CANADA
DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH
BUREAU OF GEOLOGY AND TOPOGRAPHY

ECONOMIC GEOLOGY SERIES
No. 15

Canadian Lode Gold Areas

(SUMMARY ACCOUNT)

BY

H. C. Cooke

OTTAWA
EDMOND CLOUTIER, C.M.G., B.A., L.Ph.,
KING'S PRINTER AND CONTROLLER OF STATIONERY
1946

Price, 25 cents No. 2476

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PREFACE

This report is a revised edition of Part I of "Gold Occurrences in Canada," two editions of which were issued, the first in 1932 and the second in 1933. Since the latter year the production of gold in Canada has nearly doubled, and corresponding progress has been made in all other phases of the industry's activities. Consequently, the information contained in the two previous reports no longer meets present requirements.

The report does not attempt to give a description of every gold occurrence or producing property in Canada. That is not its purpose. It attempts to bring out the widely differing geological conditions under which gold is found; and such property descriptions as are introduced are brought in to supply the factual basis for the conclusions drawn. It is hoped that thus it will afford to prospectors and exploration and mining companies such guidance as geology can give in the search for new sources of gold; and that it will also furnish those interested in gold production with a knowledge of the history, present situation, and future opportunities of the industry in Canada.

Although statistics are given in the report, they are introduced only for the purposes of giving the reader a conception (1) of the size of the operation, and (2) of the grade of the ore as milled. Detailed statistics of production are furnished by the annual reports of the Dominion Bureau of Statistics on "Mineral Production of Canada." It will be noted also that, with few exceptions, the report does not give figures for the values of gold production. As long as the currency was tied to gold at the fixed rate of $20.67 an ounce, the yield from any mine could be correctly and accurately given in either ounces or dollars. On the other hand, when, after 1930, the number of dollars obtainable for an ounce of gold began to fluctuate, and remained for many years a varying quantity, the dollar value of the output no longer gave a true picture of production, and, accordingly, the unvarying unit, the ounce, has been used in this report.

GEORGE HANSON,
Chief Geologist, Geological Survey.

OTTAWA, January 16, 1946

Lode Gold Occurrences of Canada

INTRODUCTION

Gold is an important part of the national wealth of Canada; in normal times it is, next to wheat, the most important single item of the national economy. In 1940, before war had greatly affected gold mining, 5,311,145 fine troy ounces were mined, with a currency value of $204,479,083.

The Union of South Africa, with the great Transvaal field, has led the world in gold production for many years. Its output, more than 14,000,000 ounces in 1940, and more than 12,000,000 ounces in 1944, is more than double that of any other country. Russia, the United States, and Canada for some years have been rivals for second place. In 1931 Canada took second place, and maintained the position until 1933. It then dropped to fourth place, with the United States and Russia both slightly ahead. In 1939 and 1940, however, Canada's gold production exceeded that of the United States[1], and probably that of Russia, though figures for the latter are merely estimates. During the war years no figures whatever have come out of Russia, and the production of the United States, owing to government regulations restricting the production of gold, fell to about 1,000,000 ounces in 1944.

The following table shows the sources of Canadian gold for 1940, the last year of normal production, and for 1944 to bring out how each was affected by the war.

	1940	1944
	Fine ozs.	Fine ozs.
Siliceous veins and lodes	4,607,452	2,435,796
Copper, silver, and nickel ores	591,370	453,841
Placer deposits	112,320	33,274
Totals	5,311,145	2,922,911

The relative production by provinces, both in normal times and after 4 years of war, is brought out in the following table:

	1940	1944
	Fine ozs.	Fine ozs.
Ontario	3,261,688	1,731,836
Quebec	1,019,175	746,784
British Columbia	617,011	196,857
Manitoba	152,295	74,168
Saskatchewan	102,925	122,782
Yukon	80,458	23,818
Northwest Territories	55,159	20,775
Nova Scotia	22,219	5,840
Alberta	215	51

[1] If production from the Philippines, 1,140,126 fine ounces in 1940, is included, the United States output for that year exceeds Canada's by about 700,000 ounces.

The total gold production of the various provinces from the time when gold mining in each began up to the end of 1944 is as follows:[1]

Province	Production initiated	Fine ounces
British Columbia	1858	16,004,907
Nova Scotia	1862	1,092,641
Ontario	1867	51,811,264
Quebec	1877	10,362,505
Yukon	1886	9,687,164
Alberta	1887	17,722
Manitoba	1917	1,970,234
Saskatchewan	1932	983,828
Northwest Territories	1938	367,489

The figures for total provincial production are probably somewhat low for Quebec and British Columbia. The placers of Chaudière River, Quebec, were estimated by observers to have produced between $2,000,000 and $3,000,000 worth of gold, but no government records appear to have been kept, and no such amounts are included above. Similarly, exact records for the placer gold recovered in British Columbia are hard to obtain, because the placer fields were mostly remote, and except in a few instances were operated by small numbers of men with no fixed abode. It is, therefore, reasonably certain that actual recoveries of placer gold were higher than the official figures.

ECONOMIC IMPORTANCE OF THE GOLD MINING INDUSTRY

The growing economic importance to Canada is shown by the rapid increase in the number of persons employed, and in salaries and wages paid. Each of these items increased about sixfold in the period from 1923 to 1940, as the following table indicates. The effect of war on the industry is brought out by the figures for 1942-4.[2]

Year	No. of employees	Salaries and wages
1923	5,524	$ 8,961,434
1928	9,066	14,615,990
1934	17,762	27,156,887
1938	29,647	50,462,092
1940	31,405	55,205,096
1941	32,551	61,150,810
1942	26,030	54,388,872
1943	19,038	40,665,283
1944	17,226	37,023,505

The employment of labour and payment of wages is, however, only a small part of the story, for the industry, by its need for machinery, timber, fuel, explosives, transportation, and a thousand other supplies, sends its roots ramifying throughout the whole structure of Canadian life. The relative proportions of the parts into which the returns from gold mining are divided may be illustrated by the following results of a special survey made by the Bureau of Statistics in 1937. Although the survey has not been repeated since that time, the relative proportions of the different items, except taxes, remain about the same. The effect of increased taxes is primarily to reduce the amounts distri-

[1] All statistics in this volume are those of the Dominion Bureau of Statistics, except where otherwise intimated, and are for the amounts of refined gold. Many production figures in the older provincial reports are larger than those of the Bureau of Statistics, and appear to be weights of crude gold, dust, or bullion.

[2] The figures are for the auriferous quartz mining industry only; they do not include either the placer workings, r'; he base metal mines, both of which yield much gold.

buted as dividends; it may also increase the cost of supplies, and thereby reduce still further the amounts available for dividends.

In 1937 the gold mines (excluding placers and base metal mines) yielded 3,283,795 ounces of gold and 668,590 ounces of silver, with a total currency value of $122,676,105. The industry employed directly 29,140 persons, with a total wage bill of $48,219,318. Power and fuel costs amounted to $7,345,401; explosives, chemicals, and other supplies to $16,230,722. The railroads got $2,411,127 in freight and express charges; and various forms of insurance, including group insurance and workmen's compensation, took $2,626,222 more. These costs, which total $76,800,000, are 62·7 per cent of the gross production, all of which goes directly to Canadian wage earners and Canadian industry. To them properly should be added another $13,100,000, which was spent on mining and milling machinery, building materials, and other items charged on the books against capital rather than earnings. The mines paid out $38,827,609 as dividends, much of which, perhaps the larger part, went to Canadian shareholders. The remainder, $7,016,356, went in great part for direct taxes (Dominion, Provincial, and local).

Although a relatively small proportion (45 per cent) of miners are married[1], and those that marry average only 1·6 children, nevertheless the bakers, butchers, bankers, coal dealers, theatre employees, doctors, lawyers, clergymen, and policemen required to minister to their needs and wants bring up the number of direct "dependents" to 2½ persons per miner. As the number of employees in 1937 was 29,140, the total population directly supported by the gold mines would be 102,000 persons. Not only did the miners' wages, $48,000,000, directly support all these persons, but, as they eventually found their way back to the primary and secondary producers, the farmers, millers, manufacturers, fishermen, and lumbermen, they indirectly helped to support a fairly large number of the Canadian people. In addition, the amounts distributed to the shareholders, $38,000,000, also flows from their pockets into the ordinary channels of trade; and the amounts collected as taxes lighten the load that would otherwise have to be borne by the ordinary taxpayer.

GOLD MINING AND DEPRESSION

Gold mining differs from every other business in that it is stimulated during times of depression. Countries like Canada with large gold supplies have thus within themselves a stabilizing influence that preserves them at such times from descending to the economic depths into which less fortunate countries are plunged. At such times the manufacturer, hard pressed for customers, finds the gold mines in the market for increasing amounts of mining machinery, explosives, and chemicals. Their need for more lumber and mine timber gives assistance to the lumberman who sees his other markets melting away. Power companies, facing losses in other directions, find the gold mines demanding more power; and the labourer, who has vainly tramped the country in search of work, finds employment conditions in the mining towns better than ever.

The reason for this unusual behaviour is, of course, the fall in the prices of commodities in a time of depression; so that the costs of mining decrease while the value of the product remains; or, to put it another way, the value of gold in terms of other commodities increases. The great depression that began in the autumn of 1929 was thus an immense stimulus to gold production, not only in Canada but in all countries. Many countries, including Canada, ceased exchanging their currencies freely for gold, with the result that those buying gold had to give more currency for it. The process culminated in

[1] Mining in the National Economy; The Staff, Dominion Bureau of Statistics, Ottawa; Trans. C.I.M.M., vol. 40, pp 453–61 (1937).

January 1934 when the United States officially fixed the price of an ounce of gold at $35 in its currency. Canadian currency late in 1939 fell in value 10 per cent below that of the United States, thus valuing the ounce of gold at $38.50 in Canada, whereas labour and commodities continued to be paid for with their former quantities of currency.

The increased price of gold afforded enormous stimulation to the gold mining industry. The working mines could now mine ores of lower grade than before, at a profit, so that the life of the mines, with the employment they give, was lengthened. Many deposits formerly too low in grade for profitable operation became active mines, around which flourishing settlements have grown up, with consequent extensions of roads, railroads, and industrial plants. The tempo of search for new deposits was quickened, and many discoveries made. Altogether, the number of gold mines, which in 1929 was only 38, by 1940 had risen to 149. Approximately half of these succumbed to the strains of war; only 74 produced gold in 1944. With the end of the war, interest in gold mining has once more revived; many mines closed during the war are reopening, and a host of new discoveries promises to raise the number of mines to a new high. The results obtained by the renewal of prospecting have been particularly good in northwestern Quebec, in the Red Lake area of western Ontario, in the Snow Lake section of northern Manitoba, and in the Yellowknife area of the Northwest Territories. Consequently, these areas are now (February 1946) being very intensively prospected by diamond drilling as well as by the more ordinary methods. The preliminary results already obtained seem to indicate that some, at least, of the properties tested will give rise to mines, the continued development of which will bring increased growth and prosperity to the whole of Canada.

GEOLOGICAL TERMS AND PHRASES

Geological studies have proved that the rocks of the earth's surface are divided into two main classes, *igneous* and *sedimentary*.

Igneous rocks are those that have solidified from a molten condition. They originated in the hot, inner parts of the earth's body, and rose to their present positions through openings of some sort. Those that reached the earth's surface are called *volcanic* rocks, and those that did not reach the surface but solidified at some distance below it are termed *plutonic*. The volcanic rocks are named according to the percentage of silica they contain. Those with the highest amounts of silica are the rhyolites; then, with decreasing proportions of silica, dacite, trachyte, andesite, and basalt. In some volcanoes explosions took place that hurled into the air great quantities of lava in the form of boulders, pebbles, and dust. When such fragmental material settled it formed beds of volcanic ash or tuff. Coarse, bouldery tuffs are often termed agglomerates.

The plutonic rocks are also classified according to their composition. Those highest in silica are termed granite; then in order of decreasing silica content, granodiorite, syenite, diorite, gabbro or diabase, and peridotite. The granites contain 60 to 70 per cent of silica, the peridotites about 40 per cent. Plutonic rocks are also classified according to the size and shape of the masses. Huge, irregular bodies are called batholiths and smaller bodies with at least rudely circular outlines are stocks or plugs. Long, narrow bodies, filling more or less vertical cracks in the earth's crust, are dykes; similarly shaped bodies that lie almost flat, particularly if they parallel the bedding of surrounding sediments, are sills.

The sedimentary rocks are consolidated gravels, sands, and muds. These materials were laid down mainly on lake- and sea-bottoms in rather thin, flat beds. As other beds formed on top of them, the loose materials were compressed and the separate grains became cemented together by the silica or carbonate of lime contained in the water that bathed them. Thus they became rock, and formed conglomerate, sandstone, shale, or limestone according as the original material was gravel, sand, clay, or lime mud mixed with shells.

After the rocks, either igneous or sedimentary, were formed, many things might happen to them. Movements of the earth's body lifted new-formed sediments above sea-level, and often, after a longer or shorter time, sank them again. Most of the surfaces of all our continents have been at one time or another below sea-level, and some parts many times. In these movements the rocks were cracked, forming joints. More extreme stresses frequently broke the rocks, and forced one part of the earth's crust to move past the adjoining part, perhaps only a few inches or feet, but in some cases for miles. Such fractures are termed faults. Intense pressures from the sides caused the rocks, though hard and brittle, to bend like rubber, forming folds. That part of a fold in which the beds are convex upward is an anticline; that part where the beds are concave upward is a syncline. Where pressure, or pressure and heat, were extreme, the original minerals of the rock were recrystallized to other minerals to form a metamorphic rock, such as a schist, slate, or gneiss. In many instances recrystallization of this sort occurred locally along the plane of a strong fault and the band of schist thus formed is called a shear zone.

In any quarry or cutting in sedimentary rocks, beds may be observed lying one above the other; and as these beds are merely consolidated sands, muds, and so on, it is obvious that any given bed must have been laid down later than one that lies below it. Only a comparatively few beds can be seen in any one cutting or outcrop; but by carefully tracing recognizable beds through other neighbouring outcrops, beds that do not appear in the first cutting can be found, and proved to lie either above or below the beds in that cutting. This is called determining the succession of the sedimentary beds, i.e., the order in which they succeed one another; and the task of determining the correct succession of the beds over the earth's surface is one that has occupied the attention of geologists for about 140 years. Before that time geologists had no means of making certain that the bed of sandstone or shale studied in one cutting was the same as that studied in the next, half a mile away. About 1794, however, William Smith, a famous British geologist, made the suggestion, since fully borne out by study, that the fossil remains of plants and animals found in sedimentary beds are characteristic of these beds; i.e., that one bed will everywhere contain a certain fossil assemblage, but that an earlier or later bed will contain a different fossil assemblage. This discovery gave geologists a means of following any given bed or series of beds from outcrop to outcrop, and the determination of the sedimentary succession has since gone rapidly forward.

This work has proved that the sediments on the earth are divisible into many thousands of beds, although only a limited number occur in any one locality. It has also proved that the deposition of beds was not a continuous process, but that after a number were laid down, deposition would be interrupted by some movement of the earth's body, as already mentioned. This movement might raise a given area above the sea, so that no sediments could be formed on it for a longer or shorter period; or it might fault or fold the rocks previously formed. It was further discovered that the larger movements extended over wide areas, over a great part of a continent, and in some instances over two or more continents.

The sedimentary rocks, with their fossil records of life, may be thought of as a great volume from which the earth's story can be read. The smallest subdivision of a volume is the individual line; that of the sedimentary rocks is the individual bed. A larger or smaller group of lines forms a paragraph, which is separated by a brief interval from the next. Similarly, a larger or smaller number of beds group themselves naturally into what is termed a formation, which exhibits some natural separation from formations above and below. Paragraphs are gathered into chapters, separated from one another in a more pronounced manner than the paragraphs; in the same way, formations fall naturally into larger units, the systems; and the systems are commonly separated, one from the other, by moderately long and large movements of the earth's body. Chapters are grouped into books, between which there is commonly a considerable gap in continuity; and in exactly the same way the systems form assemblages separated by intervals of great disturbance such as mountain building. These greater subdivisions of earth history are known as geologic eras.

Geologic time is divided into four such eras, and each of these again into several periods, which is the name applied to the time necessary for deposition of a system of rocks. The various eras and periods are shown in the following table in order of succession, the oldest at the bottom. Specialists in the subject carry subdivision much farther, but this is unnecessary here.

Geologic Time Table

Era	Period or system	
Cenozoic	Recent	Modern
	Pleistocene	
	Pliocene	Tertiary
	Miocene	
	Oligocene	
	Eocene	
	Paleocene	
Mesozoic	Cretaceous	
	Jurassic	
	Triassic	
Palæozoic	Permian	
	Pennsylvanian	Carboniferous
	Mississippian	
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	
Precambrian	Proterozoic	
	Archæan	

Because fossils are lacking in the Precambrian, it is difficult to determine the succession of strata when dealing with large districts, and, therefore, no wholly satisfactory method of subdividing Precambrian time has yet been devised. However, one general subdivision is almost universally recognized between groups of Proterozoic (late Precambrian) age, and other groups of Archæan (early Precambrian) age. In Ontario and western Quebec the Archæan strata consist very largely of volcanic rocks, and it has been customary to refer to these collectively as the Keewatin series. Groups of early Precambrian sediments that in various districts overlie the Keewatin with some unconformity are often spoken of as the Timiskaming series. The Keewatin rocks and the sedimentary beds are highly folded in all known localities, and invaded by granites and other plutonic rocks, the whole forming a complex much older than the Proterozoic. The latter consist of a number of groups that in Ontario pass under the name of Huronian, Animikie, and Keweenawan. The Huronian strata are the oldest of these groups and the Keweenawan the youngest.

To some readers it may seem an economic waste, a useless expenditure of energy and money, to absorb the lifetime labour of hundreds of men merely to establish the succession of the sedimentary rocks. This, however, is not the case. Isolated individuals of private means might have taken up this study for no other reason than to satisfy a scientific curosity; but few geologists have been thus economically independent. A compelling economic reason must, therefore, lie behind the expenditure of thousands and hundreds of thousands of dollars for geological work, by governments, universities, private companies, and individuals; and this reason is found in the intimate connection that exists between the rocks and the mineral deposits in them. The more there is learned of mineral deposits, the clearer it becomes that they have definite and restricted age relationships, are limited or localized by structural features such as faults or folds, and in very many cases are so closely related to some given rock that it is useless to search for them very far from that rock. Relatively insignificant expenditures on geological work, therefore, save immense sums that would otherwise be wasted in unprofitable mining or prospecting operations, and for this reason governments and individuals gladly pay for geological work.

Lode gold deposits are of two general types, fissure veins and replacement deposits. A fissure vein, as the name implies, is any fissure in the rock that has been filled with vein materials. Closely allied to the fissure veins are the shear-zone deposits, which consist of numerous rather narrow veins in the schist of a shear zone, so that the deposit as a whole consists of veins alternating with thin layers of schist.

It is obvious that solid materials filling narrow cracks must have been introduced either as liquids or gases; and there are many facts indicating that most of them entered as liquids, or solutions, of which water was a large constituent. These are commonly spoken of as the vein-forming solutions and their sources have been the subject of much study and speculation. The commonly accepted view is that they originally were constituents of molten igneous rocks; and when these cooled, and the rock minerals crystallized from them, the more liquid constituents were set free and escaped. One of the more striking proofs of this conception is found in the vast clouds of steam that rise from active volcanoes, and the deposits of sulphur, iron, and minerals of various kinds formed in volcanic craters by the escaping gases.

In replacement deposits the vein-forming solutions have not merely filled a fissure with vein matter, but have penetrated the surrounding country rock and replaced the original rock minerals with new minerals, partly by recrystallization, but mainly by addition of the new materials carried by the solutions. The reasons that some solutions merely fill fissures, whereas others penetrate the pores of the rock and react with the rock minerals, are not yet thoroughly understood; possibly the first type of solution is more glutinous, the second more aqueous, with a greater power of penetration. Probably, also, the second type of solution contained chemically active constituents that were absent from the first type. There seems to have been little difference between the temperatures of the two types.

Whatever the cause, the result has been to convert large bodies of rock into masses of vein materials mixed with more or less unaltered rock material. Where the rock was greatly sheared or broken in the beginning, very large bodies of ore may have been formed. Nearly all the large gold mines of Canada and most of the large mines of other metals were formed in this way.

Most Canadian lode gold deposits have been formed at moderately high temperatures, between 300 and 500 degrees Centigrade or 600 and 900 degrees Fahrenheit. The temperature of formation of mineral deposits is determined, roughly, by the character of the minerals present in them. By the study of large numbers of mineral deposits, of the deposits of hot springs, and of the emanations from volcanoes in cases where temperatures can be directly determined, by determining the minerals formed in smelter slags, and by numerous laboratory experiments, a great deal of information has accumulated concerning the conditions of heat, pressure, and moisture required for the formation of most minerals. Some of them form only within rather narrow limits, and these are particularly valuable evidence of the conditions prevailing when they crystallized. Such minerals are known as high-temperature minerals, low-temperature minerals, contact-metamorphic minerals, and so on.

GOLD-BEARING REGIONS

The great part of the gold of Canada comes from the Canadian Shield, an immense area of Precambrian rocks extending from the Labrador coast westward almost to the mouth of Mackenzie River. The area of the Shield is roughly 1,825,000 square miles, almost half of all Canada. It includes almost all of the province of Quebec north of St. Lawrence River, two-thirds or more of the province of Ontario, the greater part of Manitoba, parts of northern Saskatchewan and Alberta, and most of the Northwest Territories. From the Shield has come all the gold produced in Ontario and Manitoba, and most of that produced in Quebec. About 70 per cent of the total Canadian output of gold has been derived from the Shield, and about 92 per cent of the present annual production is from that source. These figures merely emphasize what has been recognized for many years, that the Canadian Shield is not only our present greatest reservoir of the precious metal, but in all probability the most fruitful region for discovery of new deposits.

The deposits of the Shield are of two main types, namely, siliceous deposits (quartz veins, replacements, etc.), from which most of the gold up to the present has been won, and sulphide deposits, which afford a small but rapidly increasing proportion.

The second great source of gold in Canada has been the western or Cordilleran section, comprising British Columbia and Yukon. The placer of British Columbia was the first gold of importance to be mined in Canada; and mining operations have since continued without interruption. To the end of 1944, the Cordilleran region has produced about 25,692,071 fine ounces of gold, or approximately 28 per cent of Canada's total. Much of this amount, however, is placer gold. Placer production, which in the heyday of the Yukon had been more than 1,000,000 ounces annually, fell off greatly in the twenties to a low, in 1927, of 38,131 ounces. It remained at about this level until 1930, then began to rise, at first slowly, then more rapidly, to a peak in 1939 of 125,369 fine ounces. During the war placer production fell off steadily, and in 1944 was only 33,218 ounces.

The lode deposits of British Columbia first began producing in 1893. From 1900 to 1931 a reasonably steady output was maintained, ranging from 120,000 to 250,000 ounces annually. Most of this gold came from complex sulphide ores. In 1929 work ceased in Rossland district, and the rich ores of the Premier mine approached exhaustion, so that lode production in 1931 reached the lowest point since 1921, 146,328 ounces. About this time, however, attention became directed to the possibilities of the auriferous quartz veins of the province and with the stimulus of the increased price of gold these were vigorously developed. Results up to 1940 were quite astonishing, as the following table on annual production shows; but, as elsewhere, output fell off during the war years.

