chlorination process was tried but the Bromo-cyanide treatment proved most successful.

Production dropped again in 1903 and 1904 being only 14,279 ounces, and since then has been very low.

From 1912 to 1927 only one year shows a production of over 7000 ounces , that being the year 1915.

In 1929 the production was 1,568 ounces coming chiefly from the Goldenville, Renfrew, Beaver Dam, and Uniacke districts.

H.S.Philpot-Province of Nova Scotia

Resources and Development 1930 P.38

General Statement

Geology

The gold bearing area is underlain by a series of sedimentary rocks and igneous intrusives.

The sedimentary or gold bearing series consists of two formations, an upper and a lower. The lower or Goldenville formation consists of 16,000 of quartzites and interbedded slates which are overlain conformably by the Halifax formation consisting of 14,500 of slates. The beds are folded into long anticlines and synclines with their axes nearly

parallel to the Atlantic Coast. The anticlines which are on the average 5 miles apart and from 5 to 100 miles long plunge at intervals to the east and west. The domes on any one anticline are 10-25 miles apart.

The Goldenville formation is exposed along the anticlines while the Halifax formation forms easterly trending belts, lying in the synclines. The beds dip at high angles and in places are overturned. Numerous faults cut the series in a northwestern direction and the horizontal displacement in some cases exceeds one mile.

The series is probably of Pre Cambrian age. The igneous rocks except for a few narrow basic dikes are granite, varying much in texture and composition.

Where they have cut the Gold Bearing series they have induced intense alteration, near the contact.

The folding of the sediments and the intrusion of the granite took place during the Devonian, and this was followed by a long period of erosion which unroofed the granite before the carboniferous was laid down.

Ore Deposits

The gold occurs in the quartz veins of the Gold Bearing series. Most of the veins lie in the stratification planes of the slate beds of the Goldenville formation but a few important veins cross the strike of the sediments. They are found on the domes and plunging anticlines and the outcrops form a series of concentric ellipses or portions of ellipses. Underground work in some districts has revealed the presence of a series of saddle veins that do not come to the surface.

Many of the interbedded veins are strongly corrugated. On the sides

of the dome, the corrugations parallel the strike of the vein, but towards the end of the dome they pitch at an angle between the dip and st strike and assume large proportions so that the term "barrel quartz" is applied.

The gold occurs in shoots which pitch at a low angle to the east or west. The location of the shoots appears to be determined by some irregularity of rock structure, such as, subordinate flesure in the fold, or a fracturing of the strata.

Most of the gold is free milling but the arsenopyrite found in considerable quantities in some veins carries gold that is not amenable to amalgamation.

It is evident that the deposition of the ore is dependent on the rock structure. It is believed that during the folding, there was a slipping of the beds one upon another with a consequent fissuring along the bedding planes of the slates. During the opening of these fissures, deposition of auriferous quartz took place in those parts where the fracturing of the rock was sufficient to permit the passage of the solutions. The problem of the origin of the solutions has not yet been satisfactorily worked out. Two theories have been advanced.----------

1. That the veins were filled by lateral secretion.

2. Minerals were deposited by ascending thermal solutions-- This later is the most generally accepted one.

Future Possibilities

Since its inception in 1862, the gold mining industry of Nova Scotia has played an active and important part in the province.

Although in the earlier years, production was higher, reaching its peak of 31112 ounces in 1898, it has latterly fallen off until now only

a very few districts are active.

T. A. Richard[1] states that gold mining in the future as in the past

1. T.A. Richard "Gold Mining in Nova Scotia", Nova Scotia Dept of Public Works and Mines Report 1926 Pgs. 163-177

must depend mainly on small enterprises of practical miners, whose chief capital is muscle and experience. That, although the small shoots of rich ore found either on the domes or along the crumples of the fold are worthy of investigation and development, they do not warrant a large equipment, extensive development, or investment of large sums of money. There is reason to believe, however, that the auriferous veins have not been exhausted.

Most of the mining of earlier days was carried on by individuals who had not sufficient capital to press operations to any considerable depth and those who had capital at their command allowed themselves to be governed too freely by the prevailing idea that the deposits were superficial. Later operations have revealed the presence of rich ore mines that were for those reasons abandoned.

Ore shoots are frequently found in a series of veins in parts of domes that have been affected by some irregularity of structure.

Where the irregularity of structure extends downward through the sediments, parallel to the axial plane of the anticline, it is reasonable to believe, if the veins had their origin in ascending thermal solutions that the series of deep veins are auriferous as well as those at the surface. It is suggested therefore that close attention be paid to those peculiar features of structure that seem to have been intimately related to ore deposition.

Faribault[1] in 1899 states in a paper,

1. E.R.Faribault--Gold Measures of Nova Scotia and Deep Mining Journal Can. Mining Institute Vol II 1899 Pgs. 119-128

"That the Gold Bearing veins of Nova Scotia bear a strong resemblance to the Bendigo saddle reefs and that he believed, if mining be carried on at greater depths gold could be extracted at a profit.

General Geology

Table of Formations

G.S.C. Memoir 156 P.20

Post Glacial	Fluvial deposit
Pleistocene	Sands, clays and gravels
Lower Carb	Limestone, Sandstone and shale
Devonian	Granites of varying texture, biotite and muscovite granites
Pre Cambrian	Halifax formation-Slates Goldenville formation Interstratifo slates and quartzites

Description of Formations

Goldenville

The Goldenville series consist of slates, conglomerates, and quartzites with quartzite predominating.

The quartzite is described by Jackson and Alder[1] as composed of

1. Jackson and Alder. "Remarks on the Mineralogy and Geology of Nova Scotia"1835 P.321

silicious matter or quartzite, which is fine, granular, but more frequently compact and breaks, not unusually with conchoidal fracture.

It is sometimes white and its grains are transparent, but it generally has a greyish or bluish tint.

Woodman states that calcite is abundant giving effervescence with acid, but Faribault is of the opinion that this is the case in only a few beds and not of general application.

Faribault[1] states of the slates that:-

1. G.S.C. Annual Report Vol II Pt.P P.146

"The principal varieties are light grey, glistening, mica slate, almost wholly composed of mica; dark bluish,papery, shining, fine micaceous slate, dull green, dirty rusty arenaceous earthy slate; greenish, soft, unctuous slate with little mica, and bluish black or dark bluish grey, compact siliceous slate generally metalliferous and holding arsenical and iron pyrites in crystals or nodular masses principally in the vicinity of auriferous quartz veins and with which they are often associated."

Woodman along the Moose River found that the pyrite lay chiefly along the bedding planes of the slate.

In some places there is no sharp line of division between the quartzite and the slates, one passing gradually into the other.

Besides the quartzites and slates there is a minor development of grits and conglomerates, occurrences of which have been noted at Mount Uniacke and Waverly.

Halifax Formation

This consists chiefly of slates of various textures and colors; a few silicious beds and a little limestone.

The limestone which is arenaceous dolomitic in character, occurs at the base of the formation, and has been seen in two places.

Faribault[1] says that the great mass of the Halifax formation in the east consist of, bluish black, ferruginous and graphitic slates,

1. G.S.C. Annual Report Vol II P. P P.147

easily distinguished from and unlike any others in the province, having a characteristic fibrous texture.

Certain flinty layers are full of arsenical and iron pyrites distributed through the mass in small perfect crystals.

Structure

The structure of the Gold Bearing Series is rather a difficult problem. The boundary between the two formations is the only horizon that may be traced throughout the field and in the west where this is unsatisfactory as the transition between the slate and quartzite is very gradual.

Traverses made across the Gold Bearing series from north to south show a succession of alternate zones of Halifax and Goldenville formations, varying in width from a fraction of a mile to several miles. In the east the quartzite zones are generally much wider than the slates. In the west both formations are more nearly equal in distribution. The slate zones of the east take in general, the form of much elgonated ellipses surrounded by quartzite, in the west the quartzite are elliptical surrounded by slate. The ellipses in the latter case are much broader.

In the east the zones of slete lie in the troughs of the great east and west folds along the anticlines of which, the zones of quartzite are exposed.