Year	Thousands of ounces
1931	146
1932	183
1933	220
1934	276
1935	367
1936	417
1937	462
1938	559
1939	587
1940	584
1941	573
1942	448
1943	229
1944	187

The third principal area for gold deposits is the hilly Acadian region extending through the Eastern Townships of Quebec into Gaspe, New Brunswick, and

Nova Scotia. Up to the present, gold has been found only in Nova Scotia and the Eastern Townships, particularly in the basin of Chaudière River, but there seems no reason that other discoveries may not ultimately be made. In the Chaudière basin placer deposits were mined extensively between 1875 and 1885, and sporadically since. The source of the placers was undoubtedly the quartz veins of the district, none of which, up to the present, has been found large enough, or rich enough, to mine. In Nova Scotia mining commenced as early as 1862 and still continues. Its best years were 1896 to 1902, when the annual output was about 30,000 ounces. The gold occurs in quartz veins following the bedding planes of folded quartzites and slates; the veins are widest at the summits of anticlines, and in many cases narrow or even disappear on the flanks. This peculiar shape has given them the name of saddle reefs.

DEPOSITS OF BRITISH COLUMBIA

With a few exceptions, the known lode gold deposits of British Columbia are in Mesozoic rocks, and are considered to be genetically related to the great granitic bodies termed the Coast Range intrusives, or to other intrusives of about the same age. The veins occur both in the granitic rocks themselves and in the more or less altered Triassic and Jurassic strata penetrated by them. The veins are presumed to represent a late stage of the differentiation of these granitic rocks. The gold may occur free, or associated intimately with sulphides.

In the following pages brief descriptions are given of the various properties and districts that are now producing gold or have produced it in the past. Mention is also made of some known occurrences not yet in the producing stage. The districts are numbered, and the numbers correspond with those on Figure 1, in which the solid dots indicate areas or mines that have produced considerable gold, and the hollow circles those that have yielded comparatively little. It will be noted that occurrences are concentrated in the southern part of the province, perhaps because ore-bearing intrusives are most numerous there, but more probably because that section is more thickly populated and easier of access.

Annual Production of Gold from British Columbia[1]

Year	Placer Fine ozs.	Lode Fine ozs.	Total
1858	34,104	....	34,104
1859	78,129	....	78,129
1860	107,806	....	107,806
1861	128,973	....	128,973
1862	128,528	....	128,528
1863	189,318	....	189,318
1864	180,722	....	180,722
1865	168,887	....	168,887
1866	128,779	....	128,779
1867	120,012	....	120,012
1868	114,792	....	114,792
1869	85,865	....	85,865
1870	64,675	....	64,675
1871	87,048	....	87,048
1872	77,931	....	77,931
1873	63,166	....	63,166
1874	89,233	....	89,233
1875	119,724	....	119,724
1876	86,429	....	86,429
1877	77,796	....	77,796
1878	61,688	....	61,688
1879	62,407	....	62,407
1880	49,044	....	49,044

[1] Figures compiled and supplied by the Dominion Bureau of Statistics.

Year	Placer Fine ozs.	Lode Fine ozs.	Total
1881	50,636	....	50,636
1882	46,154	....	46,154
1883	38,422	....	38,422
1884	35,612	....	35,612
1885	34,527	....	34,527
1886	43,714	....	43,714
1887	33,558	....	33,558
1888	29,834	....	29,834
1889	28,489	....	28,489
1890	23,918	....	23,918
1891	20,792	....	20,792
1892	19,327	....	19,327
1893	17,228	1,132	18,360
1894	19,617	6,047	25,664
1895	23,301	37,988	61,289
1896	26,317	60,187	86,504
1897	24,841	106,964	131,805
1898	31,122	111,093	142,215
1899	65,059	138,236	203,295
1900	61,858	167,058	228,916
1901	46,929	210,363	257,292
1902	51,913	236,470	288,383
1903	51,298	232,810	284,108
1904	53,953	222,022	275,975
1905	46,890	238,639	285,529
1906	45,879	224,007	269,886
1907	40,054	196,162	236,216
1908	31,299	255,559	286,858
1909	23,075	227,245	250,320
1910	26,122	235,264	261,386
1911	20,608	217,888	238,496
1912	26,872	224,943	251,815
1913	24,671	272,788	297,459
1914	27,332	225,398	252,730
1915	37,249	236,127	273,376
1916	28,082	191,551	219,633
1917	23,994	109,748	133,742
1918	15,480	164,683	180,163
1919	13,859	153,393	167,252
1920	10,719	114,089	124,808
1921	11,281	139,511	150,792
1922	17,647	189,723	207,370
1923	20,320	179,820	200,140
1924	21,037	224,682	245,719
1925	13,181	206,046	219,227
1926	16,730	209,136	225,866
1927	7,353	175,741	183,094
1928	6,739	189,878	196,617
1929	5,158	149,046	154,204
1930	7,164	157,167	164,331
1931	13,741	146,328	160,069
1932	16,320	182,684	199,004
1933	19,142	219,853	238,995
1934	20,145	276,051	296,196
1935	24,744	366,889	391,633
1936	34,711	417,227	451,938
1937	43,322	462,535	505,857
1938	46,207	559,410	605,617
1939	39,797	587,173	626,970
1940	32,128	584,883	617,011
1941	35,020	573,183	608,203
1942	26,323	448,016	474,339
1943	11,680	229,666	241,346
1944	9,402	187,455	196,857
Totals	4,124,952	11,879,957	16,004,909

Lest too much confidence be placed in the foregoing imposing columns of figures, it may be observed that the statistics, particularly the older ones of placer production, represent little more than intelligent guesses at the probable output. It is well known that placer gold formed the common currency of the mining districts in those days, and passed freely from hand to hand at fixed valuations per ounce. Inspection of the older reports of the British Columbia Minister of Mines shows that the valuations varied a good deal; gold from one creek might be valued as low as $15.50 an ounce, that from another as high as $18.60. The valuations presumably represented the average assays of the gold from the creek in question. Eventually most of the gold came into the hands of the banks, and was exported by them to the outside world; they reported the amounts to the British Columbia Government in dollars, calculated as aforesaid; and these figures have been used, both by the British Columbia Department of Mines and the Dominion Bureau of Statistics, to calculate the weights of gold extracted. The former organization, up to and including 1924, used $20 an ounce for purposes of calculation; the latter, $20.67. From 1925 onwards the British Columbia Department of Mines has published the placer production in crude ounces; from 1925 to 1933 the value was estimated at $17 an ounce on the average, but since 1934 the average value in Canadian currency has been given to it. The Dominion Bureau of Statistics, for the same period, has used the provincial figures, estimating 10 ounces of crude gold as equivalent to 8 ounces of fine gold.

Though obviously there is some room for error in the above methods of calculation, the real errors lie elsewhere. Numerous placer miners, after making their pile, left the country with their dust and nuggets, and it is impossible to make more than the crudest estimate of such amounts. For the years 1853 to 1878, it was supposed, the amounts thus unrecorded were one-third of the known returns; from 1878 to 1895, and from 1898 to 1909, the proportion was estimated at one-fifth; and from 1910 to 1925, one-tenth. These fractions were added to the annual returns, and the whole published correctly, in the first place, as "estimated production"; but the tendency of late years has been to drop the "estimated", thus giving the figures a specious appearance of accuracy.

For recent years the figures are approximately correct partly because most placer operations are carried on by a few large operators, and partly because export of gold from the country by individuals is forbidden.

(1) ATLIN DISTRICT

The Engineer mine is in Atlin district, at the northwest corner of British Columbia, on the east side of the Coast Range. The rocks are shales and greywackes of Mesozoic age, some of them tuffaceous in origin. They strike north 60 degrees west and dip about 35 degrees northeast. The sediments are cut by many acidic dykes. Both sediments and dykes are broken by numerous small faults, with displacements ranging from a few inches to 10 feet. The fault fissures are filled with quartz and other vein minerals.

Some of the veins are very large, and composed mainly of quartz with intercalated layers and fragments of country rock. Several are as much as 50 feet wide. In addition, there are two areas, described as being the "hubs" of the vein systems, 200 and 270 or more feet in width, respectively, and 300 or 400 feet long, of quartz and brecciated country rock. Other vein minerals include calcite,

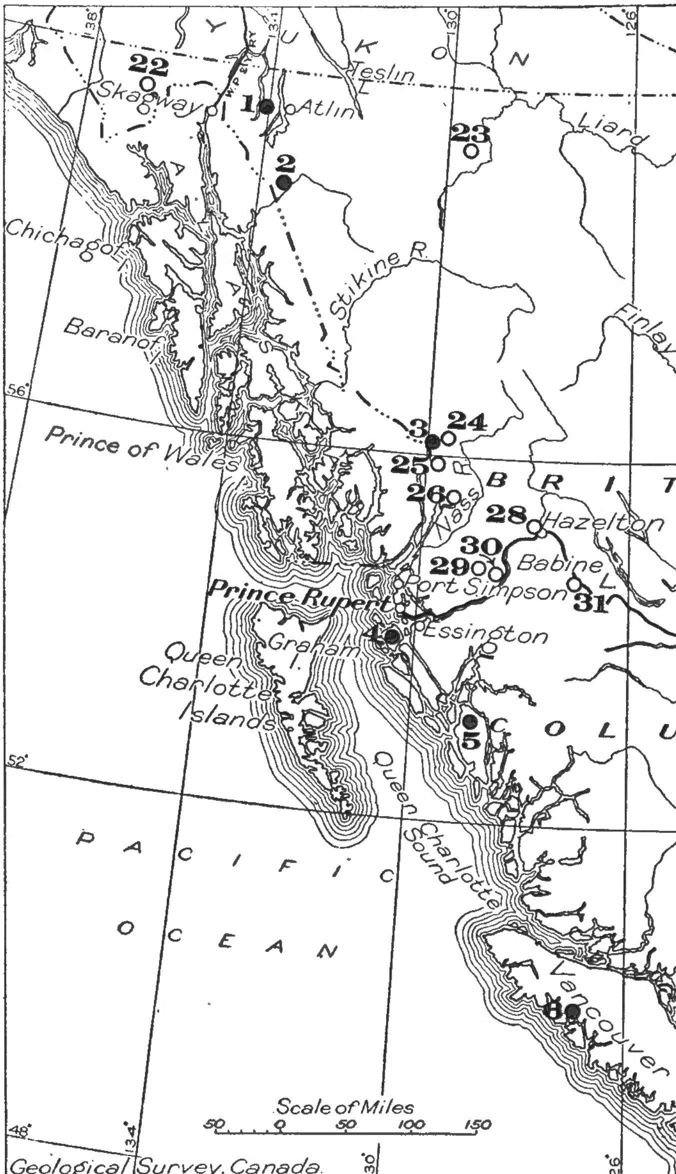
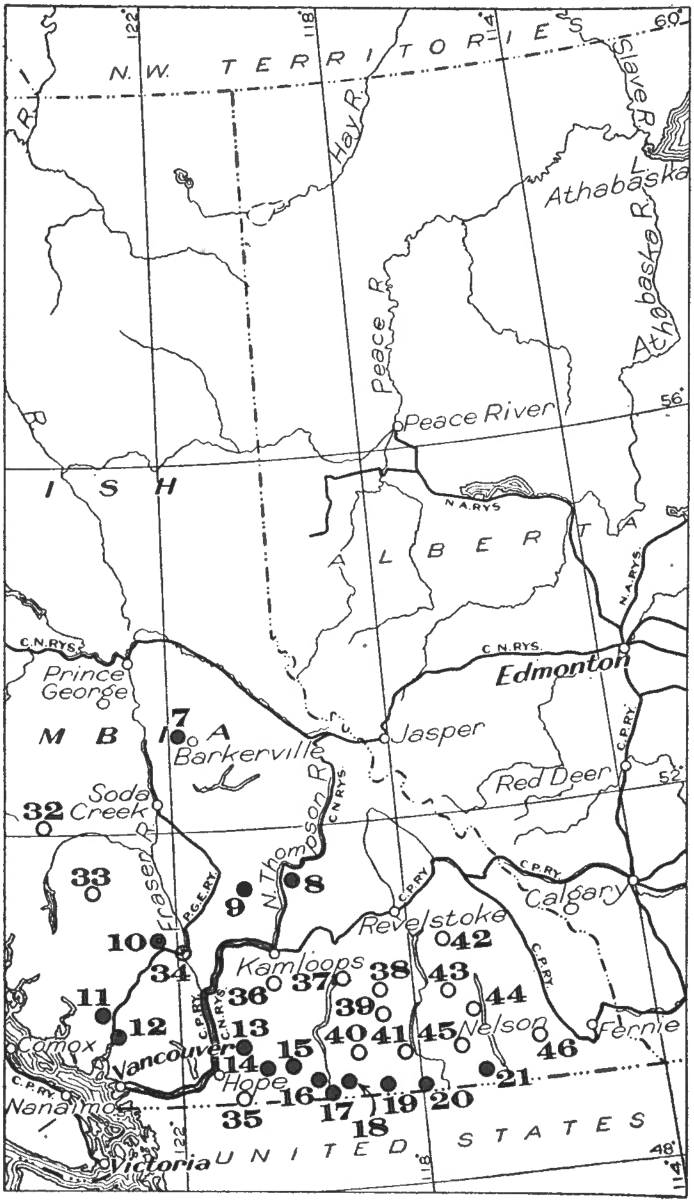


Figure 1. Index map of British Columbia, showing principal known occurrences of gold. 1, Atlin; 2, Tulsequah or Taku River; 3, Salmon River; 4, Porcher Island; 5, Princess Royal Island; 6, Zeballos; 7, Cariboo; 8, North Thompson River; 9, Vidette Lake; 10, Bridge River; 11, Squamish River; 12, Howe Sound; 13, Hope; 14, Copper Mountain; 15, Hedley; 16, Fairview; 17, Osoyoos; 18, Camp McKinney; 19, Greenwood-Grand Forks; 20, Rossland; 21, Ymir-Sheep Creek; 22, Rainy Hollow; 23, McDame Creek; 24, Bear River;



25, Marmot River; 26, Alice Arm; 27, Queen Charlotte Islands; 28, Hazelton; 29, Kitsumgallum; 30, Usk; 31, Smithers; 32, Tatla Lake; 33, Taseko Lake; 34, Lillooet; 35, Skagit River; 36, Stump Lake; 37, North Okanagan; 38, Monashee; 39, Lightning Peak; 40, Beaverdell; 41, Franklin; 42, Lardeau; 43, Slocan; 44, Ainsworth; 45, Nelson-Slocan City; 46, Cranbrook.

pyrite, and a little antimony. Gold occurs native and as telluride, along with the vanadium-bearing mica, roscoelite, in very rich pockets in the narrower veins where intersected by cross fissures. On account of the pockety nature of the occurrences, the mine has never been an important producer.

(2) TULSEQUAH (TAKU RIVER) DISTRICT

The Polaris-Taku Mining Company, operating northwest of Taku River near the Alaskan boundary, did not commence milling until October 15, 1937, but produced 89,311 ounces of gold from 329,037 tons of ore treated before it closed in April 1942. The rocks are hard, massive andesites and silicified andesitic tuffs in bands ranging from 300 to 500 feet wide, alternating with bands of soft phyllite and schist, which were probably more argillaceous tuffs, having widths of 100 to 200 feet.[1] The bands strike about north 65 degrees west and dip steeply south. The principal vein follows a contact between greenstone on the foot-wall and schist on the hanging-wall, and averages 8 feet in width, with a range of 2 to 25 feet. In addition, there are numerous "transverse veins", striking from north 10 degrees west to north 60 degrees east. These are narrower than the main vein and occur only in the hard, massive greenstones, dying out where they intersect the soft schists. The vein material is arsenopyrite, pyrite, stibnite, and gold in a gangue of quartz, calcite, and ankerite. The sulphides are extremely fine-grained and form 4 or 5 per cent of the vein materials. The gold is either in solid solution in them or in very fine intergrowth, as no gold is visible even in rich specimens.

The ore seems to be a product of several periods of mineralization. The first seems to have been an intensive replacement of the country rock along fractures by carbonates and fuchsite, with some silica and pyrite. Then the arsenopyrite and pyrite, with most of the gold, were introduced, replacing the carbonated rock. A succession of injections followed, of quartz, carbonates, or both together, accompanied by some sulphide but no gold. Fault movements and shattering recurred several times during the period of mineralization.

(3) SALMON RIVER DISTRICT

This district contains two important properties, of which one, the Big Missouri, operated by the Buena Vista Mining Company, entered production in March 1938 and closed in October 1942. In that time, 56,946 ounces of gold were recovered from the milling of 822,021 tons of ore, an average grade of 0·07 ounce a ton. The rocks are rudely stratified, volcanic fragmental types with northerly strikes and moderately steep dips to the west. Certain beds, perhaps because of their greater porosity, appear to have served as channels for ore-bearing solutions, and are now well silicified and pyritized, with local enrichments of sphalerite and a little galena. Such silicified zones range from a few feet up to 400 feet wide. In themselves they are too low in grade to be ore, but they are cut by numerous narrow quartz veins and calcite veins that in general parallel the strike of the beds. These veins have been injected at several different periods, and some of the younger carry much free gold, part of it very coarse. The value of the ore as a whole appears to depend on the number and richness of such veins.

Silbak-Premier Mines is an amalgamation of the original Premier mine, now practically exhausted, with the B.C. Silver and Sebakwe properties. The Premier mine may be considered as representative of the gold-silver ores of British Columbia, as well as their most outstanding example. Development on this famous bonanza began in a small way in 1918; and it yielded, up to

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[1] Sharpstone, D.C.: The Development and Geology of the Polaris-Taku mine; B.C. Miner, vol. 11, No. 11, pp. 49–51 (Nov. 1938).

December 31, 1935, 1,402,187 ounces of gold and 35,172,966 ounces of silver[1], together with some lead and copper. This was obtained from only 2,823,089 tons of ore, an average of nearly ½ ounce of gold and 12·4 ounces of silver a ton.

Since amalgamation, effective January 1, 1936, the combined properties have produced 326,358 ounces of gold and 5,755,002 ounces of silver from 1,391,492 tons of ore, to the end of 1944.

The veins of the Premier mine occupied fracture zones that cut a complex of andesitic tuffs and agglomerates intruded by dykes, sills, and irregular masses of granodiorite porphyry. The veins were wider and of higher grade in the brittle porphyries than in the easily sheared and relatively impermeable tuffs. The main fracture system ran north 50 degrees east, dipping 50 to 75 degrees northwest, but at the southwest end it swung to a course nearly due northwest. In the part around the bend mineralization was particularly wide, and the northeast arm of the fracture system, together with the part at the bend, was the section from which practically all the ore came. This ore-bearing section, on Premier ground, was about 1,600 feet long.

The ores appear to have been formed to some extent by the secondary enrichment of a leaner primary ore, through the agency of downward-percolating waters. The uppermost 300 feet, or, locally, 600 feet, of the orebody was a dark-coloured mixture of heavy sulphides, accompanied in places by considerable silica, though more commonly by little. The main part of this mixture was pyrite, the normal colour of which was masked by admixture of galena, sphalerite, ruby silvers, tetrahedrite, polybasite, and other silver compounds; native silver and electrum were also locally present in considerable amount. Below this upper zone partly enriched by secondary agencies, the ore was a heavy, granular pyrite, carrying small amounts of other minerals, particularly sphalerite, and a little silica. Certain shoots of limited extent carried large quantities of galena. Gold values in this material were relatively high in the upper parts, but gradually decreased with depth, although there was no visible change in the appearance of the ore, until, at a depth of about 1,200 feet, the tenor became too low for mining.

(4) PORCHER ISLAND

On the northwest side of Porcher Island, near Surf Point, there are a number of claims carrying small gold-quartz veins in quartz diorite[2]. They appear to lie close to the original roof of a protuberance, or cupola, pushed up presumably from the main Coast Range batholith into the Triassic (?) Prince Rupert formation, which occurs nearby, and consists of much altered greenstones. The veins strike easterly to northeasterly, and vary in width from a few inches to 4 feet. They appear to occupy joint planes, and, therefore, may be erratic, have great variations in width, and die out rapidly. Some, however, show evidences of shearing, and, accordingly, are more continuous. In composition they vary from pure quartz, without gold values, to heavily pyritized quartz, which may carry 3 ounces or more to the ton. The Surf Point mine was the only property commercially operated. It was brought into production in 1933, and up to the end of 1938 yielded 17,244 ounces of gold, and a little silver, from 32,401 tons of ore. The property went into liquidation in 1939.

(5) PRINCESS ROYAL ISLAND

The Surf Inlet mine is on Princess Royal Island, about a mile east of Bear Lake, or 7 miles above the head of Surf Inlet. It was operated on a large scale

[1] These figures are taken from the Annual Reports of the Premier Gold Mining Company, and are somewhat higher than the figures in the Annual Reports of the Minister of Mines for British Columbia.
[2] Dolmage, V.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 27, 28. Rept. of the Minister of Mines for British Columbia, 1934, pt. B, p. 6.

from 1917 to 1926 by Belmont-Surf Inlet Mines, Limited, and in that period yielded 322,297 ounces of gold, 176,734 ounces of silver, and 5,244,772 pounds of copper with a total value of nearly $8,000,000, from 836,500 tons of ore. It was reopened in 1936 by Surf Inlet Consolidated Gold Mines and closed again in November 1942. In that time it produced 64,302 ounces of gold from 166,546 tons of ore.

A steep-sided, east-west valley is crossed by a large shear zone striking north 3 degrees east, in which the veins occur. The Surf Inlet orebodies lie north of this valley, the Pugsley orebodies south of it. During the earlier period of operation most of the ore was drawn from the Surf Inlet properties, but since reopening the bulk of the ore has come from the Pugsley.

On the Surf Inlet claims, the deposit consisted at the surface of two veins of pyritized quartz 100 to 160 feet apart, one on each side of the large shear zone. Their width in general was about 10 feet, though they widened in places to nearly 40 feet. The greatest length on any level was 1,000 feet but was commonly much less, and not all of it was ore. The orebodies raked to the south at about 45 degrees. The veins dipped 40 to 60 degrees west, and came together to form one large vein at a depth of about 550 feet. The country rock is mainly quartz diorite of the Coast Range batholith, but the shear zone also cuts through a large mass of chlorite schist included in the batholith, and the veins were somewhat richer in the schist than outside of it. The vein materials consisted of quartz with considereable ankerite, and became ore where sufficiently mineralized with auriferous pyrite, which in places composed up to 25 per cent of the vein material. Native silver, chalcopyrite, and small amounts of other copper minerals were also present. The veins contained numerous strips and angular blocks of country rock, some of which were so highly silicified that only shadows of the original block remained. This suggests that the vein-forming solutions were fairly hot, a conclusion confirmed by the presence of a few veins carrying feldspars and biotite.

On the Pugsley claims to the south, conditions are apparently similar, but the veins are considerably narrower and the ore-shoots correspondingly smaller and somewhat lower in grade.