The chief difference between the structure of the east and west is that in the east the strata are more tightly folded and dip at steeper

angles (60-80°). The east also shows more erosion.

The anticlines, though approximately parallel, vary a great deal in length, from 3-4 miles in some local folds, to 105 miles in the Waverly Moose River fold. Cases of folds uniting and others starting again after a break have been noted. In general it is very unreliable to correlate folding in different parts unless the fold has actually been traced.

The plunge of the anticlines to the east and west are seldom more than 30° and generally they are much less, byt may vary greatly, in short distances.

It is probable that the plunging was produced simultaneously with the main folds by a force acting at right angles to that which caused the main folds.

The structure of the western part has been more difficult due to the great proportion of the Halifax formation and to the scarcity of exposure in some sections.

The most important feature of the structure is the exposure of the Goldenville formation in broad elliptical domes.

This is very noticeable in Lunenburg and Queens counties. The longer axes of the domes run northeast and southwest the domes being approximately parallel.

The formation has experienced a great deal of faulting with two kinds of faults and cross country faults.

Local faults are found in the several gold districts but do not continue very far and seem to be associated with the doming.

The cross country folds are those that persist, and can be traced across several successive anticlines. The more important of these are:

1. New Harbor river 2. Country Harbour

3. Indian Harbor 4. Sheet Harbor

Besides, folding and faulting other phenomena, such as brecciation, cleavage, jointing and fissuring occur.

The innumerable quartz veins lying in the stratification planes probably had their origin from the deposition of quartz in fissures caused by close folding and the consequent slipping of the strata on one another.

Cross fissures which occur are probably due to orogenic movements and are quite local.

There are a few cross veins which lie in faults and it is not always possible to determine whether the break is a simple fissure or a fault.

The cleavage generally is parallel to the strike of the rocks but is dipping at very high angles.

The slate of the Goldenville formation when followed through any single bed, shows no uniform thickness, but is generally thicker on the apex of a fold then on the limbs.

This is due to the more plastic properties of the slate. When folding took place the slate being more plastic then the quartzite in the sliding of the beds was pushed from the limbs to the apex of the fold, which was the point of least pressure.

This gave a thinning of the slate on the limbs and a thickening on the apex.

Many estimates of the thickness have been given with some as high as 30,000 for exposed rocks but it is practically impossible to determine the thickness of the whole series, for in no place has the bottom of the Goldenville been found.

All surrounding formations which are in contact with the Gold Bear-

ing series are younger.

It is, intruded by a series of basic dikes and sills, generally striking along the stratification planes.

There are also numerous stocks and small batholiths of granite which have caused considerable metamorphism in the series and thus show a later age.

In the Nictaux Torbrook basin and the Clementsport and Bear River basin of Annapolis County, the Gold Bearing Series is in contact with early Devonian slates, which have suffered metamorphism through intrusion of granite.

South of New Canaan, King's County, it is a narrow belt of highly altered folded, fossilferous, impure, limestone of Silurian Age.

In the vicinity of Avon River and east of Chedabucto Bay, the series is overlain by the sandstone, shale, and conglomerate of the Horton series, which is Lower Carboniferous.

This is resting unconformably on the Gold Bearing series, and is itself overlain conformably by the limestone, sandstone, and shales of the Windsor Series.

Age of Gold Bearing Series

The age of the Gold Bearing Series is one of the most difficult problems connected with it.

The age has been given as anything from Pre Cambrian to early Silurian and although Cambrian has been applied for a number of years the general conception is that it is Pre Cambrian.

Many markings and possible organic forms have been found from time to time but these have generally turned out to be concretions, or their organic origin disputed, so that nothing has come of them.

Several authors have pointed out the marked resemblance between the Gold Bearing series and the slates of the Avalon Peninsula of Newfoundland which are Pre Cambrian.

Dawson in his Acadian Geology edition 1878 believes the series to be Cambrian or Primordial which view is supported by Sellwyn and Hind.

Van Hise[1] states that the series may be as late as Cambrian but in view of the scarcity of fossil remains in the series whil Cambrian strata in the vicinity have an abundance of fossils, he is inclined to believe the series Pre Cambrian.