(6) ZEBALLOS DISTRICT

Zeballos district lies on the west coast of Vancouver Island, just north of the 50th parallel of latitude. Small though rich gold showings there have been known for some years, but attracted no particular attention until 1936, when further discoveries caused a rush into the area.

The rocks consist of a band of granodiorite some 12 miles long, striking northwest, about 2 miles wide at the southeastern end, and widening to 4 miles at the northwestern. On the south this band is flanked by the Bonanza group of andesites and more acid lavas, with much associated breccia and tuff and some interbedded sediments. To the north it is bordered in part by the same rocks, and in part by the Quatsino group of limestones. All the surficial rocks are probably Triassic in age. The important discoveries to date have been found in the narrow southeastern end of the granodiorite band, and in the lavas and tuffs south of the same part.

The productive veins are usually less than a foot in width, and strike between 50 and 80 degrees east of north. They do not appear to change in any way when they pass from granodiorite into volcanic rocks. Though narrow, the veins are very rich and fairly continuous. The vein matter is quartz, with a little calcite in places, and pyrite, arsenopyrite, sphalerite, galena, chalcopyrite, and pyrrhotite. Some veins appear to have formed in open fissures, as the quartz has grown in crystals at right angles to the walls, with open vugs at the centre. In other veins the quartz appears to have been fissured and recemented so as to form a compact material. Pyrite is moderately abundant, and in some veins forms massive bands with the other sulphides. The gold is mostly free and very finely divided, though beautiful specimens of very coarse gold have been found.

All the mines of Zeballos district were forced to close during the war. The principal properties, their periods of operation, and the production of each, are shown in the following table:

Name	Operated	Tons milled	Gold, ozs.
Privateer	1937–1943	136,997	141,582
Mount Zeballos	1939–1942	56,813	30,402
Spud Valley	1939–1942	103,985	53,519
Central Zeballos (Reno Gold Mines)	1938–1941	28,589	13,363
White Star	1940–1942	1,008	4,376
Homeward	1941–1942	1,884	1,491

(7) CARIBOO DISTRICT

In Barkerville district, Cariboo mining division, the Cariboo Gold Quartz Mining Company began milling in January 1933, and the Island Mountain Mines Company in November 1934. In the period 1933 to 1941 production of the former increased annually, from 19,769 tons in 1933 to 129,256 tons in 1941; in all, 830,968 tons were treated to the end of 1944, with a gold recovery of 331,751 ounces. The output of Island Mountain, on the other hand, has been fairly uniform; up to the end of 1944, 397,275 tons were milled, recovering 177,001 ounces of gold, with minor amounts of silver. Both companies suffered severely during the war.

A third company, Cariboo Hudson Gold Mines, operated from November 1938 to July 1939 and recovered 4,013 ounces of gold from 13,492 tons of ore milled.

The orebodies of this district are mostly quartz veins in sedimentary rocks, with some replacement bodies. The sediments, supposedly Precambrian in age, have been named the Cariboo series. They strike northwest, with dips of about 45 degrees to the northeast. The series is made up of three formations, and all the veins occur in the lowest of these, the Richfield, which outcrops as a band between 1 and 2 miles wide. The Richfield formation has been subdivided into five members, and it is found that most of the veins, including all those yet known to be mineable, lie within the fourth or Rainbow member, and in the adjoining basal part of the uppermost Baker member. Practically all the veins are thus concentrated in a band ranging from 900 to 1,500 feet in horizontal width.

The beds of the Rainbow member are mainly argillites, argillaceous quartzites, and quartzites, with a few thin beds of limestone. Individual beds can be projected for very short distances, as they change rapidly in composition along both the strike and the dip. The change is always from more quartzitic on the southeast to more argillaceous on the northwest, suggesting that the source of the sediments was to the southeast.

The beds of the Rainbow member have been much fractured, apparently by relatively small stresses, and the fractures filled by quartz veins. Argillaceous quartzites, if not strongly sheared, contain the most fractures, but quartzite and argillite also fractured well.

Most of the veins strike approximately at right angles to the beds, have maximum widths of about 6 feet, and are steep or vertical. A peculiarity of the fractures, highly important in conducting the search for ore, is that a fracture rarely continues from one bed into another of dissimilar type. Thus a fracture, strong in argillite, fades rapidly on entering a quartzite bed above or below; one strong in quartzite fades on entering argillite. This peculiarity caused much trouble in the early days of mining, because a vein found on one level was sought on the next on the projected dip of the vein, whereas, if it carried through, it would be found off to one side, on the projected dip of the bed in which it lay. On account of the peculiarities just described, most of the veins are less than 150 feet in horizontal length, though they may attain 200 feet. A smaller number of veins cut the strata at a smaller angle, striking from east to north 70 degrees east. These diagonal veins are much like the transverse type, but are generally longer, horizontally, because they cut the strata at an angle. The longest is about 300 feet. Mining has proved, however, that although individual veins do not extend far, the number of fractures is always about the same, so that the amount of ore to be expected is fairly constant. This is a feature of great importance in planning development.

The veins are of quartz, and those with good gold values contain much coarse pyrite, up to 50 per cent of the vein matter. The cubes of pyrite may be as much as 1 inch to the side. Some arsenopyrite, and a little sphalerite, galena, and lead-bismuth sulphide, are also present. The gold is free, and ranges in size from coarse nuggets to minute specks. Some beds, particularly limestones, are mineralized for a short distance from the vein, thus increasing the mineable widths.

A second type of ore has been formed by the replacement of a few thin limestone beds by sulphides. Replacement may be partial or complete. The replacing minerals are the same as those of the veins, i.e., mainly pyrite, with some arsenopyrite and minor amounts of chalcopyrite, sphalerite, galena, and gold. A little scheelite is also present. In contrast with the sulphide of the veins, the massive ore is very fine-grained, but it becomes much coarser where replacement has been incomplete. The largest body of this type is found in Island Mountain mine.[1] It is a bed about 300 feet long, ranging in thickness from a few inches to 9 feet.

(8) NORTH THOMPSON RIVER DISTRICT[2]

This district exhibits a single, but most unusual, type of gold occurrence. A sill-shaped, intrusive body a mile or more in width and some miles long strikes north. On the east side it consists of pyroxenite; on the west or upper side of a coarse sort of pegmatite, made up of large crystals of orthoclase and albite, with much micropegmatite. Though it seems likely that the variations in composition have been produced by differentiation of a single body of magma, this has not been definitely proved.

On the Windpass claim, 1½ miles east of Dunn Lake, the micropegmatite is cut by a quartz vein striking east and dipping 35 to 80 degrees north. The vein ranges in width from a few inches to 3 feet, averaging about 18 inches. The quartz has been much fractured, and contains minor amounts of pyrite, chalcopyrite, and gold, with grains of native bismuth and gold telluride.

Going east, the character of the vein is found to change gradually. It becomes less quartzose and less regular, passing finally into a series of disconnected lenses of magnetite carrying high values in gold.

This vein and a somewhat similar one on the Sweet Home claim to the south have been worked since 1934 by the Windpass Gold Mining Company. Production up to the end of 1939 was 33,026 ounces of gold from 81,206 tons of ore milled. Only 298 ounces of gold were produced in 1940, from an unstated tonnage of ore, and nothing since.

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[1] Hanson, G.: Barkerville Gold Belt, Cariboo District, B.C.; Geol. Surv., Canada, Mem. 181 (1935).
Benedict, P. C.: Structure at Island Mountain Mine, Wells, B.C.; C.M.M. Bull. Dec. 1945, pp. 755–70.

[2] Uglow, W. L.: Geology of the North Thompson Valley Area, B.C.; Geol. Surv., Canada, Sum. Rept. 1921, pt. A, pp. 72–190.

(9) VIDETTE LAKE DISTRICT[1]

Vidette Lake area is about 28 miles due north of Savona, a village at the lower end of Kamloops Lake. It lies within a plateau of flat-lying Tertiary basalts, through which Deadman River has cut to expose a long, narrow area of the underlying Triassic greenstones, known as the Nicola series. The area thus exposed strikes northwest, and is perhaps a mile wide and several miles long; but the economically important section lies around Vidette Lake, at the head of Deadman River.

The fine-grained, massive greenstones are cut by a series of quartz veins striking northwest and dipping 45 to 70 degrees northeast. The veins are rarely more than 15 inches wide, and are mineralized with pyrite, some chalcopyrite, tellurides, and native gold. The pyrite was introduced first, then intensely crushed, after which the other minerals were deposited.

Vidette Gold Mines, the only producer, commenced milling in April 1934, and from then until the end of 1939 obtained 28,256 ounces of gold, with considerable amounts of silver and copper, from the treatment of 50,890 tons of ore. The company went into liquidation in April 1940, after producing 972 ounces of gold in that year.

(10) BRIDGE RIVER DISTRICT

Bridge River district is at present the most important gold producer of British Columbia. It includes the two largest gold mines of the province, Bralorne and Pioneer, as well as two smaller mines, Wayside and Minto. In additions, there are many promising prospects, and much geologically favourable ground.

The principal deposits are veins lying in or near elongated, somewhat sill-like, intrusive bodies, to which the name "Bralorne intrusives" has been applied. These are mainly augite diorite, throughout which small masses of highly siliceous soda granite are irregularly distributed. Some of the masses are merely irregular patches, others may be roughly dyke shaped. Some contacts with the diorite are sharp, and the granite appears to be intrusive; others are gradational. The northwesterly striking intrusive mass containing the Bralorne and Pioneer mines has an unusually large proportion of this granite, which mainly forms a band along the northeast side, and widens in depth at the expense of the more basic augite diorite.

Although the granite is thus definitely later than the augite diorite and in places intrusive into it, much evidence points to the conclusion that the two are differentiates of a single magma, and that the intrusive relations were caused by movements occurring while the granite part, at least, was still fluid.

It is probably more than coincidence that the gold-bearing quartz veins are largest and richest in the body of the intrusive containing the most granite; and that the quartz of the veins closely resembles the quartz of the granite in its "dusty" appearance, due to the presence of innumerable little cavities, many of which are filled with liquid and contain a gas bubble. Such cavities characterize quartz formed at fairly high temperatures and pressures. Tentatively, therefore, it is concluded that the quartz veins represent the last stages of the differentiation of the igneous magma; and, conversely, that the best prospecting ground lies in masses of intrusive containing a fairly large proportion of the soda granite.

The Bralorne and Pioneer properties are on an elongated mass of the Bralorne intrusives lying west of Cadwallader Creek about 5 miles south of its junction with Bridge River. The mass is 2½ miles long, with a maximum width of 1,600 feet; the southeastern end is Pioneer ground, the remainder Bralorne. Most of the veins strike easterly, ranging from a few degrees north of east to a few degrees south of east, and dip north at angles ranging from 55 to 80 degrees.

[1] Cockfield, W. E.: Vidette Lake Area; Geol. Surv., Canada, Mem. 179, pp. 26–36 (1935). Also report of the Minister of Mines for British Columbia, 1936, pt. F, p. 36.

A few veins strike north or somewhat west of north, and dip steeply west. All the veins are in fault fissures produced by deformation of the sill. Veins end rather abruptly against a mass of serpentine on the southwest side of the sill, but in some cases extend a longer or shorter distance into the country rocks northeast of it. The main Pioneer vein, in particular, has been followed more than 1,000 feet into the overlying greenstone.

Veins range from a few inches up to 20 feet in width, and consist of quartz mineralized with native gold, gold telluride, and a sprinkling of pyrite and arsenopyrite. Other sulphides occur sparingly. Much of the quartz is in parallel ribbons averaging about an inch wide, the ribbons separated by films of chlorite or gouge. If the quartz is split along one of these films, the face thus laid bare is commonly found to be striated, indicating that the ribboning has been caused by fault movement. The best values occur in quartz thus ribboned or otherwise fractured by fault movement; the tenor of unsheared quartz is low.

The wall-rocks for distances ranging from a few inches to 10 feet from a vein are altered to a yellowish or whitish product with a greasy feel, a mixture of sericite, carbonates, and residual quartz. It carries crystals of pyrite and arsenopyrite, but no gold.

The Pioneer mine was operated on a small scale from 1914 to 1917, during which bullion to the value of $135,000 was produced. It was reopened in 1925, but in the 5 years from 1925 to 1929 yielded only 26,881 ounces of gold. In the next 5 years production rose rapidly to more than 87,000 ounces annually, but then began to fall off due to lowering of grade with depth and, of late years, to war disturbances. Bralorne was brought into production in 1932, although its predecessor, the Lorne property, yielded a small amount of gold. Annual production figures for these mines are shown in the following table.

Annual Production, Pioneer and Bralorne Mines

Year	Pioneer		Bralorne	
	Ore, tons	Gold, ozs.	Ore, tons	Gold, ozs.
1944	16,865	9,111	109,751	70,350
1943	26,435	11,261	118,462	73,817
1942	79,624	40,563	171,095	90,817
1941	109,311	53,645	191,970	101,063
1940	77,585	42,923	191,412	101,282
1939	88,009	43,570	184,922	104,862
1938	123,304	58,271	180,526	103,867
1937	130,864	61,335	170,686	83,081
1936	145,847	69,407	167,264	63,829
1935	135,647	87,700	145,113	47,023
1934	130,198	87,536	98,664	45,971
1933	100,159	82,519	....	25,779
1932	50,000	38,705	....	21,835
1931	32,300	28,153	....	....
1930	29,000	18,067	....	....
1929	....	5,061	....	....
1928	....	7,730	....	....
1927	....	5,979	....	....
1926	....	4,580	....	....
1925	....	3,531	....	....

The Wayside mine lies about 6½ miles due north of Bralorne, on another small stock of augite diorite and soda granite. The geological features are much like those already described. A 100-ton mill was installed late in 1935, and in that and the following year produced 5,216 ounces of gold from 40,228 tons of ore. Operations then ceased.

The Minto mine is about 4 miles east-northeast of the Wayside, and is geologically unlike those described in the preceding paragraphs. Ancient sediments and greenstones (Permian ?) striking north to northwest with steep dips are intruded by a fine-grained basic dyke some 20 feet wide. A strong fault follows the edge of the dyke for some hundreds of feet, and a fairly regular vein 3 to 4 feet wide lies in this part of the fault. Where the fault leaves the dyke to pass into less competent rock, the vein becomes irregular and discontinuous. In the vein, bands of quartz with some calcite alternate with bands of heavy sulphide. The latter is generally coarsely crystalline and includes arsenopyrite, pyrite, and sphalerite, with small amounts of several others. The property began to produce in 1934, and closed in December 1937. In that time 16,977 ounces of gold were won from 83,824 tons of ore.

(11) SQUAMISH RIVER DISTRICT

The only property in this district that has been brought into commercial production is that operated by Ashloo Gold Mines. In the period 1936 to 1939, 6,323 ounces of gold were obtained from 15,029 tons of ore. According to press reports, ore was exhausted in 1939. The following statements have been gleaned from the Report for 1935 of the Minister of Mines of British Columbia.

The rocks are a rather dark, basic granodiorite cut by dykes and irregular masses of lighter coloured, coarse-grained granite. A rather narrow band of dark, fine-grained, basic rock, highly altered, transverses the granodiorite, but whether it is an inclusion, an altered dyke, or the granodiorite itself altered along a shear zone, is not clear. A shear zone appears to follow it, however, and quartz irregularly mineralized with pyrite, chalcopyrite, and in places pyrrhotite occurs in it. The distribution of the quartz ranges from discontinuous small stringers and irregular patches to a strong vein 5½ feet wide. Gold values fluctuate with the percentage of sulphides and appear to be associated with pyrite rather than with chalcopyrite. Little or no values are found where sulphides are absent. The "vein" strikes somewhat east of north and dips 23 degrees west.

(12) HOWE SOUND DISTRICT

The Britannia mine, operated by the Britannia Mining and Smelting Company, is a large producer of copper—more than 33,000,000 pounds in 1938—but gold is a profitable by-product of the operation. Production for years has ranged from 11,000 to 14,000 ounces annually; in 1938 it was 12,449 ounces. In 1939, for no apparent reason, the gold yield rose to 22,238 ounces, although the amount of ore handled was about the same. No returns for the war years have been published.

(13) HOPE DISTRICT[1]

In 1928 much interest was aroused by the discovery of gold in talcose seams in serpentine at the Aurum property, lying about a mile north of Verona on the Kettle Valley Railway. The serpentine, with associated lavas and tuffs, forms a belt more than 10 miles long and half a mile to a mile wide, striking a little west of north. The serpentine, before alteration, was apparently intrusive into the other rocks, and cuts across bedded contacts. The gold lies in a talcose shear of very irregular shape that follows the eastern contact of the serpentine body. This shear or seam ranges from a foot to several feet thick, and the rock within it exhibits all gradations from dark green serpentine to talc. It is thought that the talc formed by the interaction of the serpentine with the silica of the vein-forming solutions. The fact that very little quartz occurs along with the other vein minerals seems to support the conclusion.

The ore occurs in small but very rich pockets, separated by long lengths of barren talcose seam. In the pockets, arsenopyrite and pyrrhotite are abundant, with small amounts of other sulphides. Gold commonly occurs as polished films

[1] Cairnes, C. E.: Geol. Surv., Canada, Sum. Rept. 1929, pt. A, pp. 148–157.

over slickensided surfaces of serpentine and talc, but may also form plates, thin wedges, or solid prongs up to one-eighth inch or more in thickness. In places, roughly corrugated beads of gold are scattered sporadically through massive talc; in others, gold forms grains, wires, or leaves between thin, plate-like masses of arsenopyrite.

Although no body of ore large enough to make mining profitable has yet been found, the unusual nature of the occurrence warrants its description.

(14) COPPER MOUNTAIN

Copper Mountain, operated by the Granby Consolidated Mining, Smelting, and Power Company, is primarily a copper mine, but produces some gold as a by-product. The mine was not operated during the years 1930-36, but was reopened in 1937 and came into full production in 1938. In that year 8,730 ounces of gold were recovered, together with 214,676 ounces of silver and 29,652,613 pounds of copper. The proportion of gold to other metals is roughly the same as that obtained in its previous years of operation.

(15) HEDLEY DISTRICT[1]

The deposits of Hedley district are, in the main, on Nickel Plate Mountain, in Osoyoos mining district of southern British Columbia. The largest property was the Nickel Plate mine, which was worked from 1903 to 1930, and in that time produced, roughly, $11,000,000 in gold. With gold at $20.67 an ounce, the old price, this figure corresponds to about 532,000 ounces. Accurate figures cannot, unfortunately, be given, as many of the old production reports give the returns only in dollar values.

The deposits lay idle from the end of 1930 to December 1, 1934, when milling was resumed under the operation of the Kelowna Exploration Company. An independent company, Hedley Mascot Gold Mines, also began operations early in 1936 on the Mascot fraction, a small area withheld from the older company. In the period 1935-44, the Kelowna Exploration Company has milled 811,160 tons of ore and recovered 279,807 ounces of gold, with a little silver and copper. Hedley Mascot, in the years 1936-44, has treated 517,706 tons of ore, which yielded 167,478 ounces of gold and some silver.

The rocks are interbedded quartzites, chert, and limestones of varying purity, striking approximately north and dipping 23 degrees west. They are slightly flexed to form an anticlinal cross-fold plunging slightly north of west; and exhibit numerous small cross-folds, the axes of which do not plunge straight down the dip, i.e., west, but rather plunge northwest. This structure is of importance as it apparently controlled and localized ore deposition. Numerous sills of gabbro-diorite have been injected into the sediments parallel to the bedding. It seems probable that injection took place either during or after the folding; at any rate the sills parallel closely the bedding of the sediments.

The ore-bearing solutions entered the base of one of the minor synclines, from the northwest, and followed the bedding planes upward, at the same time working somewhat south into the axis of the next adjoining anticline. They altered the country rock to various silicates and introduced auriferous sulphides. The gabbro-diorite sills formed barriers, causing the solutions to spread out along their contacts. In this way a series of flat, plate-like masses of ore was formed, with gabbro-diorite along the foot-wall, or the hanging-wall, or both. The other walls of the orebodies are vague and ill-defined, the ore fading gradually into unmineralized country rock.

[1] Bostock, H. S.: Geology and Ore Deposits of Nickel Plate Mountain, Hedley, B.C.; Geol. Surv., Canada, Sum. Rept. 1929, pt. A, pp. 198-252.

The orebodies occur throughout a zone some 2,000 feet long, 350 feet wide, and 215 feet thick. In this zone there are five of the irregular sheets described, overlapping *en échelon*. The maximum thickness of any single orebody is about 65 feet, and its length 500 feet.

The ore-bearing solutions were very hot and converted the siliceous limestones into contact-metamorphic minerals such as garnet, epidote, diopside, tremolite, and axinite. They added large quantities of auriferous arsenopyrite, and small amounts of pyrrhotite, chalcopyrite, pyrite, and zinc blende. The arsenopyrite is massive in places, but more commonly forms 10 to 50 per cent of the volume of the rock.

(16) FAIRVIEW CAMP[1]

Fairview camp lies a short distance northwest of the town of Oliver, in southern Okanagan Valley. The orebodies are quartz veins in a series of mica schists named the Anarchist series. The schists strike northwest and dip fairly steeply northeast, and the veins, as a general rule, follow the schistosity, though cutting it in places.

The veins are quartz, sporadically mineralized with pyrite, sphalerite, and galena. Values appear to be mainly associated with the sphalerite and galena and not with the pyrite; but this rule is not invariable, for sections have been found heavily mineralized with sphalerite and galena, but with low gold values. The ore is in the form of shoots, separated by low-grade sections. In places the wall-rocks have been strongly silicified, yielding widths of quartz up to 30 feet.

There was some production from this camp shortly after 1900, particularly from the Stemwinder claim, but no work was then done for about 30 years. In 1936, Fairview Amalgamated Gold Mines began operations on the Morning Star and Fairview properties, and between that time and the end of 1939 produced 10,681 ounces of gold, and a large amount of silver, from the milling of 109,405 tons of ore. The mine has not been operated since 1939.

(17) OSOYOOS CAMP

The rocks of this camp, which lies near Osoyoos, B.C., are schists of the Anarchist series, as at Fairview and Camp McKinney; but associated with them are some limestone lenses and some altered basic volcanic rocks, also high in lime. The orebodies are typical high-temperature replacement deposits developed in the limestone beds and in some of the volcanic rocks. These have been recrystallized with abundant development of garnet, epidote, diopside, and wollastonite, and heavily mineralized with pyrrhotite, chalcopyrite, magnetite, and some arsenopyrite. The proportions of these minerals vary widely from place to place. The pyrrhotite in general carries low gold values, and it is thought that the gold is mainly associated with the arsenopyrite.

Osoyoos Mines, the only operating company, holds the Dividend, Manx, and Lake View claims. Milling began in 1935, and from that time until it ceased at the end of 1940, 112,891 tons were treated, yielding 14,638 ounces of gold.

(18) CAMP MCKINNEY[2]

Camp McKinney, in Greenwood mining division, was one of the early lode gold camps of British Columbia, with one property, the Cariboo-Amelia, producing more than $1,000,000 in gold, largely between 1894 and 1903. The geology of the area, the nature of the veins, and the relations of the veins to the

[1] Cockfield, W. E.: Fairview Camp; Geol. Surv., Canada, Mem. 179, pp. 1-10 (1935).

[2] Cockfield, W. E.: Camp McKinney; Geol. Surv., Canada, Mem. 179, pp. 11-19 (1935).

country rock are all much like those of Fairview camp, and need not be redescribed. The general strike, however, is west instead of northwest.

(19) GREENWOOD-GRAND FORKS DISTRICT

The rocks of this district are a series of late Palæozoic sediments and volcanics, intruded by granodiorite, quartz diorite, and other igneous rocks, and overlain by Tertiary sediments and lavas. The Palæozoic sediments are chiefly limestones and argillites, and they, together with parts of the associated lavas, have suffered intense silicification, and have thereby been converted into chert and jasperoid. Remnants that escaped silicification, particularly of the limy rocks, then underwent contact metamorphism, with development of garnet, epidote, and minor amounts of actinolite, tremolite, etc. At the same time magnetite, specularite, chalcopyrite, pyrite, pyrrhotite, and arsenopyrite were introduced. Between 1900 and the middle of 1919 there was a large production of copper from this district, with gold and silver as important by-products.

Efforts have recently been made to reopen some of the properties. In 1937 mining was again begun on the Brooklyn claim, at Phoenix, and continued until ore was exhausted in March 1940. Altogether 34,741 tons of ore were extracted, from which were recovered 6,336 ounces of gold, 7,877 ounces of silver, and 494,410 pounds of copper.

In addition to the contact-metamorphic orebodies, quartz veins are common, particularly around bodies of granodiorite. They range from 1 to 5 feet in width, are mineralized with pyrite, galena, sphalerite, and chalcopyrite, and in places assay high in gold. Many of these veins have been worked sporadically, generally by lessees, and the ore shipped to the Trail smelter. Such lots of ore have ranged from ⅓ ounce to 3 ounces a ton in gold, with fairly large amounts of silver and lead.

The Dentonia claim, near Jewel Lake, appears to have been a deposit of this type, and one of the largest producers. Opened in 1934, it was closed again in November 1936, presumably for lack of ore. In that time 66,523 tons of ore were treated, and 19,974 ounces of gold obtained. Production for 1936 was probably reasonably typical. In that year 11,612 tons of ore yielded 4,178 ounces of gold, 27,638 ounces of silver, and 67,647 pounds of lead.

(20) ROSSLAND CAMP

Rossland camp is in the Trail Creek mining division of West Kootenay district, about 6 miles west of Columbia River and 5 miles north of the International Boundary. The deposits were mined principally for gold, although they also yielded large amounts of silver and copper. Production began in 1894, and continued on a large scale from 1897 to 1916, during which time the annual output of gold was about 130,000 ounces. From 1917 to 1921, gold production averaged some 40,000 ounces annually, then fell off rapidly, until in 1927 only 6,625 ounces were obtained. Of late years the principal mines have been shut, but until 1930 a little production was maintained from small, high-grade veins. In 1932 the Consolidated Mining and Smelting Company announced that it would lease parts of the old mines to individuals, and treat the ore obtained at its smelter. Mining under this arrangement began in August 1933, and so much ore was produced in 1934 as to exceed the available smelter capacity. In 1935, accordingly, the company limited the amount it would receive from each lessee to 25 tons a month, and this arrangement was thereafter maintained. Gold production in 1933 was 7,224 ounces; 1934, 25,432 ounces; 1935, weight not stated, value of gold and silver given at $680,000; 1936, 8,528 ounces; 1937, 6,381 ounces; 1938, 6,807 ounces; 1939, 5,915 ounces. The ores mined average about ⅔ ounce gold a ton, and about the same amount of silver.

Prior production of the camp, from 1894 to 1930 inclusive, was 2,868,227 ounces of gold, 3,616,465 ounces of silver, and 118,037,675 pounds of copper.

The Rossland orebodies were replacement veins. Ore-bearing solutions, forced into fissures and sheeted zones, replaced the country rock so as to form tabular masses of rich sulphide ore ranging from a few inches to 130 feet in width, and up to 4,000 feet or more in length. The typical ore consisted of pyrrhotite and chalcopyrite associated with a gangue of altered country rock, some quartz, and calcite. All gradations could be obtained from country rock and gangue sprinkled with sulphides to massive sulphide ore, but in average ore there was from 50 to 70 per cent of sulphides.

The rocks of the area include a series of highly silicified slates and tuffs known as the Mount Roberts formation, sills of augite porphyrite intrusive into the sediments, stock-like masses of granodiorite, a closely related, irregular body of monzonite, and a basic border and dyke facies of the granodiorite known as diorite porphyrite. All these rocks are older than the orebodies, and each influenced deposition in its own manner. In the intrusives, fissures were strong and persistent, so that the ore-bearing solutions were restricted within zones of moderate width and moved freely in those zones; good orebodies were formed as a result. The sediments, on the other hand, were completely shattered by the great dynamic stresses, so that the mineralizing solutions diffused over wide areas instead of being confined to particular channels. Thus no deposits of importance were formed in the sediments. Again, where fissures cut deeply into the granodiorite or monzonite it was found that, although they might remain wide and strong, the ore-shoots became small, low grade, and sporadic in occurrence; and that instead of depositing ore the solutions had silicified the granodiorite and formed such minerals as biotite, epidote, and pyrite. Apparently, therefore, temperatures within these intrusives were too high for ore deposition. The best orebodies were found in the augite and diorite porphyrites and along contacts between the augite porphyrite and the monzonite, granodiorite, or diorite porphyrite. Veins were wider and richer in the diorite porphyrite than in the augite porphyrite, suggesting that the diorite porphyrite was the more easily replaced. Where veins traversed diorite porphyrite they tended to be richer in gold, and where they traversed augite porphyrite, to be richer in copper.

(21) YMIR-SHEEP CREEK DISTRICT

This district produced in 1938 more than 114,000 ounces of gold, and hence is second only to Bridge River district in this regard. This amount came from ten producing properties. Nearly all the ores also yield important amounts of silver, lead, and zinc, and in the three producing properties east of Ymir, namely the Wesko, Ymir Consolidated, and Ymir Yankee Girl, the amounts of the base metals are very large.

Mining began in this district in 1899 and was prosecuted fairly vigorously until about 1916. During that period operations were confined mainly to the upper parts of the veins, which had been enriched by oxidation and leaching. These oxidized zones ranged in depth from a few feet to 500 feet, with a known maximum in one vein of 1,000 feet. The higher costs involved in working the leaner primary ores beneath them made mining unprofitable, and little was done until 1929, when primary ore of good grade was discovered on the Reno property. This caused a revival of interest in the district, which was further stimulated by the rise of the price of gold in 1934. Four of the ten producing properties opened in 1934, three in 1935, one in 1936, and one in 1938.

The rocks of the district are the Windermere series of Late Precambrian sediments, overlain by Triassic (?) volcanic rocks, and intruded by granite, granodiorite, etc., of Mesozoic age. Most of the veins occur in quartzite beds of the Windermere series; these are in small faults that strike east to east-northeast, thus crossing the bedding, which strikes north. Where the fractures pass out of quartzite into schists or other soft rocks, they close and contain little vein matter. Some veins, however, are in the Triassic (?) volcanic rocks—the Second Relief mine is an example—and at least one—the Granite Poorman—is in granodiorite. It would seem, therefore, that the physical nature of the rock, its competency, hardness, or brittleness, has been an important factor in localizing ore deposition.

The veins on the whole are narrow, less than 5 feet, though in places widths up to 20 feet have been found. The gangue is quartz more or less mixed with country rock crushed by the fault movements. Auriferous pyrite, galena, and sphalerite are the principal sulphides.

Since reopening in 1934, Ymir Consolidated Gold Mines has produced, to the end of 1939, 19,654 ounces of gold from 59,306 tons of ore. In 1938, 13,978 tons were treated, yielding 5,481 ounces of gold, 34,938 ounces of silver, 410,274 pounds of lead, and 225,710 pounds of zinc. Milling ceased in August 1939. In the same 6 years, Ymir Yankee Girl milled 218,115 tons of ore, obtaining 64,207 ounces of gold, 312,011 ounces of silver, 5,732,143 pounds of lead, and nearly 5,000,000 pounds of zinc (no figures are available for zinc production in 1935). In 1940, 53,526 tons of ore yielded 10,205 ounces of gold and 55,292 ounces of silver, as well as lead and zinc. The mine was closed in 1942. Wesko Mines, the third operating property east of Ymir, in the period 1936 to 1938 milled 55,802 tons of ore and recovered 11,294 ounces of gold, 87,410 ounces of silver, 1,962,845 pounds of lead, and 791,667 pounds of zinc. There was no production in 1939-40.

The Second Relief mine, operated by Relief Arlington Mines, in the Tertiary (?) volcanic rocks west of Ymir, produced during the years 1934 to 1941, 76,413 ounces of gold and 19,249 ounces of silver from 183,453 tons of ore. The mine was closed in June 1941.

In Sheep Creek district: Kootenay Belle Gold Mines (1934 to June 1943) produced 101,323 ounces of gold, with a little silver, lead, and zinc, from 274,062 tons of ore; Gold Belt Mining Company (1938 to 1943) milled 256,688 tons of ore and obtained 79,168 ounces of gold and considerable silver; Reno Gold Mines (1928 to 1941) recovered 167,140 ounces of gold, with some silver, lead, and zinc, from 270,598 tons of ore; Sheep Creek Gold Mines, operating the Queen mine (1935 to 1944), milled 455,594 tons of ore, which yielded 196,500 ounces of gold and about a third as much silver; the Arlington mine (1935-42) obtained 5,703 ounces of gold from 4,022 tons of ore, together with much silver, lead, and zinc.

The Bayonne property, which has been included for convenience with this group, really lies somewhat east of it, about 17 miles from Kootenay Lake. The veins are in every way like those described, but the country rock is granodiorite. Milling began at this property in November 1936, though small shipments to Trail smelter were made in 1935. Total production, 1935 to 1942, was 40,643 ounces of gold, and considerable silver, from 82,878 tons of ore.

Total output of gold for 1940, from the eight remaining producers, was 100,203 fine ounces.

(22-46) MISCELLANEOUS OCCURRENCES

The occurrences listed under this head are of two types. Some are valuable mainly for their gold, but have either been worked out or have not been proved commercially profitable. In the others gold is merely a by-product in the mining of other metals. The following brief notes are given to indicate the character of each. When references are given, "B.C. 1932" means "Report of the Minister of Mines of British Columbia for 1932".

Rainy Hollow area[1] has some quartz veins carrying free gold, in batholithic masses of diorite. The gold has attracted some attention of late, but the chief metals are copper with some silver.

Bear River and Marmot River areas lie on the eastern contact of the Coast Range intrusives. Gold is a minor constituent of the ores, which are mixed sulphides yielding chiefly lead with good silver values and subordinate quantities of copper and zinc.

Alice Arm is also a silver camp, though some gold has been obtained from the Esperanza mine, and some fairly high gold values have recently been obtained from the Homestake prospect.

On Queen Charlotte Islands was made the first lode gold discovery of British Columbia, in 1852. This property, the Early Bird, is on Mitchell Inlet on the west coast of Moresby Island; it was mined for a time in a small way. Later other veins were found and mined on both Moresby and Graham Islands.

Gold was found on McDame Creek in 1935. Numerous gold-quartz veins are reported, but the area is so remote that its possibilities are not yet known.

Hazelton district is mainly a silver-lead camp, but some silver-copper ores on Rocher Déboulé Mountain carry gold.

In Kitsumgallum district quartz veins have been found carrying gold with considerable sulphides. The veins are small, but values have been sufficient to attract attention.

In Usk district, quartz veins in granite, averaging about 22 inches wide and carrying fair gold values, were developed by Columario Consolidated Mines, but operations were later discontinued. On the Zymoetz claims, quartz veins carrying gold have been found in quartz diorite.

Smithers district is mainly a silver camp, but some bismuth-gold ore and some arsenopyrite-gold veins have been found on Hudson Bay Mountain.

In Tatla Lake district some lode gold prospects have recently been discovered on Blackburn Mountain and Perkins Peak, near the eastern contact of the Coast Range intrusives[2].

Taseko Lake district has been known somewhat longer. Considerable work has been done on the Taylor-Windgate property, and a little gold produced. Copper-gold veins have also been found near the eastern contact of the Coast Range intrusives[3].

In Lillooet district quartz veins on Cayoosh Creek have attracted attention for many years, following the discovery of rich placer deposits at the mouth of the creek. The principal property was the Golden Cache, afterwards called the Bonanza Cache[4]. Much work was also done at the Grange mine on Fraser River, but values did not prove commercial.

In Skagit River district much prospecting has been done on veins carrying mixed sulphides with some gold values.

Stump Lake district has yielded a considerable production of silver-lead-zinc ores with accessory gold values.

In North Okanagan district there has been some production of gold from quartz veins carrying free gold with a little sulphide[5].

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[1] Geol. Surv., Canada, Mem. 77. B.C. 1907, pp. 43-8.
[2] B.C. 1938, pt. F, pp. 29-41.
[3] Geol. Surv., Canada, Sum. Rept. 1928, pt. A, pp. 89-91. B.C. 1935, pp. 17-21.
[4] B.C. 1935, pt. F, pp. 7-9.
[5] Geol. Surv., Canada, Sum. Rept. 1931, pt. A, pp. 74-90.

Beaverdell area, though chiefly a silver-lead-zinc camp, has produced a little gold from copper-gold ores.[1]

On Monashee Mountain, quartz veins are found in volcanic rocks near batholithic instrusives. They carry free gold and sulphides. Monashee Gold Mines, Limited, installed a 25-ton mill in July 1937.

In Lightning Peak area narrow gold quartz veins have been found, on which much prospecting has been done.[2]

Franklin camp has been known for many years. Copper ores of contact-metamorphic types attracted principal attention, but there were three fissure veins carrying galena, sphalerite, pyrite, chalcopyrite, and some gold, in a quartz gangue. One of these, the Union, was mined sporadically from 1913 to 1940.

Lardeau district is chiefly a silver-lead camp, but has produced minor amounts of gold.[3]

Slocan district is also essentially a silver-lead-zinc camp, but some properties have yielded a little gold, commonly only a few ounces, but in a few instances up to 1,000 ounces.[4] Ainsworth camp is of the same character.

In Cranbrook district large and persistent, low-grade quartz veins have been found in the valley of Perry Creek, but none has as yet been proved of economic value.[5]

In Nelson-Slocan City area much prospecting for gold has been done on veins in the Nelson granite.

SUMMARY AND GENERALIZATIONS

A study of the mineral deposits of British Columbia indicates quite clearly that most, if not all, were deposited by waters emanating from the numerous cooling masses of igneous rock so widely scattered throughout the province. For the most part these rocks vary in composition between granite and diorite. The greatest continuous body of them forms the Coast Range, the western quarter or fifth of the province. Other very large bodies occur across the southern part of the province, nearly as far as the western boundary of the Rocky Mountains. Still other masses of varying size are scattered throughout the interior. Only the Rocky Mountains, the eastern range of the Cordillera, contain no batholithic instrusives, so far as known, except one small mass south of Field.

It has been established, chiefly by the work of the last decade, that these great igneous masses are composite, i.e., that they are not the result of a single great period of igneous injection, but that on the contrary they are made up of many individual smaller masses, gradually brought into their present positions throughout a very great period of time. They range in age from late Jurassic or early Cretaceous to early Tertiary. It has not yet been proved that the ore deposits are related to only one or only some of these intrusions; so that for the present it must be assumed that they have an equally great range in age, and may have originated from various cooling igneous masses.

That the ore-bearing solutions given off by these igneous masses had very complex compositions may be inferred from the nature of the ores deposited by them. The minerals of these ores include not only quartz with, usually, some carbonate of lime and iron, but also gold and gold tellurides, sulphides and arsenides of iron, copper, silver, lead, and zinc, together with minor amounts of other metallic and non-metallic constituents. They contrast rather strikingly with the more simple ores of the Canadian Shield, which for the most part are

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1 Geol. Surv., Canada, Prel. Rept. 37-21, pp. 32-4, 36.
2 Geol. Surv., Canada, Sum. Rept. 1930, pt. A, p. 95.
3 Geol. Surv., Canada, Mem. 161, pp. 22-3.
4 Geol. Surv., Canada, Mem. 173, pp. 12-19 (*See* production table).
5 Geol. Surv., Canada, Sum. Rept. 1932, pt. AII, p. 85.

quartz veins carrying gold, with minor amounts of the various sulphides, chiefly iron sulphide.

It might be expected that from complex solutions of this sort different constituents might crystallize out at different stages of cooling; so that, if the solutions were moving through fissures, cooling as they did so, the materials deposited near the source might be quite different in composition from those deposited farther away. As a matter of fact, a study of the mineral deposits of the province as a whole does suggest, in some places, a zonal arrangement of the sort, with gold deposits nearest the supposed source, copper deposits somewhat farther away, and silver-lead-zinc deposits still farther.

Unfortunately for the prospector, to whom such a simple arrangement would be so useful in directing his operations, the situation has been complicated by the fact that in any one area ore-bearing solutions may have risen from many sources and over a long period of time. Such events would, of course, mix the normal zonal sequences so as to render them unrecognizable. Nevertheless, a thorough, careful, and intelligent study of the areal arrangements of known occurrences of ore would, the writer suggests, be of much value in projecting future prospecting.

In the cordillera, the presence of ores in granitic rocks is of moderately common occurrence. In fact, two of the largest gold producers of the region, the Pioneer and Bralorne mines, are working veins in granite and augite diorite; and the veins of Zeballos, the newest gold field, are likewise in granodiorite. A possible explanation of this situation is that the cordilleran instrusives are not yet deeply eroded—some, in fact, are barely unroofed—so that any upper, ore-containing parts still remain.

None of the gold deposits of the cordillera has been proved to extend to great depth, as yet. At the Nickel Plate mine the orebodies did not extend beyond a vertical depth of 1,150 feet. The Rossland deposits bottomed at 1,800 to 1,900 feet, and the Premier mine at 1,200 feet. Pioneer and Bralorne mines, in Bridge River district, have attained greater depths, 3,675 feet at Pioneer below the main adit; a peculiarity explained by C. E. Cairnes as probably due to the veins having formed in a still hot body of scarcely consolidated intrusive, so that the temperature gradient between the upper and lower parts was small. Production at Pioneer, however, has fallen off greatly with increasing depth; and although this may be due merely to the existence of a lean streak, it may also be that the end of the productive ore is near. Cariboo Gold Quartz and Island Mountain, both fairly large producers, have as yet (1938) attained depths of only 1,900 and 1,650 feet, respectively; it, therefore, remains to be seen whether they will prove exceptions to the usual cordilleran set-up. In some instances orebodies bottom because the fissures become too narrow for mining or close entirely. In other instances the nature of the vein fillings change; barren pyrite takes the place of other sulphides; sulphides become smaller in quantity and sparsely disseminated, etc.

It seems likely that this particular behaviour is due to the proximity of the sources of the ores to the original surface. It has been indicated that these sources seem to be intrusive bodies, and few of these are deeply eroded; some, in fact, are barely unroofed. Many of them appear to have risen, before consolidation, within a mile or two of the original surface. If these speculations are correct, ore-bearing solutions in passing upwards from their supposed sources would undergo rapid changes of temperature and pressure; and such changes would cause correspondingly rapid variations in the composition of the materials deposited.

DEPOSITS OF YUKON

There has been only one lode gold producing property that could be termed a mine in Yukon as yet, but two districts of promise may be briefly described.

Freegold Mountain[1] is 28 miles northwest of Carmacks post office, and gold discoveries of two types have been made there. Those of the first type are magnetite bodies that lie within quartzites and schists of the ancient Yukon group of metamorphosed sediments. Though the shape and dimensions of the bodies have not been definitely determined, they are believed to be irregular lenses striking west to northwest, and dipping steeply north. The principal mineral is magnetite, and with it are associated other contact-metamorphic minerals such as specular hematite, garnet, epidote, and actinolite. These minerals were formed, perhaps, by contact metamorphism of calcareous bands in the quartzites. After they formed, mineralizing agents of somewhat different composition introduced quartz, with some pyrite, chalcopyrite, and gold. The quartz and other minerals fill fractures in the magnetite, and in places bands of magnetite one-sixteenth to one-half inch wide alternate with narrow layers of quartz. Limonite, formed by oxidation of iron minerals, occurs abundantly throughout the quartz and magnetite, in fractures and cavities. Rich gold values were found near the surface in this material, associated with the limonite and quartz, but deeper work has been disappointing. Probably the gold has been concentrated at the surface by oxidation of the other materials.

The discoveries of the second type are quartz veins, mainly within or near bodies of granodiorite. The most promising lie in sheared zones that strike 30 to 70 degrees east of north and dip steeply northwest. Typically, such a sheared zone may contain one vein up to 3 feet wide, paralleled by a number of smaller ones, the whole assemblage ranging from 2 to 10 or more feet in width. The quartz is well mineralized with pyrite and arsenopyrite, and carries small quantities of chalcopyrite, pyrrhotite, sphalerite, and galena. Gold seems to be associated mainly with the sulphides, although spectacular specimens of gold in quartz have been found. Tourmaline occurs here and there.

Production from one property, the Laforma group of claims, began on January 16, 1939, and continued intermittently throughout the year, though hampered considerably by lack of water for milling operations, and of other supplies due to poor transportation facilities. During that year 892 tons of ore were treated, from which 1,146 ounces of gold and 75 ounces of silver were obtained. Operations were suspended in June 1940, after obtaining 292 ounces more of gold. When the means of access to the property have been improved and other difficulties solved, the deposit may become a profitable mine, as the vein, though only 1 to 2 feet wide, is rich and extends at least 2,000 feet horizontally and 1,000 feet vertically.

The second locality of promise is a few miles south of Dawson, on Bonanza Creek. A triangle of ground about 4 miles wide is enclosed between Eldorado Creek, Upper Bonanza Creek, and Victoria Gulch.[2] The richest placers of the Yukon were found in these creeks at this locality, but did not extend upstream above it. It is evident the gold must have been carried into the creeks from this triangle. The area, unfortunately, is heavily drift covered, and rises to a height of 1,500 feet above the creeks, so that its exploration will involve an expensive drilling program.

[1] Johnston, J. R.: Geology and Mineral Deposits of Freegold Mountain, Carmacks District, Yukon; Geol. Surv., Canada, Mem. 214 (1937).

[2] *See* Ogilvie sheet; Geol. Surv., Canada, Map 373A.

DEPOSITS OF THE CANADIAN SHIELD

Gold has been found in many places throughout the Canadian Shield from Great Slave Lake southeastward through northern Saskatchewan and eastern Manitoba into western and northern Ontario and western Quebec. In addition to deposits valued solely or chiefly for their gold content, other ores hold the precious metal, as in the case of the nickel-copper ores of Sudbury, the copper ores of Noranda, and the Flinflon sulphide body in Manitoba. Discoveries have been made within areas of varying extent, which in some instances are separated from one another by very broad areas in which no auriferous deposits have yet been found. Most of the discoveries have been made in the more readily accessible areas where, so far as known, general geological conditions are much the same as in the rest of the Shield.