1. C.R. Van Hise:- Principles of North American Pre Cambrian Geology U.S.G.S. XVI Annual Report P.811

Small patches of Lower Carboniferous sediments are scattered along the coast at St.Margaret and Mahone Bays. They consist of limestone, sandstone and shale resting unconformably upon the Gold Bearing Series.

Igneous Geology

Basic Intrusives

Intrusives of basic dikes and sills cut the Gold Bearing Series but are limited wholly to western part of the fields. Such intrusions are quite numerous in Kings County where they nearly all lie in the bedding planes of highly inclined strata.

The most striking of these dikes is one that cuts the Gold Bearing Series and the Granite in the southern part of Queens and Shelburne counties. It is from 200'-600' wide and persists for a distance of 60 miles.

All of these basic intrusives are called diorite.

As far as their age is concerned little seems to be known exc that they are of remote age. This is probably from the great deg

of alteration that they have undergone.

Granite

Granite is widely distributed throughout the Gold Bearing Series consisting chiefly of masses not exceeding 10 miles in width of 40 miles in length. The largest mass however extends southwest from Halifax in a crescent shape, for 95 miles and has a width of 20 miles.

The texture of the granite varies a good deal while the granite itself is of at least two different intrusions.

Faribault[1] in his report on the eastern counties says that granite

1. G.S.C. Annual Report Vol II Pt P.132

varies much in composition and texture according to position. It is composed of white or pink fedspar, white colorless or smoky quartz and white mica forming a uniform towards the centre.

In 1849 Gesner[1] mentions some granite that he examined as containing

1. A.Gesner Industrial Resources of Nova Scotia 1849

blocks of older granite and suggests that it is of at least two different intrusions. W. J. Wright describes an older and a younger granite in the New Ross area and Woodman[1] is of the opinion that the granites are not all of the same age.

1. J.E.Woodman American Geology Vol 33 July 1904

The evidence points to the intrusions of the granite during the Devonian rocks of the Nictaux Torbrook area and was itself unroofed before the deposition of the Horton series of Lower Carboniferous which directly overlies the granite.

Metamorphic rocks are found generally encircling the granite and in a few local patches. They consist of gneiss and schists, the gneiss being foliated and consisting of quartz and mica while the schists are

micacious and some show a marked development of staurolite and andelusite crystals.

It seems almost certain that the metamorphosis was induced by contact action of the granite magma, and that those local areas of metamorphosis are probably due to a granite contact close below the surface.

Geological History

The great thickness of sediments contained in the Goldenville and Halifax series suggests a long period of submergence and sedimentation during the Pre Cambrian. In the early part of the epoch the sediment probably consisted of silicious material, with some very fine muds, which, on consolidation formed the slates and quartzites of the Goldenville. There was evidently a slight disturbance which caused the deposition of a great deal of mud which formed the slates of the Halifax series.

Evidence of what happened between the depostion of the Halifax series and Devonian sediments is lacking, but it is quite probable that at this time the land was elevated above sea level.

Devonian eime is one of importance in the district for it is during this period that the gold bearing series received its economic value.

The close of the period was characterized by intense igneous activity during which time the large masses of granite now covering a large part of the area were intruded.

The mineralizing solutions which caused the gold deposits are generally believed to be connected with the intrusion of the granite.

The folding and uplift accompanying the intrusion left the land high above sea, and a period of erosion set in.

During the Carboniferous times the sediments of the Horton and Windsor Series were laid down, following which there was another uplift causing rejuvenation of the topography.

A period of erosion followed this uplift and has continued to the present day, reducing the area to a peneplane.

Gold Deposits

General Character

Most of the gold bearing series are interbedded with the sediments, but there are a few which cut across the strike.

They are not limited to any special horizon but occur at various depths in the Goldenville.

The slate bands seem to have been more favored by the mineralizing solutions, for it is chiefly along these that the ore deposits occur.

The structure of the gold bearing series has had an influence on the ore deposition. This is shown by the concentration of the deposits around the domes along the anticlines.

The Halifax series is not very rich in paying veins, and Goldenville has supplied most of the production.