The most productive part of the Shield, up to the present, is the Porcupine-Kirkland Lake-western Quebec section, roughly 200 miles long and perhaps 5,000 square miles in areal extent. This district, within which are the important gold mines of Porcupine and Kirkland Lake, has been producing of recent years approximately two-thirds of the total annual output of Canada.

ALBERTA

No lode gold deposits have as yet been found in Alberta. The small production from that province has come entirely from placer deposits. It is unlikely that Alberta will ever be an important producer, as almost the whole province is underlain by Palæozoic and Mesozoic sediments thousands of feet thick. The extreme northeast corner, however, takes in a small part of the Canadian Shield, and gold deposits are being worked not far to the east of the provincial boundary, on the north shore of Lake Athabaska. Discoveries may yet be made, therefore, in the part of the Shield lying within the Alberta boundary.

NORTHWEST TERRITORIES AND NORTHERN SASKATCHEWAN

The area thus designated extends from the north shore of Lake Athabaska to a line about halfway between Great Slave and Great Bear Lakes. No gold deposits of importance have as yet been found north of this line, and a gap of more than 400 miles separates Lake Athabaska from the next auriferous region to the southeast.

Although river steamers have plied Mackenzie River for many years, the lack of any other form of transportation, except canoes, not only made it difficult for prospectors to get into the region, but rendered it practically certain that any discoveries they might make would be valueless. Hence, the country lay practically untouched, except by fur traders, until the great development of aeroplane transportation that followed the war of 1914-18. In the late twenties several companies were organized to prospect with aeroplane aid, and LaBine's discoveries of rich radium and silver ores on Great Bear Lake, early in 1930, gave the movement tremendous impetus. The rush of prospectors and others into the region resulted in the establishment of regular air services by several commercial companies, who also supplied planes and pilots for special trips. In addition, some mining companies own and operate their own planes. As a result, the region is now readily accessible and important discoveries have been made.

The area, from both the geological and the mining standpoint, may be divided into three sub-areas more or less separated in space, and with differing geology and ore types.

The northernmost or Yellowknife sub-area is northeast of the north arm of Great Slave Lake in the basin of Yellowknife River. The rocks are lavas and tuffs ranging in composition from basaltic to rhyolitic, overlain and in part interbedded with sediments of all types from conglomerate to slate, but mainly impure quartzites. These rocks, known as the Yellowknife group, are intruded by great bodies of granite and more or less metamorphosed around the contacts to knotty schist and hornfels. They stand on edge in a series of intricate, closely spaced, isoclinal folds, and have been displaced by a series of great faults striking north 20 degrees west and also by a second set practically at right angles to the first. Rupture on a smaller scale is also common along the axes of the tight folds.

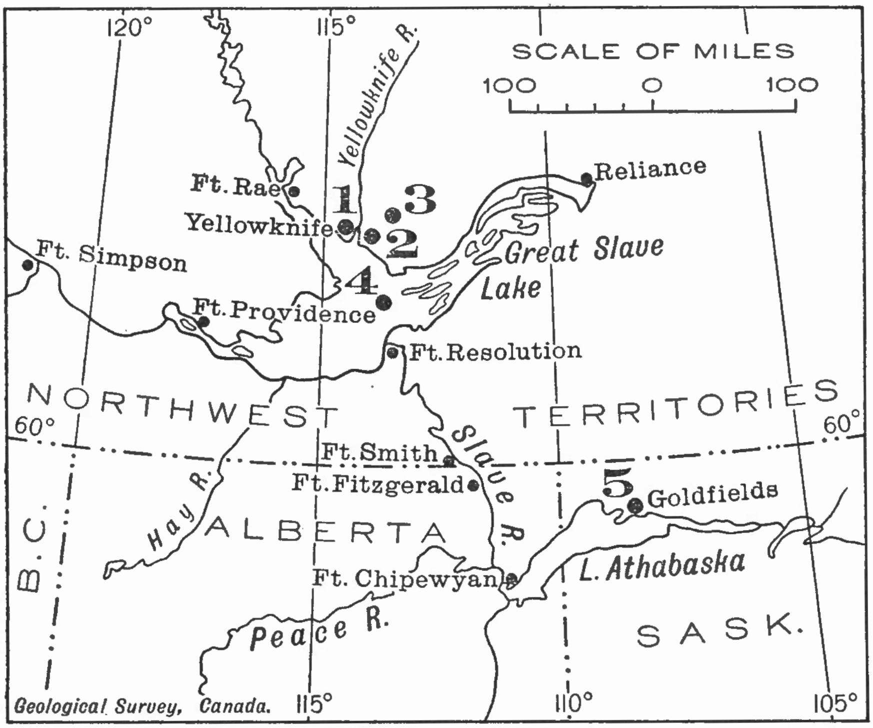

Figure 2. Index map of part of Northwest Territories and Saskatchewan, showing principal known occurrences of gold. 1, Con-Rycon and Negus; 2, Ptarmigan; 3, Thompson-Lundmark; 4, Outpost Islands; 5, Goldfields.

Gold-bearing veins are found both in the lavas and in the sediments, and, singularly enough, those in the lavas have a different composition from those in the sediments. The veins in the sediments are mainly bedded veins, saddle reefs, and veins introduced along the fractured axes of folds. They appear near the outer edge of the aureole of metamorphosed sediments surrounding certain granite bodies, and run outwardly into less metamorphosed sediments. Nearest the granite they consist of glassy, bluish quartz carrying crystals of feldspar and needle-like tourmaline; with increasing distance the tourmaline disappears, then the feldspar, and finally the quartz becomes white or milky and contains much rusty weathering carbonate. Promising gold values have been found in both the high- and low-temperature types. These veins seem to have originated, therefore, from certain granite bodies that at the same time caused metamorphism of the surrounding sediments; and the veins, the metamorphosed sediments, and the granite are cut by the faults mentioned in the preceding paragraph, and by diabase dykes parallel to these faults though somewhat older.

Two mines have been developed on veins in the sedimentary rocks, the Ptarmigan, owned by Consolidated Mining and Smelting Company, and the Thompson-Lundmark Gold Mines. Both commenced milling in the latter part of 1941, but wartime conditions compelled both to close, in 1942 and 1943 respectively. In 1941-2 the Ptarmigan yielded 11,921 ounces of gold from 34,429 tons of ore; in the 1941-3 period the Thompson-Lundmark milled 73,215 tons of ore, from which 47,632 ounces of gold were won.

The veins in the lavas, unlike those in the sediments, lie in smaller shear zones that parallel the large faults and have similar offsets. The large faults cut and displace the late diabase dykes with great offsets; and at least one vein, developed on a small parallel shear, also offsets a late diabase dyke. As the late diabase is the youngest rock of the region, it is thus evident that some vein material was formed a long time after that which is found in the sedimentary rocks and which originated from the intrusive granites. Whether the actual post-diabase vein material carries much gold is a point still undecided.

The veins in the lavas are of two types. The first discovered are lenticular bodies of quartz averaging about 5 feet wide, though attaining in places widths of 15 feet or more. They lie in small shear zones that parallel the large faults striking north 20 degrees west. The quartz, moderately mineralized with pyrite, is much cracked, and the cracks filled with a great variety of minerals, not only the commoner sulphides such as chalcopyrite, sphalerite, galena, and arsenopyrite, but a great variety of sulpharsenides, sulphantimonides, and tellurides in small amount. The gold, which is mostly free, is the latest of the minerals and tends to be most abundant in the relatively pure quartz. This is probably because the brittle quartz fractured more readily and was, consequently, more permeable to solutions than the surrounding materials. The veins are vuggy in places, suggesting that they were developed after the main movements had been completed.

The Con, Rycon, and Negus mines were developed on veins of this type. The first two are adjoining properties operated by Consolidated Mining and Smelting Company; a single mill services both. They were brought into production in September 1938, and closed owing to war conditions in September 1943. In that time 286,266 tons of ore were milled from the combined properties, and 181,688 ounces of gold were obtained. The Negus came into production in February 1939, and was closed in October 1944, in which time it yielded 114,859 ounces of gold from 129,546 tons of ore. It was reopened in the summer of 1945.

The latest discoveries such as Giant Yellowknife are of a somewhat different type. They are rather wide shear zones that trend north-northeast, and have widths up to 150 feet—possibly more in places. The typical ore in them consists of grey sericite schist with 30 to 75 per cent of quartz as stringers or lenses; it generally has a banded or ribboned appearance. Auriferous arsenopyrite and pyrite are abundant in the schist and to a lesser extent in the quartz; native gold is rarely seen. In places much carbonate is present, and in these gold values are usually lower. An ore-shoot may comprise up to 90 per cent of the width of the shear zone. On both sides the ore grades into chlorite or chlorite-sericite schist, which rarely carries values of importance; and this in turn passes into massive greenstone. Rather numerous post-ore faults cut and displace the ore-shoots.

The second sub-area of this region is the east arm and south shore of Great Slave Lake. Only one gold deposit has been found, on Outpost Island, opposite the mouth of the north arm of the lake. The deposit displays a number of unusual features. The rocks belong to an early Precambrian series named by Stockwell the Wilson Island group; it is petrographically quite different from the Yellowknife group north of the lake, and the relations between the two are not known. The beds are mainly impure quartzites, strongly ripple-marked and crossbedded, and somewhat recrystallized with development of mica and staurolite. They are interbanded with conglomerates and argillites much recrystallized to andalusite. They strike east-northeast and dip steeply south. Certain beds of quartzite have suffered brecciation over widths of 4 or 5 feet, in some places as much as 8 feet. The brecciation extends along the strike for distances of 300 to 400 feet, and then seems to die out or possibly to be transferred to a different bed. Singularly enough, the fracturing is said to dip vertically, and so crosses the bedding at a small angle. The fracture zones, commonly known as "shears", have been healed by deposition of chalcopyrite and pyrite, together with a great variety of other minerals such as ferberite (tungstate of iron), magnetite, hematite, marcasite, bornite, chalcocite, and so on. Quartz is present only in minute stringers. Coarse gold occurs free in fractures both in the sulphides and in the quartzite. Some parts are very rich, but values are extremely erratic, so that during the war attempts were made to operate the property mainly for its tungsten content, with the gold merely a valuable by-product.

The property was first developed, down to the 425-foot level, by Consolidated Mining and Smelting Company. This company then dropped its option, and Slave Lake Gold Mines took over the operation, obtaining, in 1941, 5,816 ounces of gold and unstated amounts of tungsten and copper, from 13,057 tons of ore. Another reorganization took place about the end of the year, and a company called International Tungsten Mines operated for the first 8 months of 1942, in which time 3,895 ounces of gold were obtained from 7,368 tons of ore. The mine closed in August 1942.

In the remainder of this sub-area there are a few prospects, but nothing of particular promise as yet.

The third sub-area of the region is near Goldfields on the north shore of Athabaska Lake. There, bodies of coarse, reddish granite that intrude Precambrian sediments have been greatly fractured and quartz has been injected into the fractures to form stockworks of small veinlets. The quartz is sparsely mineralized with coarse-grained, auriferous pyrite, and a very few grains of chalcopyrite, sphalerite, and free gold. Individual veins are too small to mine, but attempts have been made to mine the stockworks as a whole, or selected parts of them.

Two properties of this type were extensively investigated in the years shortly before the last war. On the Box property, which lies just west of Goldfields, a 1,000-ton mill was erected by Consolidated Mining and Smelting Company, and milling began in July 1939, after much preliminary development. The mine was closed in August 1942, after milling 1,418,320 tons of ore and recovering 64,066 ounces of gold. The average tenor of the ore was thus 0·0452 ounce a ton, or $1.74 with gold at $38.50 an ounce, Canadian currency.

The Athona property, which lies about a mile south of Goldfields, is similar in character, but the orebody is somewhat smaller. A small test mill was erected and the ore taken out during development operations was treated in it. The average tenor proved low, and no further operations were attempted.

MANITOBA AND EASTERN SASKATCHEWAN

Little or no interest was taken in the possibilities of metal mining in Manitoba until about 1910, when the great discoveries of Cobalt and Porcupine emphasized the importance of the Precambrian formations as potential reservoirs of ore. Prospecting followed, and gold was discovered in 1911 at Big Rice Lake, east of Lake Winnipeg, and in 1914 at Herb (Wekusko) Lake. In 1915 the great Flinflon orebody was found on the shore of Flinflon Lake, and in

October of the same year the smaller, but high-grade, Mandy deposit, 3½ miles southeast of Flin Flon was discovered. Great interest was aroused by these and other discoveries, and much of the region was prospected; but the gold ores, mostly, proved to be either small bodies or low in grade, so that, with the exception of Central Manitoba, no mine was actually brought into production until the

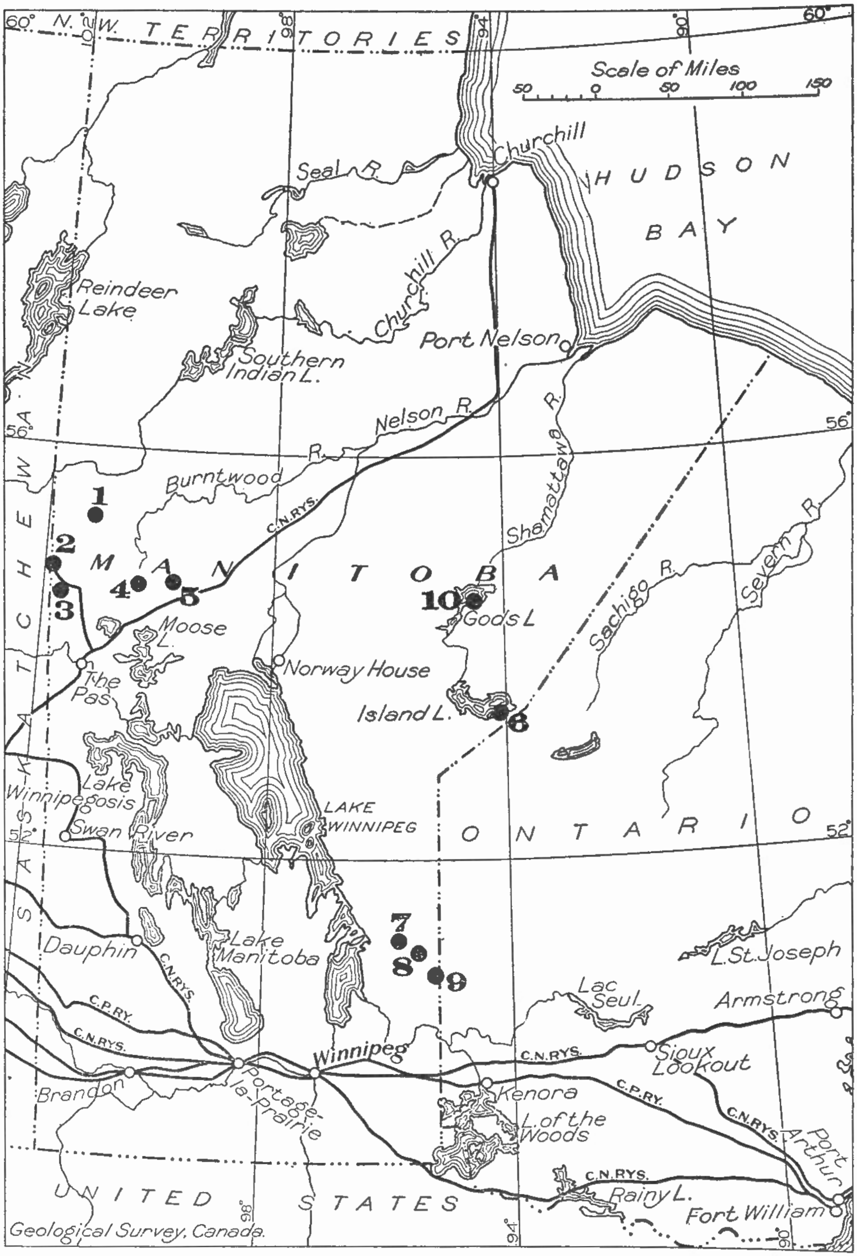

Figure 3. Index map of Manitoba, showing principal known occurrences of gold. 1, Sherritt-Gordon (copper-zinc-gold); 2, Mandy, Flinflon (copper-gold); 3, Gurney; 4, Reed Lake; 5, Laguna; 6, Island Lake; 7, San Antonio, Forty-four; 8, Central Manitoba; 9, Diana, Gunnar, Beresford Lake; 10, Gods Lake.

rise in the currency price of gold made it possible to work such ores at a profit. Altogether, ten gold mines in Manitoba have been brought into production, but nine of them, through exhaustion of ore or war difficulties, have been closed after operating for longer or shorter periods.

The gold deposits fall into three small groups (Figure 3). One, which lies east of the south end of Lake Winnipeg, includes San Antonio Gold Mines, the most important producer, and a number of smaller mines. A second, northwest of the lake, consists of two deposits of auriferous quartz, the Gurney and the Laguna, together with the Flinflon, Mandy, and Sherritt-Gordon mines, which are copper deposits carrying some gold. The third group is northeast of Lake Winnipeg, and includes only one producing mine, at Gods Lake. The output of these mines is shown in the following table:

Name of property	Period of operation	Tons milled	Gold, ozs.
Beresford Lake	1938–40	15,865	5,020
Central Manitoba	1927–37	435,737	160,034
Diana	1934–36	18,398	6,117
Forty Four	1935	1,068	241
Gods Lake	1935–43	540,452	160,531
Gunnar	1936–42	300,933	101,463
Gurney	1937–39	99,455	25,164
Island Lake	1934–35	8,619	6,390
Laguna	1936–39	102,670	52,463
Ogama-Rockland	1942	....	3,765
San Antonio	1932–44	1,479,818	442,744

The San Antonio mine[1] lies on the north shore of Rice Lake, where a sill of brittle diabase cuts soft, sedimentary schists. The sill varies from 200 to 700 feet in width, strikes southeast at the mine, and dips about 45 degrees to the northeast. The veins are fissures in the diabase and generally narrow and die out as the edges of the diabase body are approached; only in rare instances do they extend into the surrounding schist. There are two complementary sets of veins, each set intersecting the edges of the dyke at about 45 degrees; and they dip nearly vertically. Exploration along and down the dip of the dyke has resulted, up to now, in the discovery of more and more veins. The vein material is quartz with patches of iron carbonate, and some albite and chlorite, mineralized with patches and streaks of fine pyrite, cubes of coarse pyrite, a little chalcopyrite, and free gold. The best values are generally associated with the fine pyrite. The wall-rock is somewhat albitized and carbonated; it carries only insignificant amounts of gold, but in many places is cut by so many small veins that the whole mass can be mined.

Forty Four Mines was incorporated to explore the diabase dyke to the east of San Antonio, and a small amount of ore was found in 1935, and milled in the San Antonio mill. Work was then suspended.

The orebodies of Beresford Lake Mines[2] also lie within a wide sill of somewhat altered diorite or gabbro. The sill, which there strikes north 20 degrees west and dips about 70 degrees east, is cut by a strong shear zone nearly parallelling the strike. The shear ranges in width from 6 to 20 feet, and carries lenses of quartz up to 20 feet in length. The quartz is a fine, grey, sugary variety, carrying a little carbonate and chlorite, and mineralized with free gold and scattered grains of pyrite, pyrrhotite, chalcopyrite, and sphalerite.

Central Manitoba Gold Mines produced much gold between the years 1927 and 1937. Two large faults, one striking east and dipping south, the other

[1] Stockwell, C. H.: Rice Lake Area, Southeastern Manitoba; Geol. Surv., Canada, Mem. 210 (1938).
[2] Stockwell, C. H., and Lord, C. S.: Halfway Lake-Beresford Lake Area, Manitoba; Geol. Surv., Canada, Mem. 219 (1939).

striking east-southeast and dipping north, enclosed between them a trough-shaped block of ground in which the productive veins occurred. All the ore-bodies lay above the 375-foot level; those that went deep enough to encounter either fault were there cut off. Orebodies were found in eight veins, and were commonly much longer than deep. The ore was chiefly a grey, smoky quartz, well mineralized with chalcopyrite, pyrite, and a little pyrrhotite. The gold appears to have been free, but was so fine that it could rarely be seen even with a hand lens.

Gunnar Gold Mines lies about half a mile west of Beresford Lake village. A number of shear zones striking roughly west cut massive andesites and basalts, and contain lenses and veins of quartz. The quartz may occur as solid lenses, as lenses containing fragments of country rock, or as stockworks of sub-parallel interlacing veinlets. The bodies for the most part are rather narrow, but of high grade. Three varieties of quartz are present, the most productive being the grey, sugary type found in other properties described; it is mineralized rather plentifully with pyrite, galena, chalcopyrite, sphalerite, pyrrhotite, and free gold. Much of the gold is visible, but the larger part is very fine. The wall-rock is not greatly altered, and never constitutes ore. In several places the shear zones are constricted where they cut through dykes of porphyry or lamprophyre, and excellent orebodies have been found on one side or the other of such constrictions, as if they had acted as dams to the movement of the ore-bearing solutions.

Laguna Gold Mines[1] is a short distance north of Herb Lake settlement, on the east shore of Wekusko Lake. The mine ran from 1936 to 1939, when operations were discontinued. The property had previously been worked for short periods in 1918, 1920-1, and 1924-5, with productions of 1,377 ounces, 268 ounces, and 5,517 ounces, respectively.

A body of quartz-feldspar porphyry about 3,300 feet long and 350 feet wide is injected into ancient Precambrian conglomerates and other sediments. It parallels the bedding of these sediments with a strike of north 35 degrees east and an almost vertical dip. A quartz vein ranging from 2 to 6 feet in width runs through the porphyry close to its western boundary, in some places following the contact between porphyry and sediments; it pinches and dies out in small stringers where it runs into sediments at either end. The quartz carries small amounts of tourmaline, red feldspar, muscovite, and carbonate, and is mineralized with finely divided arsenopyrite in streaks parallel to the walls. Small amounts of galena, sphalerite, pyrite, pyrrhotite, and native gold are mixed with the arsenopyrite of some bands.

The property of Gods Lake Gold Mines[2] is on the north shore of Elk Island, a large island in Gods Lake. Lavas and tuffs of the Hayes River group strike east-northeast and dip steeply north. They are intruded by a sill of augite diorite with a known length of 10 miles and an average width of 300 feet. The sill and, to a lesser extent, the surrounding rocks are cut by many dykes of quartz-feldspar porphyry, and others of pink granite containing large "eyes" of opalescent blue quartz. The dykes seem to be concentrated in the sill because of its superior brittleness. The diorite sill, during injection, seems to have followed a bed of tuff; and thicknesses of tuff ranging from 1 foot to 18 feet have been found along the north contact throughout an explored length of 5 miles. Where the tuff is thicker, the central parts (usually) are converted into ore; these parts may have been lenses of acidic tuff. In the change to ore, the tuff was fractured and the fractures cemented by dark bluish or grey quartz. In places the quartz stringers follow bedding planes and give the ore a marked banded appearance. On the whole, the ore is not more

[1] Stockwell, C. H.: Gold Deposits of Herb Lake Area, Northern Manitoba; Geol. Surv., Canada, Mem. 208, pp. 28-31 (1937).