Mineralogy

The veins consist of a gangue of quartz and calcite, which contain pyrite and arsenopyrite with some galena, pyrrhotite, chalcopyrite and sphalerite in subordinate amounts.

The gold occurs either free or intermixed with the sulphides and is generally most abundant along the footwalls. Two varieties of quartz occur; one a coarse white crystalline variety and the other a smoky, generally laminated type.

Veins of auriferous stibnite occur at West Gore.

The presence of pyrrhotite would seem to indicate the formation of the veins at a high temperature, but Lindgren[1] classes them as mesothermal

1. Lindgren- Mineral Deposits 1928 Pgs. 598,635.

deposits being formed at a depth of 4000 feet to 12000 feet below the surface.

The approximate temperature would be in that case between 50° and 125° C.

Character and Relation to Country Rock

The Auriferous veins are found chiefly on the domes of the anticlines and distribution in such a case is intimately related to the rock structure.

On sharp closely folded anticlines when the planes of bedding on one limb form an angle less than 40° or 45° with those on the other the veins are found, close to the apex and generally curve over the anticline to form a saddle.

On the broader folds where the angle is more than 45° the veins are found a greater distance from the axes. As a general rule the veins are most abundant and richest within the limit of the curvature of the strata of the fold. At the apex of the fold the strata are horizontal and the dip increases with distance from the apex until it finally becomes uniform usually at a high angle. It is within this area of increasing dip that is within the area of curvature of the strata, that the veins are found.

Most of the veins lie in slate beds a few feet wide and are generally conformable with the strata but occasionally they pass from one wall to another.

Corrugations appear on some of the inter stratified veins usually

near the apex of an anticline and run parallel to the axis of the anticline.

Sometimes a part of a vein takes on a roll which is generally richer than the rest of the vein. Position of roll determined by some peculiarity of rock structure.

Thickness of veins vary from a fraction of an inch to 24" but the great greater number are not over an inch, but some reach a thickness of 20'.

The largest veins are usually found on sharp anticlines.

Each lead has a peculiarity of its own which distinguishes it from other leads in the same area.

Important, cross or fissure veins are the Libby and Liepsigate. The Liepsigate has a length of 9000' and varies in width from 12"-50".

Seldom does a cross vein lie in a fault plane.

Many of the main veins give off branches; which pass into the hanging and foot walls. These branches are called angulars. Their distribution and attitude depend entirely on the rock structure.

Veins occur that may cross or be inter-stratified with slates and which are composed of coarse crystalline quartz carrying no gold values. These are known as"Bull" veins.

Ore Distribution

Although some of the richest ore, mined has been found in pockets at the intersection of angulars with the main lead, the great proportion of ore occurs in shoots having a definite boundary and direction.

As a rule pay shoots are composed of rolls, that is, where there is some irregularity in size, form, and structure.

It has been found that there is some order to distribution of the pay shoots and Faribault revealed that a linear arrangement of the out-

cropping pay shoots, occurs in nearly every district.

Frequently the distribution of ore shoots depends upon subordinate crumples or flexures of the strata, and is consequently never the same for any two districts.

Pay Zone

Certain facts point to the existence in most districts of zones extending to an indefinite depth in which a succession of auriferous quartz veins of similar character and extent lie superimposed one above the other.

The above and numerous other relations led Faribault to expound the Pay Zone theory which states;--

The subordinate flexures and peculiarities of structure upon which the distribution of pay shoots depends, extend to an unknown depth and it is claimed that inter bedded veins and pay shoots would succeed one another with depth so long as the structures dontinue the same as those which produced the ore shoots at the surface. These structural conditions generally extend in depth parallel to the axial plane of the dome. Thus a pay zone is produced that coincides on the surface with the area over which the pay shoots outcrop, and which extends parallel with the axial plane of the dome to an indefinite depth.

Although the hypothesis may be of fairly general application it is not claimed to hold for all particular cases.

The hypothesis was put to a successful test at the Bluenose mine Goldenville.

Genesis

During the folding of the strata there was slipping between the beds. The slipping produced openings along the bedding planes which

were widest at the apex of a fold. During, or subsequent to the opening solutions induced vein filling. This shows the dependence of vein distribution on rock structure. On closely folded domes the arching of the rocks produced fissures passing over the apex and down each limb. On the broad domes the arches were not strong enough to sustain themselves and the fissures were formed only on the limbs.

Origin of the Mineralizing Solutions

There have been three different opinions as to the origin of the mineralizing solutions.

1. That they were deposited from descending solutions.
2. That they were dissolved out of the country rock.
3. That they were deposited by ascending solutions.

Little evidence has been found to support the first and of the second and third, the last is the one which is most generally held.

Gilpin[1] expounds the second theory and points out the fact that it is only the slate beds which carry the pay streaks and that this might be brought about by currents circulating within the beds during their formation.

The third is held by Faribault and others from the general character of the veins. The ascending solutions found a passage upward through the fractured portion of the domes as well as the fracturing across and along the bedding.

Age of the Veins

The source of the solutions is not definitely known and the age of the mineralization is still an open point.

The granite intrusives of the area are considered to be of two different periods but are both classes as Devonian.

Some field relations suggest the veins to be earlier than the granite. If this were true the trend of events would be opposite to those which have taken place in similar districts.

There necessarily must be some source from which the veins can originate. As there is no known source, older than the granite, it seems probable that this might be the source. The conflicting field relations may be dur to the two periods of intrusion; the earlier one, of which was gold bearing and the later, which cut the veins.

As both intrusions of granite are classes as Devonian it seems rather likely that the veins are of this general age.

Description of Producing Districts

Although many districts of Nova Scotia's area have been producers in the past, in later years the number of active districts has decreased until in 1929 only four were producing, there being Renfrew, Beaver Dam, Uniake and Malaga.

In 1930-31 active mining was confined to Goldenville district in Guysborough County and Montague district in Halifax County.

Montague District

Montague district is underlain by the Goldenville formation which forms a long elliptical dome with an axis running N 78° E. The plunge to the east varies from 5°-8° and to the west from 5°-15°-26°. The axial plane of the fold dips north at about 80°.

Faults are neither numerous nor large, one radiating south, from the centre of the dome shows a displacement of 40 feet while a few other parallel faults strike with the strata and dip south at a low angle.

These are in the nature of thrusts.

Deposits

The veins follow the bedding planes and the remunerative ones lie in a zone 600' wide, the northern limit of which is about 500 feet south of the anticlinal axis on that part of the south limb, where the dip varies from 80°-90°.

Some of the most important leads are the Belt, DeWolfe, Twin, Rose and Skerry.

In many pf the leads the pay-shoots dip west at low angles, whereas in others, expecially in the south-west part, the pay-shoots occur at the intersections of angulars with the main lead.

Location

The district lies in the Halifax County about 5 miles northeast of Dartmouth, across the harbour from Halifax, from which it is accessible by wagon road.

In the early history of the district there were many companies in the field. In 1923 the Clarke Gold Mines Corporation, acquired nearly all the properties in the district and continued operations on the Skerry lead.

In 1928 work again was carried on with the Skerry.

Faribault says of the Lawson, Annand, Rose and Twin leads;

"Although there is reason to believe the limit of the pay zone has not been reached at the depths to which they have been mined, it is probable that in some of them the limit of high grade ore is near at hand.

The zone of rich streaks is narrow and parallel with the axis. It dips to the north at an angle of 80° while veins dip south at 80°. Hence the two planes give a diverging angle of 20° and thus limit the

length of the pay streaks on individual veins.

To keep in the pay zone it is necessary to crosscut North when the limit of the pay zone has been reached, and new veins will in this way be opened up, which might be barren on the surface.

It would be advisable to do this in the Annand, Belt and Rose leads.

Goldenville District

Goldenville district is one of the most important in Guysborough County, and lies about two miles west of the town of Sherbrooke, and close to the N. W. arm of St. Mary River.

It is about 90 miles E of Halifax.

The Goldenville formation is exposed here and takes its name from the district.

The anticline runs approximately N. 75° W. and plunges West at angles varying from 0° to 30°.

Although the rock structure appears to be a simple anticline there are very important exceptions to its uniformity.