[2] Baker, W. F.: Geology of Gods Lake Gold Mines, Limited; Trans. Can. Inst. Min. and Met., vol. 38, pp. 155-62 (1935).

than 25 per cent quartz. The quartz is mineralized with sulphides and native gold, which in places is coarse and conspicuous, but the tuff fragments and bands also carry disseminated sulphides. The predominant sulphide is pyrrhotite; there is also considerable pyrite and a little chalcoprite and sphalerite.

In addition to the auriferous quartz deposits, important amounts of gold have been obtained from the large sulphide deposits of the Mandy, Flinflon, and Sherritt-Gordon mines. These are irregular, lens-like masses of sulphides formed by replacement of very ancient Precambrian rocks. At the Sherritt-Gordon mine the rocks are highly metamorphosed sediments, in the others, lavas and tuffs. Certain of the orebodies consist only of country rock thickly spattered with sulphides, but in most of the commercially important bodies replacement has been complete enough to produce solid masses of sulphides with a few unimportant inclusions of rock. In all of them the first-formed sulphide was pyrite, pyrrhotite, or a mixture of the two, and this initial deposit was then replaced by chalcopyrite or a mixture of chalcopyrite and sphalerite.

Gold production from the copper mines mentioned amounted in 1940 to 158,241 ounces, a quantity considerably greater than the total obtained from the auriferous quartz ores of Manitoba and Saskatchewan. Since these mines began their smelting operations in 1931 they have yielded approximately 1,910,812 ounces of gold, in addition to silver and copper, by the end of 1944. In addition, the Mandy mine, which operated from 1915-9, produced in those years some 25,000 tons of ore stated to carry $5 a ton in gold, or about ¼ ounce. Some 6,000 ounces should, therefore, be added to the above figure to obtain the total output of gold from the copper-gold ores.

ONTARIO

The first gold discovery in Ontario was made in 1866 at the Richardson location in Hastings county (Madoc tp., con. V, east half of lot 18). The discoverer, Marcus Powell, was following what he thought was a copper seam. "The seam was six inches wide at the top", he states, "and was decomposed for six feet; then it was solid rock to 15 feet, where it suddenly opened out into a cave 12 feet long, 6 feet wide, and 6 feet high, so that I could stand upright in it. The hanging wall was quartzite and the footwall granite, while the roof was composed of spar, talc, quartzite, black mica, and other minerals. The gold was found in all these rocks in the form of leaves and nuggets, and in the roof it ran through a foot thickness like knife blades. The largest nugget was about the size of a butternut. . . . We sold the property to Lombard and Hardin of Chicago for $36,000. I don't know how much gold was taken out; but I guess the miners got as much as the owners, for I have seen specimens of it all over the country".[1]

According to Vennor, who examined the discovery for the Geological Survey shortly after it was made, the seam lay on the contact of an irregular layer of chlorite and epidotic gneiss overlain by a bed of siliceous dolomite, the whole striking north 85 degrees west and dipping 45 degrees or less to the north. He was inclined to regard the openings in which the gold was found merely as solution cavities.

Needless to say, the Richardson discovery created a fever of excitement, and numerous other discoveries were made, though none as rich as the first. It was soon found, however, that below the shallow zone of weathering appeared the hard primary ores in which the gold was closely bound up with fresh arsenopyrite. No means of treating such ore successfully was then known;

[1] Ont. Bur. Mines Rept., vol. III, p. 54 (1893).

consequently, interest in the district languished. Within the last few years attempts have beeen made to reopen some of the properties but the orebodies have been too small and low in grade, or so erratic, that none has proved successful.

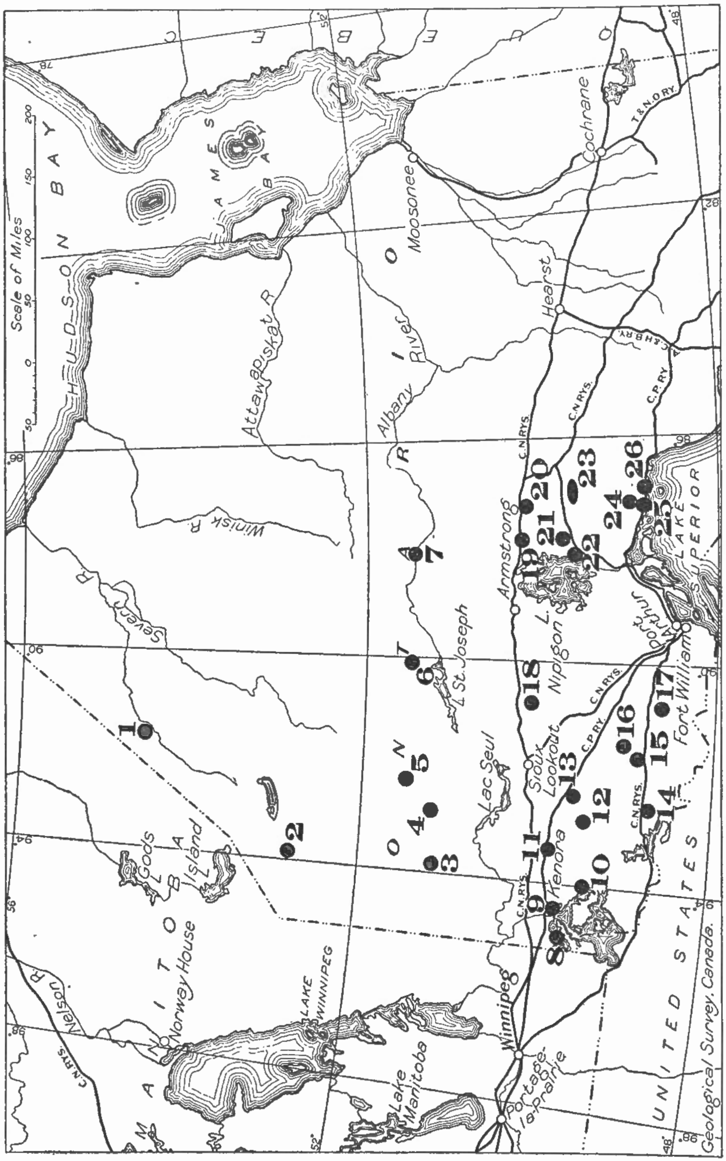

Figure 4. Index map of Lake of the Woods, Patricia, and Thunder Bay districts, western Ontario, showing principal known occurrences of gold. 1, Sachigo; 2, Favourable Lake; 3, Red Lake (Gold Eagle, Hasaga, Howey, Madsen Red Lake, McKenzie Red Lake, Red Lake Gold Shore); 4, Woman Lake (Hudson Patricia, J. M. Consolidated, Uchi); 5, Argosy (now Jason); 6, Pickle Lake (Central Patricia, Pickle Crow); 7, Port Hope; 8, Mikado, Duport; 9, Sultana; 10, Regina; 11, Eagle Lake; 12, Manitou Lake; 13, Sakoose; 14, Mine Centre; 15, Harold Lake; 16, Hammond Reef; 17, Moss mine; 18, Sturgeon Lake (St. Anthony); 19, Tashota; 20, Kowkash; 21, Sturgeon River; 22, Leitch, Sand River, Northern Empire; 23, Bankfield, Hard Rock, Jellicoe, Little Long Lac, MacLeod-Cockshutt, Magnet, Tombill; 24, Duck Lake; 25, Schreiber; 26, Empress.

The construction of the Canadian Pacific Railway made access to western Ontario easy, and its completion in 1886 was followed by an important series of discoveries between Port Arthur and the Manitoba boundary. These were most numerous near Lake of the Woods. A boom followed that reached its peak in 1897, and much money was lost through erection of unwarranted mills, inefficient management, and stock-jobbing operations. Neverthelesss, the field produced, between 1897 and 1903, more than $2,000,000 in gold, and several of the properties have been operated intermittently since that time.

The failure of the Lake of the Woods district to fulfil the bright promise of its early days greatly discouraged gold mining in the Precambrian for many years. Fortunately, however, the great silver discoveries at Cobalt in 1903-4 caused an influx of thousands of prospectors into northern Ontario; and as the Cobalt field was taken up, these men spread far and wide over the surrounding country. The result was the discovery in 1909 of the Porcupine gold field, and in 1911-12 of the Kirkland Lake field. The yield from these fields has made Ontario the premier province of the Dominion in gold production, and has brought Canada into second or third place as a world producer.

LAKE OF THE WOODS AND PATRICIA DISTRICTS

In Lake of the Woods district (Figure 4) gold veins, for the most part, occur in the altered lavas—greenstones and schists—of the Keewatin series, in the neighbourhood of granite contacts. Some of them run into, or lie wholly in, the granite. The more productive were rarely more than 5 feet wide. Larger veins are apt to be of the lode type, composed of a multitude of quartz stringers separated by bands of country rock. The width of the individual veins varies considerably, so that an ordinary 5-foot vein will narrow in places to 1 foot or 2 feet, and swell in others to 7 or 8 feet.

The vein materials consist chiefly of quartz with some carbonate, but include tourmaline in many cases. The principal constituent of value is free gold, which in many instances is so coarse as to give rise to extraordinarily spectacular hand specimens and ore-shoots. This condition rendered the mines unusually liable to theft, and large quantities of gold were lost in this way. Tellurides of gold were found in some of the more important mines. The principal sulphide of the veins is pyrite, but arsenopyrite, chalcopyrite, bismuthinite, and molybdenite also occur.

The most important mines of the district were the Mikado, Regina, and Sultana, the first two of which produced about $500,000 each, the last nearly $1,000,000. Attempts have been made from time to time to reopen these and other properties, but the operations lasted for short periods only. Brief descriptions of these properties will perhaps help to define the conditions prevailing throughout the region.

The Sultana mine is on Sultana Island, Lake of the Woods, about 7 miles from Kenora (*See* Figure 4). It was opened in 1891 and was worked almost continuously until 1906, attaining a depth of 600 feet. The rocks are Keewatin basalts, schistose in places, and intrusive, grey, granitoid gneiss. The veins occur in both rocks. For the most part the veins are lode-like, composed of bands and stringers of quartz separated by layers of schist, though in places, over short lengths, they are pure quartz. All were well mineralized, principally with iron pyrites, but also with other sulphides such as pyrrhotite, galena, zinc blende, and molybdenite. The largest vein varied from 20 to 30 feet in width, though in one place in the mine it swelled to 60 feet. Mining operations proved that the pay ore in the main vein formed a sort of irregular chimney extending downward from the second level, with a maximum cross-section of about 60 by 120 feet. It has been stated that all the higher value sections of the different veins occurred close to the contacts of the granite and Keewatin rocks, so it seems likely that this chimney followed the contact downward. The ore-shoot pinched out at about the 7th level and was originally supposed to have been cut off by a flat fault, but more recent work indicates that in all probability no such fault exists. The mine was dewatered in 1935 for sampling and drilling, presumably with unsatisfactory results as no attempt has been made to resume operations.

The Mikado mine was discovered in 1893 and operated until 1903 and again in 1910-11 and in 1924. It lies on the shore of Shoal Lake about 25 miles southwest of Kenora (*See* Figure 4). The rocks are Keewatin basalts intruded by a mass of pinkish granite. With the granite are associated dykes of reddish pegmatite. The principal vein strikes north 30 degrees west and dips 85 degrees northeast. It varied from 16 inches to 5 feet in width, and where it cut greenstone it was a series of quartz-calcite stringers separated by bands of rock. Where it entered granite or pegmatite, it widened to a mass of clean quartz with a well-defined foot-wall. The vein material seems to have been rather heavily mineralized with sulphides, including pyrite, chalcopyrite, bismuthinite, molybdenite, and others, accompanied by native gold. Some of the ore-shoots yielded highly spectacular specimens of coarse gold. According to the reports, the veins at depth ran out of the granite into greenstone, and the values fell off so greatly that mining became unprofitable.

The geological conditions prevailing at the Regina mine are much like those at the Mikado. The rocks are greenstones intruded by a mass of grey to pink granite. The veins strike about north 70 degrees west, with steep dips. The main vein varies from 2 to 5 feet in width at the surface, but widens in depth to 7 or 8 feet. Vein material was mainly quartz, with some iron-bearing carbonate and pyrite.

Wendigo Gold Mines, a property on the east shore of Lake of the Woods, near the north end of the lake and about 10 miles south of the Sultana, came into production in 1936, and between that time and the end of operations, in January 1943, it yielded 67,414 ounces of gold from 204,854 tons of ore treated. The orebody is a vein with a maximum width of 2 feet, developed in a well-defined shear zone striking a little north of east and dipping steeply north. Vein material is quartz, heavily mineralized with pyrrhotite and chalcopyrite, and a subordinate amount of pyrite.

An occurrence of some interest is the Duport mine on Cameron Island, in Shoal Lake. A basic diorite is cut by shear zones striking northeast, and the schist is much silicified and replaced by arsenopyrite, with some pyrite, pyrrhotite, chalcopyrite, and native gold. The arsenopyrite is auriferous and carries the bulk of the values. Unfortunately, the orebodies seem to have been too small to justify construction of a roasting plant, so that the ore had to be sent to Tacoma for treatment. In 1935-6, 1,126 tons were thus sent, and yielded 4,572 ounces of gold. Since that time no production is reported.

In the vicinity of Atikokan, gold has been produced by the Elizabeth, Hammond Reef, Sunbeam, and other mines. The deposits consist of single quartz veins or a network of them traversing Keewatin schists or bodies of granite invading the schists. Besides free gold, the veins contain pyrite, chalcopyrite, and galena, with, in some cases, sphalerite and magnetite. Near Eagle Lake, on the Grace, Golden Eagle, and other properties, gold-bearing quartz veins carrying galena, sphalerite, and pyrite occur in granite over a width of a mile or more from the contact with Keewatin rocks. About Dryden and the general vicinity of Wabigoon Lake, a number of discoveries of auriferous veins have been made. They occur chiefly in Keewatin rocks and are particularly numerous in the vicinity of intrusive bodies of gneissic granite. The individual veins vary much in width and are composed largely of quartz, but ankerite, pyrite, and tourmaline are plentiful and chalcopyrite, hematite, and gold are less abundant.

In Manitou Lake area and in the general vicinity of Mine Centre, many deposits of gold-bearing quartz have been discovered, and the Foley, Golden Star, and Laurentian, together with other mines, have afforded considerable gold. The quartz carries various sulphides as well as gold and occurs in lenticular bodies, in irregular veins, and in groups of branching veins and veinlets commonly cutting Keewatin rocks in the vicinity of intrusive masses of granite.

These descriptions serve to bring out the intimate connection existing in Lake of the Woods area between the gold-bearing quartz veins and the granites. The veins are either in the granite itself or in the surrounding country rocks, but always near the boundary of the granite. The composition of the granite is probably a factor governing gold occurrence, for, according to T. L. Tanton, granite bodies commonly grade into quartz porphyries where gold deposits are found. The physical nature of the granite, i.e., its hardness and brittleness, was probably another important factor determining the economic value of a deposit, for the fissures in granite are generally clean cut and large, but when they leave the granite they not uncommonly break into a series of stringers. Veins in this district usually carry free gold as their principal constituent of value, though auriferous sulphides may also be present; and the best values commonly follow the granite contact pretty closely, so that the orebodies are apt to be chimneys in shape. Veins may show local enrichments where they cross dykes of granite or pegmatite.

The same general conditions control gold deposition throughout Red Lake and Woman Lake districts[1] (Figure 4). The rocks of the latter district consist of basic Keewatin lavas intruded by diorites, the whole overlain unconformably by sediments supposedly of Timiskaming age. These rocks were intruded by dykes and masses of quartz porphyry, by other acidic porphyries, and then by bosses of granite. The veins occur in the vicinity of the granite bosses, in any of the older rocks. At Red Lake, particularly, the quartz porphyry has proved an unusually favourable host for ore, because, being brittle, it fractured readily and in many places. The Howey orebody consisted of a dyke of quartz porphyry 30 to 100 feet wide, which was so severely fractured as to convert large sections of the dyke into ore. The fissures were lenticular, and rarely more than a foot wide. The vein material was deposited in two stages; during the first, high-temperature quartz with some pyrite was formed; in the second, a fracturing of the earlier quartz was followed by deposition in the fractures of native gold with small quantities of galena, sphalerite, and gold telluride. The Howey orebody was very low in average grade, but so large that a big daily tonnage could be treated at a profit. Grade averaged 0·2 ounce a ton during the first year of operation, but became gradually less until in 1940 it was only 0·055 ounce a ton. Operating costs in 1939, however, are reported as only $1.255 a ton. Approximately 450,000 tons a year were treated; from the beginning of operations in 1930 to their end in November 1941, 4,540,895 tons of ore were milled and 421,322 ounces of gold were recovered.

A second rock, the interbanded mixture of cherty silica and iron carbonate or oxide termed iron formation, has also proved to be a favourable host for ore in this region, and presumably for the same reason, i.e., its brittleness. Two important mines, Central Patricia and Pickle Crow, have been opened on veins in this formation, Central Patricia in 1934 and Pickle Crow in 1935. The iron formation does not form continuous beds, but rather a series of lenses ranging in width from a few inches to 250 feet, and in length up to many hundreds of feet. An "horizon" of iron formation, made up of several such bands, may commonly be traced for several miles. At the mines, the iron formation has been folded into a tight syncline striking northeast, both limbs of which dip steeply northwest. The plunge of the syncline is about 55 degrees to the northeast. All the orebodies appear closely related to the general structure. On Central Patricia they are much fractured parts of the iron formation found where it has been bent, apparently by drag during the folding movements. The pipes or shoots of ore rake northeast at about the same angle as the general plunge. They are made up of quartz heavily mineralized with

[1] Bothwell, S. A.: Geology of the Pickle Crow Mine; Trans. Can. Inst. Min. and Met., vol. 41, pp. 132–8 (1938).
McKenzie Red Lake Gold Mines, Limited, Ibid., pp. 346–9.
Thomson, J. E.: Structure of Gold Deposits in the Crow River Area, Ontario; Ibid., pp. 358–374.
Hurst, M. E.: Pickle Lake-Crow River Area, District of Kenora (Patricia Portion); Ont. Dept. Mines Rept., vol. 39, pt. 2, pp. 1–35 (1930).
Bruce, E. L., and Hawley, J. E.: Geology of the Basin of Red Lake, District of Kenora (Patricia Portion); Ont. Dept. Mines Rept., vol. 36, pt. 3, pp. 1–72 (1927).
Horwood, H. C.: Geology and Mineral Deposits o fthe Red Lake Area; Ont. Dept. Mines Rept., vol. 49, pt. 2 (1940).

auriferous pyrrhotite and arsenopyrite, and smaller amounts of pyrite and chalcopyrite. The carbonate and chlorite of the adjacent iron formation has also been replaced to a considerable extent by auriferous pyrrhotite. At Pickle Crow, which adjoins Central Patricia farther east along the syncline, the main orebody at present is the Howell vein, which crossess the band of iron formation on a strike of north 50 to 60 degrees east to run into the surrounding greenstone for a few hundred feet to the east and west. The vein has been bent into a series of drag-folds, and it is in and near these that the vein is highest in grade. The minerals of the vein are the same as those of Central Patricia, with addition of free gold. The iron formation next to the vein is much fractured and replaced by sulphides, giving mineable widths of 8 to 15 feet, but in the greenstone the wall-rock is not ore, and the vein has an average width of about 3 feet. The tenor of the ore is, however, somewhat higher in the greenstone than in the iron formation.

At Uchi Gold Mines[1], the ore zone lies along the contact of two basic flows, which are separated in places by thin sheets of rhyolite and silicic tuff. This zone is followed by a "vein", which in places consists of a massive quartz lead 2 to 4 feet in width, in others of a series of quartz stringers. The ore zone is widened here and there by narrow quartz stringers striking away from the main zone into the country rock. Carbonates and tourmaline accompany the quartz. Visible gold occurs in the quartz, but is not common; the best ore values are reported to come from silicified and pyritized greenstone adjoining the vein. Besides pyrite, pyrrhotite is locally present and in some places is the dominant sulphide. Sphalerite has been observed in some sections.

Production figures for the various mines of Patricia district up to the end of 1944 are as follows:

Name	Period of operation	Tons milled	Gold, ozs.
Argosy	1936–38	42,529	14,835
Berens River	1939–44	368,477	119,463[2]
Central Patricia	1934–44	987,852	405,802
Cochenour Willans	1939–44	285,237	130,155
Gold Eagle	1937–41	180,095	40,204
Hasaga	1938–44	656,735	113,806
Howey	1930–41	4,540,895	421,322
Hudson Patricia	1936	8,228	1,566
Jason	1940–42	105,318	44,165
J. M. Consolidated	1934–40	105,357	27,125
Madsen Red Lake	1938–44	892,989	205,880
McKenzie Red Lake	1935–44	689,966	239,339
McMarmac Red Lake	1940–44	130,907	40,265
Pickle Crow	1935–44	992,714	562,989
Red Lake Gold Shore	1936–38	85,674	21,300
Sachigo River	1938–41	46,416	52,560
Uchi	1939–43	757,074	114,467

Somewhat east of the Lake of the Woods and Patricia groups of mines, but in the same general region, are the St. Anthony and Moss mines. The latter, in Moss township, was the first gold discovery of western Ontario (1871), and has been operated intermittently since 1883. The latest attempt was during the years 1932-6, inclusive, under the name of Ardeen Gold Mines, and during that period the treatment of 143,724 tons of ore yielded 29,628 ounces of gold. St. Anthony Gold Mines, on Sturgeon Lake, operated from 1900 to 1908, and was then shut down for many years. Reopened in 1934, it produced up to December 1941, when it closed, 54,282 ounces of gold from 300,503 tons of ore milled.

[1] Bateman, J. D.: Uchi-Slate Lakes Area; Can. Min. Jour., vol. 59, pp. 695–7 (1938).
[2] Also large amounts of silver and lead. In 1941, the only year for which the Bureau of Statistics gives the figures, total production was 27,837 ounces of gold, 1,194,730 ounces of silver, and 521 tons of lead, from 86,373 tons of ore.

SUMMARY AND GENERALIZATIONS

The part of the Canadian Shield that lies between Lake Winnipeg on the west and Lake Nipigon on the east, and comprises all the mines described in the preceding two sections, appears to be one region or sub-province throughout which similar conditions of deposition prevail. The gold deposits lie in the neighbourhood of granite bodies. The greater part of the gold is free; accompanying sulphides, in most of the known properties, carry a minor percentage of the values. Practically all the gold occurs in the quartz; mineralized schist of the vein walls carries little or none. Very rich and spectacular ore-shoots occur, but are mostly too small to justify the expense of a mining and milling plant.

In general, conditions are most favourable for deposition where there are hard, brittle rocks that fracture readily to form open channels through which solutions can easily pass. Softer rocks, which shear to relatively impermeable schists, have not commonly proved favourable to deposition. The favourable brittle rocks include rhyolites, cherts, iron formation, quartz porphyry, and various basic dykes. In each case, the occurrence of fracturing instead of shearing under stress can be ascribed to the fact that the rocks are composed of primary minerals. Rocks made up of secondary minerals such as kaolin, sericite, chlorite, and carbonates commonly crush under stress to relatively impermeable schists.

The conditions required for the formation of a large ore deposit in this region, therefore, appear to be: (1) the existence of a fairly large body of brittle rock; (2) shearing movements sufficiently great to shatter this rock over a wide belt; and (3) the proximity of a body of granite from which have come solutions sufficient in quantity to fill the fissures with auriferous quartz.

The gold-bearing veins of this region commonly exhibit a characteristic mineral association. Almost everywhere pyrite, chalcopyrite, galena, sphalerite, molybdenite, and iron carbonate accompany the quartz; pyrrhotite, calcite, feldspar, and magnetite are not uncommon, and tourmaline and bismuthinite are occasionally found. Oxidation of the iron minerals gives rise to rusty zones, which are useful as indicators to prospectors, and in places the presence of silicified zones also serves to suggest the neighbourhood of auriferous veins.

THUNDER BAY DISTRICT[1]

An important gold mining industry has arisen east of Lake Nipigon, in the 55-mile stretch between it and Little Long Lac (Figure 4). At least eleven mines have produced gold from this district. Some of these deposits resemble closely those of the Patricia-Manitoba area, but others, including the most important, are of an entirely different character. All the latter occur in Errington and Ashmore townships near the eastern end of the district under consideration. They include the Hard Rock, McLeod-Cockshutt, Little Long Lac, Bankfield, and Tombill mines.

At Little Long Lac mine, the largest and the oldest of these, the rocks are ancient Timiskaming-like sediments on the north side of a major syncline. The beds have been further bent into a large drag-fold some 2,000 feet across; it plunges to the west at about 50 degrees. The orebodies are confined to arkose beds 1,500 to 2,000 feet in total thickness. Near the anticlinal crest of the drag-fold the arkose is cut by a number of shear zones striking approximately east, and apparently formed by upward movement of the south sides in a direction closely parallel to the westward plunge. These shear zones in the arkose have been converted into lodes by the injection of narrow stringers of quartz, which are continuous and uniform in width over remarkably long distances. The quartz carries free gold, with small amounts of other minerals such as arsenopyrite,

[1] Bruce, E. L.: Little Long Lac Gold Area; Ont. Dept. Mines, Ann. Rept. vol 44, pt. 3 (1935).
New Developments in; ibid., vol. 45, pt. 2 (1936).
Eastern part of Sturgeon River Area; ibid., vol. 45, pt. 2.
Laird, H. C.; Western part of Sturgeon River Area; ibid.

pyrite, bournonite, stibnite, and tetrahedrite. The amount of gold in these stringers is so large, and so remarkably uniform in distribution, that 20 per cent of quartz in a stope is ordinarily sufficient to make ore of the present mill grade—nearly one-half ounce a ton.

The Hard Rock and McLeod-Cockshutt mines are adjoining properties about 2 miles southeast of the Little Long Lac mine. The rocks are the same series of sediments, here intruded by a highly irregular mass of feldspar porphyry that outcrops over an area one-quarter mile or more in length and somewhat less in width. Extensive drilling operations have shown that the upper surface of the porphyry mass contains a deep, westward-plunging trough or roof pendant of the sediments; and also that fin-like offshoots of the porphyry run into the sediments both to the east and west, but do not outcrop. The ore, which consists of coarse pyrite with a little free gold and much arsenopyrite, is found along the contacts between the tongues of porphyry and the sediments. Sulphides, fairly massive, have replaced certain of the thin, sedimentary beds, forming a banded ore; and, where the porphyry tongues are narrow, the porphyry itself is filled with disseminated grains of sulphide, forming wide orebodies. Annual production figures show that the average grade is about one-fifth ounce a ton.

The Bankfield and Tombill properties adjoin southwest of Magnet Lake, about 6 miles west of the mines just described. Ancient Timiskaming-like sediments are here intruded by a set of feldspar porphyry dykes 10 to 60 feet in width and striking west or a little north of west. Some of the dykes, together with the greywacke along their margins, have been sheared and fractured; and the fractures filled with tiny quartz veins. Pyrite, and arsenopyrite, with a little native gold and minor amounts of other sulphides, are found in the quartz veinlets and also disseminated through the sheared wall-rock. There appear to have been two periods of movement, each accompanied or followed by mineralization. The first produced a general low-grade enrichment of the sheared porphyries, and the second gave rise to moderately rich, westward-raking oreshoots.

Production figures for the various mines of the district up to the end of 1944 are as follows:

Name	Period of operation	Tons milled	Gold, ozs.
Bankfield Consolidated	1937–42	230,809	65,992
Hard Rock	1938–44	760,294	179,979
Jellicoe	1939–41	14,722	5,620
Leitch	1937–44	225,700	163,872
Little Long Lac	1934–44	956,848	350,386
McLeod-Cockshutt	1938–44	1,350,003	348,370
Magnet Consolidated	1938–43	201,206	105,371
Northern Empire	1934–41	425,866	149,324
Sand River	1938–42	155,333	50,065
Sturgeon River	1936–42	145,796	72,932
Tombill	1938–42	190,622	69,097

MICHIPICOTEN-GOUDREAU DISTRICT[1]

Gold was discovered in Michipicoten district in 1897, and since then sporadic attempts have been made to mine the deposits. Three of the better properties were re-opened in the early thirties, and operated for longer or shorter periods before closing. With the exception of the Jubilee lens, a body of very low-grade quartz some 600 feet long and 10 to 40 feet in width, the property of Minto Gold Mines, all the deposits are rather narrow quartz veins characterized by

[1] Burwash, E. M.: The Michipicoten-Missinaibi Area; Ont. Dept. Mines Rept., vol. 44, pt. 8, pp.1–26 (1935).
Frohberg, M. H.: The Ore Deposits of the Michipicoten Area; ibid., pp. 39–83.
Moore, E. S.: Goudreau and Michipicoten Gold Areas, District of Algoma; Ont. Dept. Mines Rept., vol. 40, pt. 4, pp. 1–54 (1931).

high-temperature minerals such as tourmaline, pyrrhotite, and albite, and carrying spectacular splashes and pockets of native gold. On the whole, however, the grade was not high, as the following production table indicates:

Name	Period	Tons treated	Gold, fine ozs.
Agawa (Centennial)	1939	8,612	510
Darwin	1935–37	34,421	13,233
Minto	1930–39 (No production in 1937)	169,043	36,295
Parkhill	1931–37	125,421	53,613
Ronson	1939	774	156
Regnery Metals	1940–42	11,708	2,906

In Goudreau area, some 25 miles northeast of Michipicoten, conditions appear to be slightly different, according to the rather incomplete accounts available. There, on the principal properties, quartz accompanied again by tourmaline and other high-temperature minerals has been injected into sheared zones and has reacted with the country rock to produce fairly wide silicified and mineralized zones carrying gold values. Production figures for the three principal properties are:

Name	Period	Tons treated	Gold, fine ozs.
Algold	1936–38	22,679	2,320
Algoma Summit	1934–39	116,627	8,466
Cline Lake	1938–42	331,842	63,178

PORCUPINE DISTRICT[1]

The Porcupine gold field, discovered in 1909, lies largely in Tisdale township. There are, however, a few mines in the northern part of Deloro township, which adjoins Tisdale on the south; and in recent years valuable deposits have been developed in Whitney township, east of Tisdale. The rocks are altered basic lavas of Keewatin age intruded by bodies of a grey quartz-feldspar porphyry, and overlain unconformably by conglomerates, greywackes, and slates of the Timiskaming series. The porphyry is not found in contact with the sediments, so that it is not definitely known which is the younger. The lavas and sediments have been tightly folded into a long syncline, the axis of which strikes east-northeast, so that all the strata now have steep or near-vertical dips. Subordinate or drag-folds have been found on both north and south limbs of the syncline; and an anticlinal cross-fold strikes north-northwest approximately through the town of Timmins, giving the main syncline a rather steep eastward plunge for 3 or 4 miles. To the east of this steep part, however, the plunge is nearly horizontal.

Two of the three large mines of the district, the Hollinger and the McIntyre, lie on the north limb of the syncline close to the anticlinal cross-fold; and three other properties that have produced a good deal of gold, namely the Vipond,

[1] Burrows, A. G.: The Porcupine Gold Area; Ont. Dept. Mines Rept., vol. 33, pt. 2 (1924).
Ringsleben, W. C.: Hollinger Geology; Can. Min. Jour., vol. 56, pp. 364–372 (1935).
Skavlem, H. G.: McIntyre Geology; Eng. Min. Jour., vol. 134, pp. 451–7 (1933).
Derry, D. R.: Notes on Geology: Report on Coniaurum Mines for the year ended Dec. 31, 1939.
Hurst, M.E.: Vein Formation at Porcupine, Ontario; Ec. Geol., vol 30, pp. 103–127 (1935).
Unpublished data, obtained through the courteous co-operation of the officials of Hollinger Consolidated Gold Mines. Ltd.
Personal observations.

Moneta, and Porcupine Crown, are likewise in this position. Most of the other mines are also in lavas on one limb or the other of the syncline. The first orebodies of the Dome Mines, however, were in a small, tightly infolded syncline of Timiskaming series on the south side of the main syncline; these were

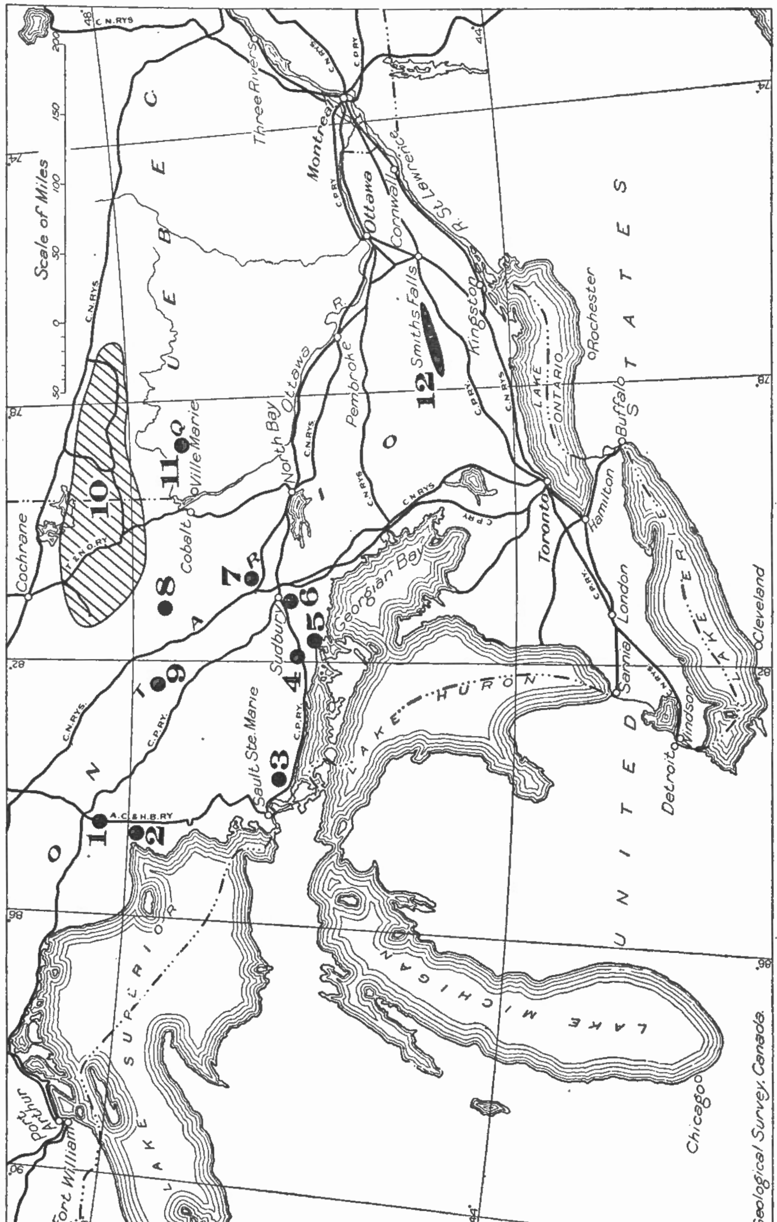

Figure 5. Index map of southeastern Ontario and southwestern Quebec, showing principal known occurrences of gold. 1, Goudreau (Algold, Algoma Summit, Cline Lake); 2, Michipicoten (Agawa, Darwin, Minto, Parkhill, Ronson); 3, Havilah; 4, Shakespeare; 5, Howry Creek; 6, Lebel Oro (formerly Long Lake); 7, Crystal; 8, West Shiningtree (Ronda); 9, Swayze (Kenty); 10, Porcupine-Kirkland-western Quebec gold belt; 11, Guillet Lake (Belleterre); 12, Southeastern Ontario.

completely mined out about 1928. The recently discovered orebodies of Pamour and Hallnor mines, in Whitney township, lie partly in the basal beds of the Timiskaming series and partly in the adjoining Keewatin rocks, on the north side of the main syncline.

A striking feature of the area is the presence of long and wide belts of shearing that may be traced for miles in a general east-west direction. They dip very steeply, some to the north, others southward; and they cut indiscriminately through lavas, sediments, and porphyries. The widths of the sheared zones, however, and the perfection of the schistosity are both dependent on the hardness and massiveness of the rock cut. Thus, relatively soft sediments are rendered highly schistose over wide belts, whereas in massive lavas the belts of schist are narrower and the schistose texture is less perfectly developed. Where the lava is particularly hard and massive the sheared zone may become very narrow or may grade into a fracture zone very difficult to recognize or trace. These features make it evident that the sheared zones are the result of differential stress acting at some period after the intrusion of the porphyry masses and the folding. Their economic importance is that they contain many, if not most, of the important orebodies of the district, so that the shearing was evidently very favourable to ore formation. The Hollinger and McIntyre mines, in particular, lie on a shear zone some 1,600 feet wide, formed by the coalescence of several narrower belts. This shear zone strikes a little north of east and extends completely through McIntyre ground into the Coniaurum claims to the east of it.

The Hollinger and McIntyre mines are adjacent properties developed on the same series of veins, the Hollinger lying to the southwest, the McIntyre to the northeast. The veins, with a few exceptions, lie within the sheared zone above described, cutting across it on a strike about north 50 degrees east, whereas the zone strikes north 60 to 70 degrees east. Most of the veins dip steeply south, following in a general way the dip of the strata; but a few, toward the northern side of the sheared zone, dip steeply to the north. Where the veins run out of the sheared zone they feather and die out.

A number of porphyry masses intrude the lavas on the Hollinger and McIntyre properties, and like them are sheared where they fall within the schistose belt. The porphyry is a light grey rock carrying small phenocrysts of quartz and acid plagioclase. The principal mass, termed the Pearl Lake porphyry, lies in the centre of the zone of shearing and vein formation, with its west end on Hollinger property about 1,400 feet from the McIntyre boundary. The outcrop is canoe-shaped, and underground work has shown that the western "prow" of the canoe dips or rakes eastward at about 40 to 45 degrees, along a line striking north 85 degrees east. It follows, therefore, that in depth the porphyry is found both farther and farther east, and progressively farther toward the south of the vein zones, which, as mentioned, strike about north 50 degrees east. The recognition of this structure has been of the highest importance in directing the development of the McIntyre mine.

On the Hollinger property the main ore zone, comprising a hundred or more productive veins, extends on the surface approximately 3,500 feet southwest of the end of the Pearl Lake porphyry mass, and rakes east-northeast at about the same angle as the porphyry. Recent developments on the lower levels indicate a marked increase in the angle of plunge at those depths. At the nose of the Pearl Lake porphyry mass the main vein system splits into two branches, one of which parallels the north side of the porphyry, the other the south side. These facts suggest that the porphyry offered so much resistance to the major stresses that adjustment by fracturing was concentrated in the less competent lava bands surrounding it. Such concentration of fracturing around the porphyry buttress created a condition very favourable to ore deposition.

The porphyry, however, did not wholly escape fracturing. It has been shown that it was sheared along the schist belts, along with the other rocks of the region; and underground exploration has shown that many veins enter the schistose porphyry, and in some instances run long distances through it. Such veins, however, have not proved to be of much value in the past, for the porphyry has not been a favourable host for ore. Thus, a vein carrying $8 a ton in greenstone drops at once below commercial grade on entering porphyry, though a vein running $50 a ton in greenstone may retain commercial values in porphyry for 50 to 100 feet from the greenstone contact. It would seem that the chloritic greenstones acted as a precipitant of gold, but that the sericitic schistose porphyries did not. Developments at depth, however, seem to indicate that there

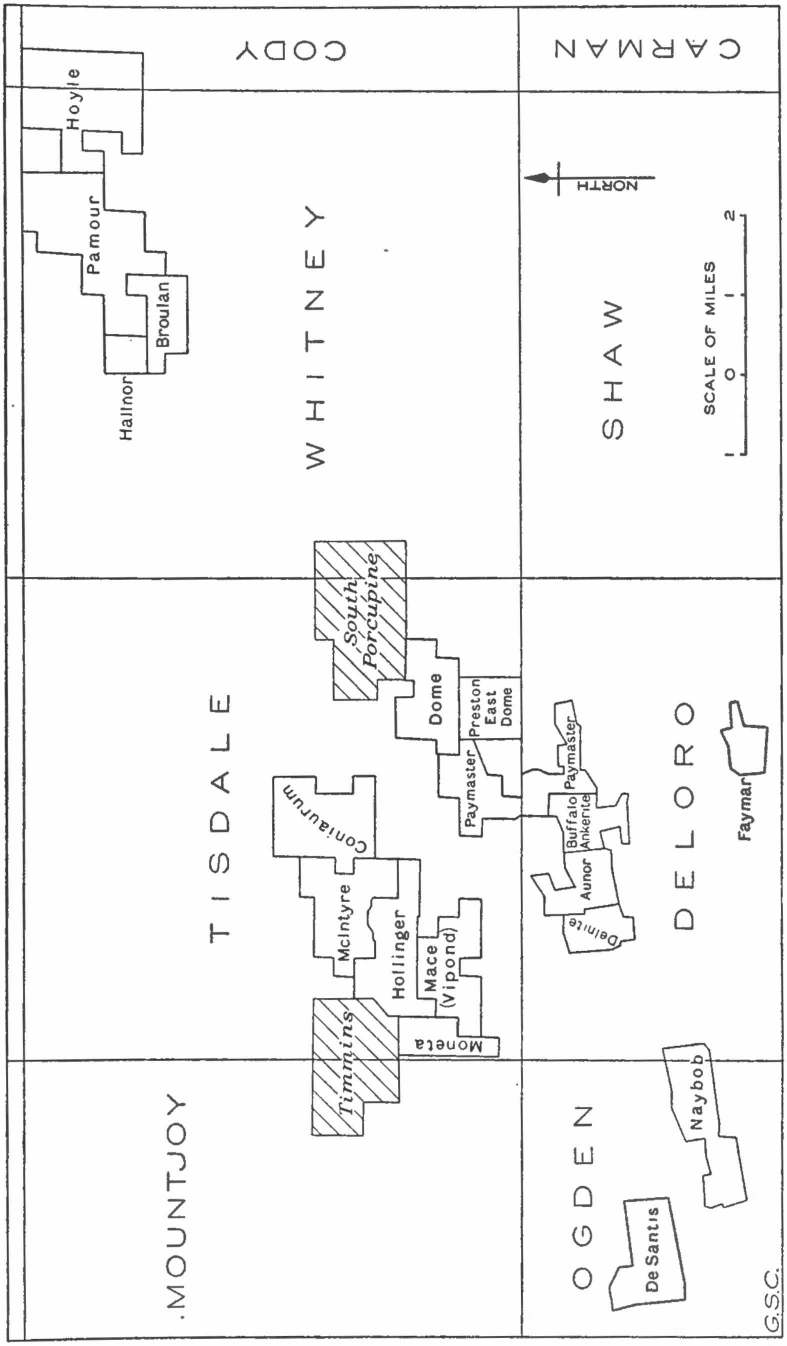

Figure 6. Position of principal mines, Porcupine district, Ontario. 1, Hoyle; 2, Pamour; 3, Hallnor; 4, Broulan; 5, Porcupine Lake; 6, Preston East Dome; 7, Dome; 8, Coniaurum; 9, McIntyre; 10, Gillies Lake Porcupine; 11, Hollinger; 12, Moneta; 13, Mace; 14, Paymaster Consolidated; 15, Buffalo Ankerite; 16, Delnite; 17, Naybob; 18, De Santis.

the porphyry is a somewhat more favourable host for ore, for some of the best developments of the last few years are said to have been in veins in the porphyry.

On the McIntyre property northeast of the Hollinger only one vein of importance and a few of subordinate value outcrop north of the Pearl Lake porphyry mass. Owing, however, to the southward dip of the porphyry body, and its eastward recession with depth, other members of the Hollinger vein system appear at depth on McIntyre ground *beneath* the porphyry mass. Development of the McIntyre mine has been based on the hypothesis that with increasing depth more and more of such veins would be found. Time has proved the truth of this geological inference, so that the McIntyre mine has become progressively more valuable as exploration at depth continued.

On the property of Coniaurum Mines, lying east of the McIntyre, the zone of maximum shearing has narrowed to about 500 feet, and appears to be narrowing still more to the east. Other sheared belts are known on the property, but whether they are branches of the wide Hollinger sheared zone is not known. The dip of the shearing is steeply north here, instead of steeply south as on the Hollinger. The flows, however, dip steeply south, so that the shearing cuts across them at angles of 15 to 20 degrees. Orebodies are found in those sections where the zone of shearing cuts across the rather coarse-grained, non-pillowed lower parts of the lava flows, locally termed "greenstones"; and are particularly numerous in the neighbourhood of porphyry masses, several of which have been found underground that do not come to the surface. As in the Hollinger and McIntyre mines, the orebodies of Coniaurum mine pitch or rake to the east at a general angle of about 65 degrees, following the pitch of the drag-folding and of the porphyry masses.

The ore in the Hollinger and McIntyre mines consists of quartz and mineralized schist. The quartz of the productive veins in the central ore zone is accompanied by ankerite and small amounts of albite, tourmaline, and scheelite. Albite is most abundant near the margins of the quartz-ankerite zone, and tourmaline and scheelite near the Millerton porphyry. The metallic minerals are arsenopyrite, pyrite, pyrrhotite, sphalerite, chalcopyrite, galena, tellurides, and native gold. The schist near the veins is much altered by addition of silica, carbonate, potash, which appears as sericite, and auriferous pyrite; and the orebodies, composed of quartz and auriferous schist, range in width from 1 foot to 75 feet, with an average of about 10 feet. The amount of auriferous schist mined is considerably greater than the amount of quartz. Few of the veins, or rather lodes, are continuous for long distances, though some have been traced as much as 1,000 feet laterally and vertically.

The distribution of the quartz in the veins is most irregular, but most of them can be classed under three general types. In one of these quartz fills the whole width of the vein, forming a definite lead usually composed of a succession of lens-like masses. The second type consists of a main body of quartz with numerous branching stringers running off into the surrounding schist, some parallel to the schistosity, others cutting it at various angles. In the third type, the "vein" is composed of a succession of quartz lenses separated by schist, each lens lying parallel to the schistosity, with the next lens offset to the left, *en échelon*. Lodes may also consist of a multitude of narrow stringers varying widely in dip and strike. Others may have a banded appearance through the inclusion of numerous, narrow, sub-parallel strips of schist in the quartz.