Several gentle undulations radiate from the main anticline, which play an important part in the ore deposition.

In the east end of the district several small faults occur, the largest of which gives a displacement of 40 to 42 feet on the south side of the fold.

The productive veins, all lie in the stratification planes generally in belts of slate, with walls of quartzite.

On the North the pay-shoots occur along well defined lines, corresponding with the subordinate undulations which radiate from the main anticline.

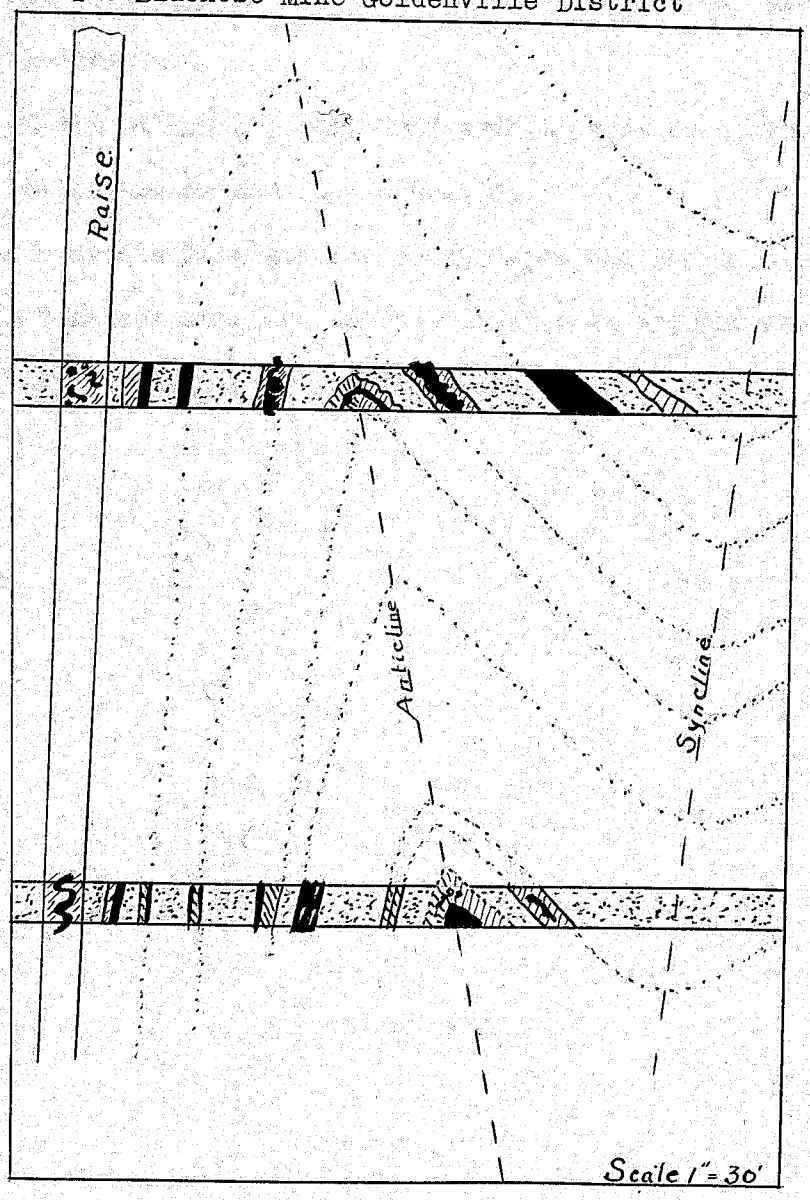
On the South of the fold the pay-shoots run nearly parallel to the

Plate VI

Transverse Section

of

The Bluenose Mine Goldenville District



Slate

Quartzite

Quartz.

axis, receding from it at the west.

Each vein is richest where it has a straight course and vertical dip just near where it begins to curve toward the axis.

In general the pay-shoots dip West, with the plunge of the anticline, approximately 35°. On the south a few dip 35° East and include very rich streaks.

At Bluenose Mine, a series of saddle reefs fold over the apex of the anticline and extend down each limb.

These attain largest size on the apex and decrease until they assume a vertical attitude and then as far as present developments show, diminish but little in size, with depth.

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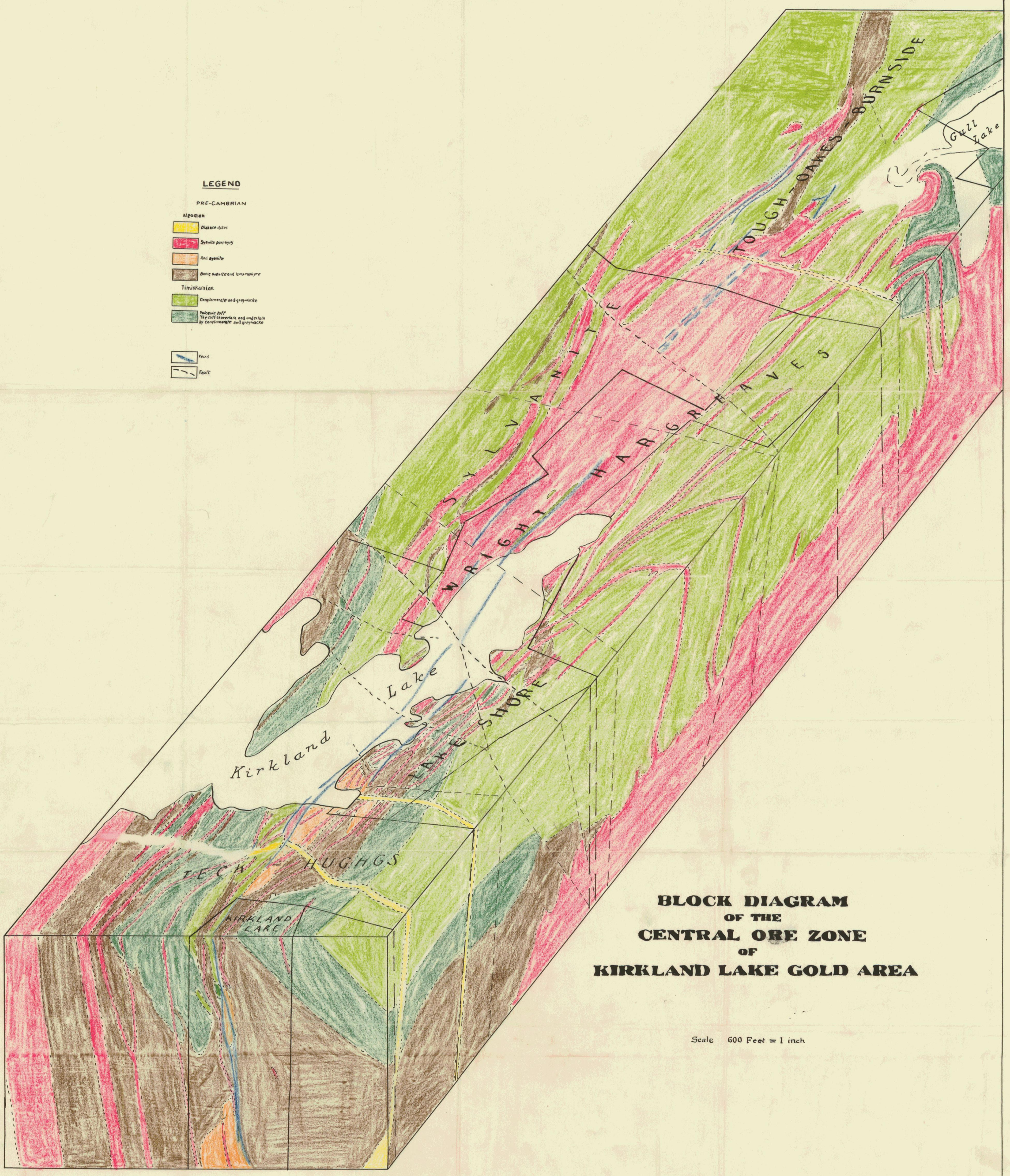

BLOCK DIAGRAM OF THE CENTRAL ORE ZONE OF KIRKLAND LAKE GOLD AREA

Scale 600 Feet = 1 inch