Gold is the principal constituent of value, in places free, but more commonly combined with pyrite or other sulphides. Some of the ore is highly spectacular, with gold in coarse plates and cords traversing the quartz and binding it together. As a rule the gold contains a little silver, and averages about 850 fine. The gold associated with the pyrite occurs as blebs on the surface of the pyrite cubes or enclosed in them, or traversing the cubes in the form of veinlets.

Veinlets of gold also cut through crystals of tourmaline, scheelite, albite, and arsenopyrite, so that it was evidently one of the last minerals deposited. Much gold is found in and near patches of ankerite, generally where the latter are embedded in quartz; and the gold is likewise later than the ankerite.

It is clear that these veins were formed at high temperatures and pressures. In addition to the presence of high-temperature minerals such as albite, tourmaline, pyrrohotite, and scheelite, their quartz, which is coarsely crystalline, contains numerous gas and liquid inclusions. The veins, also, nowhere exhibit the banded or crustified structure characteristic of low-temperature fissure fillings.

A second type of vein, later in age, is found outside of the central productive ore zone mainly, but is also present to some extent within it. In these veins calcite is found, instead of the ankerite of the productive type; the amount of calcite may be small relative to that of quartz, or the veins may be nearly all calcite. Other constituents, present in small amounts, are tourmaline, axinite, epidote, fouqueite, sericite, chlorite, and gold. None of these veins carries mineable ore.

The Dome mine began its operations in 1910 on orebodies of a somewhat different character, though with much the same mineral associations. The property lies close to the extreme south edge of the main syncline of Timiskaming sediments, where a sharp drag-fold has infolded a deep, narrow, synclinal trough of the sediments in the Keewatin greenstone. The first orebodies of the Dome were found in the sediments of this infold. Like the main syncline, it plunges to the east-northeast. The north side is almost vertical, and the sediments within it are carried to a depth of about 2,500 feet. Toward the western end the syncline is simple, but some hundreds of feet farther east an anticlinal wrinkle appears at the bottom, so that the syncline thus becomes compound and broader. The sediments of the syncline are beds of conglomerate with more or less greywacke, interspersed with beds of slate. All the rocks in and near this minor syncline are strongly sheared and form part of a belt of schistose rock some miles in length.

The orebodies were of extremely irregular shape, utterly unlike the more or less regular veins and lodes of the Hollinger and McIntyre mines. They might be termed irregular lenses. They varied in length up to 600 feet, and in width from 30 to 150 feet. The depth of some was found to be as much as 800 feet, that of others less than 100 feet. More than thirty such bodies were found. They were commonly developed in the conglomerate-greywacke parts of the Timiskaming series, but not in the slate, which appears to have been impermeable to the ore-bearing solutions. Many were, therefore, overlain or underlain by slate bands; at the sides and ends, however, they faded imperceptibly into barren conglomerate. As the syncline plunges east-northeast, the orebodies also naturally plunged in the same direction. They had a more easterly strike than the sediments, so that they tended to pass across the syncline from the north side to the south.

Toward the middle of the south side of the syncline an intrusive body of porphyry broke across the steeply dipping sedimentary beds. Beneath the overhanging porphyry roof, and extending upward a short distance into the porphyry itself, were some of the richest orebodies of the mine. This occurrence, together with those of ore formed beneath impervious slates, suggests that one factor of ore formation may have been the damming of moving solutions by slate or porphyry.

In the eastern part of the mine, where the syncline is broken into two by the anticlinal wrinkle already mentioned, it was found that orebodies were most numerous along the synclinal axes and were practically absent along the anticlinal axis.

The ores consisted, as at the Hollinger, of quartz and mineralized schist, but the proportion of schist was much larger, amounting to nearly 85 per cent.

The proportion of quartz in the different orebodies varied greatly, from moderately large in some to insignificant in others. Some of the ore was simply dark grey schist spotted with pyrite and cut by vague veinlets of quartz. Most of the gold occurred in combination with pyrite, which sulphide formed nearly 5 per cent of the ore. The other minerals present were, for the most part, those found in the Hollinger.

These orebodies were completely worked out about the year 1928, and the management then proceeded to push exploration into the greenstones to the north. The work in this section opened valuable new orebodies, the discovery of which has greatly lengthened the life of the mine. The following information has been obtained through the courtesy of the mine management, to whom the writer wishes to express his sincere thanks.

The Keewatin rocks are a succession of flows, named respectively, leucoxene lava, amygdaloidal pillow lava, dacite, andesite, and spherulitic lavas. All these strike north 75 degrees east, dip about 70 degrees north, and face north. The flows range from 60 to 300 feet in width, and the individual members are remarkably uniform. Volcanic structures and textures are remarkably well developed in them. Some exhibit the characteristic succession of chilled base, massive equigranular body, and brecciated or flowy top. Others have pillow structures and may be amygdaloidal. Still others display characteristic spherulitic horizons that have proved to be excellent markers in the series. In places narrow, persistent bands of thinly bedded, carbonaceous tuff or bedded chert separate the flows. To the south of these lies the small syncline of Timiskaming sediments, and it seems clear that there must have been faulting along this contact to account for the manner in which the sedimentary beds abut on the contact.

During the final stages of the folding, or perhaps at some later date, stresses caused fracturing along vertical, east-west zones. These zones average about 30 feet in width, but may attain 100 feet or even more. Where the fracture zones cut brittle rocks, such as the dacite or andesite of the Keewatin or the conglomerate of the sediments, they give rise to important orebodies, but where they pass into softer rocks that shear rather than fracture, no orebodies are formed. The dacite fractures more readily than the andesite, so that some important orebodies are found in it alone.

The fracture zones are a complex of quartz veins, which in general strike northeast and dip 35 to 45 degrees northwest, thus crossing the zones both along the strike and the dip. Individual veins may attain widths of 2 feet. Small quartz veins also fill fractures running in various direction, yielding irregular and interlocking masses. Altogether about 30 per cent of the total volume of the fracture zones in the greenstones is quartz.

The quartz veins carry pyrite, pyrrhotite, and free gold, and are normally selvaged with ankerite. The rock between the veins is altered and carbonated, and carries about 3 per cent of the same sulphides. Alteration gradually fades out with increasing distance from the veins.

In addition to the orebodies formed in the lavas and sediments by fracturing a third type is produced by the alteration of tuff beds lying between lava flows. These beds were apparently cut and more or less altered by an older set of barren veins made up of quartz, tourmaline, and ankerite. Later movement fractured this material, and permitted the entry of gold-bearing quartz mineralized with small amounts of pyrite and pyrrhotite. This quartz forms a series of veinlets crossing the older vein material in a ladder structure. The bodies thus formed range from a few inches to 14 feet in width, and have been proved to have horizontal and vertical dimensions, in some cases, of more than 1,000 feet.

The Buffalo Ankerite property is in Deloro township about a mile from the north boundary. The rocks are a series of rather acid flows alternating with basic flows and ash rocks, the whole intruded by sill-like lenses of quartz porphyry. Much of the basic volcanic material has been converted into chlorite schist, and this in turn, apparently, to brown carbonate rock netted with small quartz veins. These rocks have been bent into a synclinal drag-fold, the axis of which strikes west-northwest and plunges northwest at a high angle. Such a drag implies a westward, almost horizontal movement of the rocks to the north.

Three principal vein zones have been developed, two on the normal west-striking limb of the drag-fold, and one on the limb that strikes a little west of north. The latter, or North Zone, is a series of veins striking approximately north 40 degrees west, or slightly more westerly than the strike of the lavas, and dipping about 80 degrees southwest. They tend to lie in a band of acid lava, or along its contact with an andesite flow, but they also in places cut into the andesite. Numerous branch veins and stringers run off westerly from the main veins into the hanging-wall, particularly where this is acid lava.

The vein material is chiefly massive black tourmaline carrying fragments of carbonate and cut by horizontal or vertical stringers of quartz that lie at right angles to the walls. These seem to fill tension cracks and are probably later than the main mineralization. The tourmaline is mineralized with finely crystalline pyrite, which carries all the gold; in many places it occurs in rosette-like patches. The foot-wall of the veins exhibits little or no alteration, but the hanging-wall, especially where branch veins are numerous, has been extensively metamorphosed. In andesite the alteration is mainly silicification accompanied by addition of pyrite, and is sufficient in places to convert the whole mass into ore. The acid lava, on the other hand, is altered to carbonate, and becomes bright orange in colour where alteration has been intense.

The north orebody, in places 100 feet or more in width, rakes southward at angles of 60 to 70 degrees.

The south vein zone includes at least three veins that strike east-west, approximately parallel to the strike of the lavas, and dip about 60 degrees north. In composition they are similar to the north vein, but with somewhat more quartz. The quartz is smoky, due to the presence of minute tourmaline needles, and in many places contains free gold. As in the north vein, also, the veins tend either to lie entirely within bands of acid lava, or to follow contacts between such bands and the bands of basic lavas or tuffs. Where the latter is the case, the foot-wall is not uncommonly altered to brown carbonate, but this alteration does not appear to have been caused by the vein-forming solutions, but was, apparently, completed before they were introduced.

The Hallnor, Broulan, Pamour, and Hoyle properties are situated in the northeast quarter of Whitney township, on or close to the northern contact of the main syncline of Timiskaming sediments with the underlying lavas. As no good description of these properties has yet been published, Dr. M. E. Hurst, Provincial Geologist of Ontario, has very kindly supplied the following descriptions.

"The belt of Timiskaming sediments that occupies the central portion of the main Porcupine syncline extends in a northeasterly direction from the Dome mine in Tisdale township across Whitney, Cody, and Matheson townships. Since 1934 considerable exploration has been carried out along the easterly extension of this belt and especially along its north flank in the northeastern part of Whitney township. In this locality the sediments rest unconformably upon lavas and volcanic fragmentals of Keewatin age. They consist of a persistent basal conglomerate overlain by interbedded slates, greywackes, and quartzites. These rocks face south and appear to form the north limb of an overturned eastward-pitching syncline, the south limb of which has been removed by faulting and erosion. In general the strata strike north 75 degrees east and dip 80 degrees north, but local variations in strike and dip due to drag-folding are not uncommon. Numerous north-trending, post-ore faults intersect the lavas and sediments in the vicinity of the contact.

"Owing to the prevalence of overburden preliminary exploration of the volcanic-sediment contact was done by diamond-drilling. This led to the discovery of the gold-bearing deposits now being developed on the Hallnor, Broulan, Pamour, and Hoyle properties. Some of these deposits extend into the volcanic rocks but the majority of them occur in conglomerate and greywacke. They owe their location primarily to structural deformation and especially to differential movements between rocks or strata of different competency. The ore shoots occur chiefly in fracture zones in the more competent strata. They consist of sets of short, closely spaced quartz veins, usually of more than one age, which follow or angle across the favourable beds. In addition to quartz, the veins may contain one or more of the following minerals: pyrite, albite, ankerite, calcite, zincblende, galena, and, more rarely, tourmaline, chalcopyrite, pyrrhotite or arsenopyrite. The gold occurs in the native state in the vein matter and, in some instances, in intimate association with pyrite in the wall rocks.

"On the Hallnor property the volcanic-sediment contact strikes north 75 degrees east and varies in dip from vertical to 75 degrees north. The principal ore shoots lie to the south-west of the shaft. They occur in a fracture zone that strikes north 60 degrees east, dips 70 degrees southeast, rakes steeply east, and intersects the contact at an angle of 15 degrees. The combined effects of the divergence in dips and the easterly rake are such that the fracture zone passes with depth from the lavas into the sediments but tends to maintain its position relative to the volcanic-sediment contact. Throughout most of its length the fracture zone is occupied by a well-defined fissure vein, 1 to 5 feet in width, but in places the vein splits into a stock-work of stringers extending across widths up to 50 feet. The vein matter consists of much-fractured quartz containing coarse, friable pyrite, some calcite, and conspicuous amounts of native gold. Lower-grade ore shoots occur to the east of the main vein and about 350 feet south of the volcanic-sediment contact. These consist of quartz stringers, which follow the bedding of the enclosing slates and greywackes and are cut off to the east by a fault, known as the Hallnor fault. This fault strikes north 35 degrees west, dips 65 degrees northeast, and displaces the volcanic-sediment contact about 500 feet to the southeast. At the end of 1939 ore reserves down to the 960-foot level were estimated by the management at 414,653 tons averaging 0·52 ounce gold per ton.

"The deposits being developed on the Broulan property occur near the middle of the sedimentary belt, east of the projected extension of the Hallnor fault and close to the Pamour boundary. In the vicinity of the workings the sediments strike east-west, dip 65 to 80 degrees north, and have a total thickness of about 700 feet. The deposits are confined to a zone about 150 feet wide consisting of interbedded slates and greywackes bordered on the north and south by thickly bedded quartzites. The relatively incompetent slates and greywackes have been contorted into eastward-pitching drag folds. The ore shoots occur chiefly along the south, more steeply inclined limbs of the anticlinal flexures where differential movements have given rise to breccia zones extending parallel to the axes of the folds. Gently dipping, quartz-filled fractures extend outward from the breccia zones, thus producing herringbone or "S"-shaped vein patterns. The vein zones appear to migrate with the drag-folds to the north and east on successive levels. The gold occurs chiefly in the veins and is frequently found in association with zinc blende and galena. Up to April, 1940, exploration of the deposits had been carried out on four levels to a depth of 523 feet and, according to the management, ore reserves amounting to 543,000 tons, having an average grade of 0·254 ounce gold per ton, had been indicated.

"The deposits being developed on the Pamour property occur principally in a persistent band of conglomerate, which adjoins the lavas and volcanic fragmentals on the north side of the sedimentary belt or is separated from them by a band of greywacke ranging from a few feet to 100 feet in width. The conglomerate bed varies in thickness from 40 to 80 feet and is overturned to the north at an angle of 77 degrees. It is bordered on the south by 1 to 10 feet of highly sheared slate. Differential movements have been largely concentrated along the conglomerate-slate (footwall) contact. These have given rise to several sets of fractures, now filled with quartz, which extend from the contact into or across the conglomerate. The prevailing set of fractures strikes northeast and dips 30 degrees southeast. The loci of fracturing are thought to have been controlled by undulations or irregularities on the footwall contact of the conglomerate. The orebodies are lenticular in outline, their limits being determined roughly by the extent and spacing of the quartz veins. In the vinicity of the veins the conglomerate is carbonatized and impregnated with finegrained auriferous pyrite. In addition to quartz, albite is frequently present as a selvage along the margins of the veins or about wall-rock inclusions. Native gold, though present, is not as conspicuously abundant as in the Hallnor and Broulan veins. The principal ore-bearing zone dips less steeply north than the conglomerate and appears to rake eastward at an angle of about 30 degrees. At the 400-foot level stoping on this zone extends across a width of about 40 feet and a total length of 1,250 feet. At the end of 1939 ore reserves were estimated by the management at 1,778,500 tons containing an average of 0·131 ounces of gold per ton.

Production from Hollinger, McIntyre, and Dome Mines

Year	Hollinger		Dome		McIntyre	
	Tons	Fine ozs.	Tons	Fine ozs.	Tons	Fine ozs.
1910	813	1,733	247	214	....	....
1911	(a)	300	....	207(b)	....	....
1912	45,195	43,690	75,088	35,515	14,500	3,742
1913	140,131[1]	119,618[1]	131,149	59,912	29,669	11,349
1914	211,846[1]	130,853[1]	221,390	51,026	62,284	26,398
1915	441,236[1]	202,606[1]	317,740	73,726	101,955	36,094
1916	601,854	244,140	444,900	103,809	136,489	55,755
1917	514,301	204,810	359,570	71,193	175,893	81,827
1918	578,755	276,045	....	3,948	176,976	75,556
1919	711,882	322,022	187,580	61,893	185,018	95,038
1920	650,205	298,223	295,220	97,023	191,032	106,527
1921	1,072,493	435,404	335,680	110,316	172,287	87,837
1922	1,491,381	590,385	368,400	201,124	217,208	97,229
1923	1,366,352	502,680	399,800	210,610	291,390	122,528
1924	1,659,476	645,965	493,400	207,277	390,497	173,193
1925	1,929,988	757,306	530,200	210,051	419,640	178,556
1926	1,932,559	713,421	555,700	189,632	498,653	185,685
1927	2,178,329	699,657	543,300	194,200	522,880	190,562
1928	1,778,470	515,233	548,000	188,626	524,695	201,842
1929	1,549,157	455,094	452,900	173,042	550,100	206,628
1930	1,625,868	494,532	67,600	37,416	565,510	226,266
1931	1,640,705	487,123	542,600	169,686	617,425	229,413
1932	1,754,863	499,648	536,450	195,111	723,285	261,725
1933	1,727,102	481,279	546,500	218,485	754,360	261,529
1934	1,900,490	434,257	547,600	206,158	851,345	239,099
1935	1,837,153	416,050	549,100	206,795	869,100	245,206
1936	1,755,768	413,966	553,900	208,528	869,000	230,822
1937	1,719,199	424,073	576,300	213,403	870,160	233,029
1938	1,734,647	439,194	601,700	206,957	872,740	234,737
1939	1,700,355	425,614	615,000	205,480	877,830	231,744
1940	1,780,377	436,712	621,600	205,584	885,930	247,772
1941	1,756,923	425,633	627,700	201,472	865,670	238,118
1942	1,530,712	370,611	559,700	170,547	798,260	224,031
1943	1,078,946	282,356	525,900	149,641	668,700	192,869
1944	955,447	226,434	519,800	134,230	589,940	170,636
	43,352,978	13,416,667	14,251,714	4,972,837	16,340,421	5,403,342

(a) Records destroyed by fire.
(b) Recovered in laboratory.
[1] Includes production from Acme.

"The principal deposits so far developed on the Hoyle property occur in the easterly continuation of the conglomerate bed which contains the main Pamour ore zone. In the vicinity of the workings the conglomerate has a thickness, including a narrow parting of shale, of 40 to 50 feet. It dips 70 degrees north and is separated from the lavas to the north by 40 to 100 feet of greywacke. A diabase dyke encountered in the shaft has a width of 100 feet and intersects both lavas and sediments. The principal ore zone has been explored most extensively to the west of the shaft and above the 575-foot level. It consists of intersecting sets of quartz-filled fractures concentrated mainly in the footwall portion of the conglomerate. The dominant set of fractures angles across the conglomerate in a northeasterly direction and dips about 45 degrees southeast. The deposit is similar in vein pattern and mineralization to that of the main zone on the Pamour. The ore zone as a whole rakes east at 25 to 30 degrees. Early in 1940 the management estimated that exploration of this zone to a depth of 600 feet had indicated the presence of 1,300,000 tons of material containing 0·126 ounce in gold per ton."

The Preston East Dome mine[1], which although staked in 1909 had lain practically dormant until 1936, is in the southeast corner of Tisdale township. The mine differs from all the others of the district, in that practically all the ore found to date lies within a body of grey porphyry. The porphyry body is a somewhat irregular mass that extends almost completely across the property in a north-northwest direction, and dips northeast at about 45 degrees. Within the Preston East Dome boundaries the mass has a length of about 2,400 feet and widths ranging from 150 to 900 feet. The west or foot-wall side of the mass is a belt of strongly sheared rock 100 feet or more in width, which probably is the locus of a major fault. Subsidiary shears branch from this into the porphyry and appear to have exercised an important degree of control on ore deposition.

All the ore lies either within the porphyry or in the country rock immediately along contacts. The principal bodies are replacement lenses in the porphyry following zones of fracturing. They are of erratic distribution and considerable size, some of them attaining widths of more than 100 feet. They have no well-defined walls, but grade into the country rock. The mineralized porphyry, which is cut by veins and lenses of quartz, is bleached and converted to mixtures of sericite, secondary quartz, carbonates, and albite. The ore minerals comprise a great deal of pyrite, with pyrrhotite, sphalerite, chalcopyrite, galena, and native gold. Tourmaline is fairly plentiful and scheelite common. These ores average about a quarter of an ounce of gold per ton.

In addition to these ores, a number of high-grade veins have been found, made up of bluish white quartz with abundant black tourmaline. These veins, which are usually less than a foot wide and are most irregular in shape, have been found to carry rich "bonanza shoots" in which native gold is abundant and in places spectacular. Although the relative volume of these veins is small, they have been estimated to produce one-quarter or more of the gold recovered.

Production figures for the remaining mines of Porcupine district, during the life of the mine or to the end of 1944 as the case may be, are given in the following table.

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[1] The Preston East Dome Mine, by the Staff; Can. Min. Jour. 62, pp. 503–516 (1941).

Name	Period of operation	Tons milled	Gold, ozs.
Aunor	1940–44	756,578	226,529
Ankerite	1926–29	172,441	41,547
Bonetal	1941–44	101,002	15,340
Broulan Porcupine	1939–44	620,625	136,892
Buffalo Ankerite	1932–44	3,469,957	664,522
Coniaurum	1928–44	2,445,135	623,937
Davidson Consolidated	1918–20	9,371	2,438
Delnite	1937–44	967,024	168,657
De Santis Porcupine	1939–42	191,298	35,213
Devon	1940	2,333	42
Dome Lake	1917–20	37,457	10,481
Faymar Porcupine	1940–42	119,181	21,851
Gillies Lake Porcupine	1935–37	27,936	10,136
Hallnor	1938–44	793,902	383,848
Hoyle	1941–43	452,696	47,441
Mace[1]	1937–39	193,825	23,275
Marbuan[2]	1934–35	85,410	11,449
March Gold[3]	1926–31	202,747	45,628
Moneta Porcupine	1938–43	314,829	149,251
McLaren Porcupine	1934–35	650	119
Nakhodas	1940–42	44,028	6,521
Naybob	1935, 1938–42	231,492	46,317
Newray[4]	1913–4, 1917–9	14,804	7,084
Night Hawk Peninsular	1924–26	99,708	27,258
Northcrown Porcupine	1920–21	11,678	5,458
Pamour Porcupine	1936–44	4,220,945	540,426
Paymaster Consolidated	1934–44	1,696,612	358,366
Porcupine Crown	1913–20	209,409	133,272
Porcupine Lake	1937–40	9,889	1,267
Porcupine Paymaster	{1922, 1926–28}	184,228	18,547
Porcupine United	1929–31	14,259	5,141
Preston East Dome	1938–44	1,298,553	372,971
Ross Mine[5], Hislop tp	1936–44	618,485	139,002
Schumacher[6]	1916–18	102,884	24,858
Vipond[7]	1911–18	144,345	39,363
Vipond	1923–36	1,227,245	350,671
West Dome Lake	{1924–27, 1929–30}	133,875	37,379

[1] Also yielded 1,300 ounces of gold in 1941 from cleanup operations.
[2] Sold to Buffalo Ankerite, Dec. 31, 1935.
[3] Sold to Marbuan Gold Mines in 1933.
[4] Sold to Coniaurum Mines, June 12, 1924.
[5] Owned by Hollinger Consolidated Gold Mines, Limited.
[6] Afterwards bought by Hollinger Consolidated Gold Mines.
[7] Became Mace Gold Mines in March 1937.

Small amount of gold have also been produced from time to time by a number of other properties.

KIRKLAND LAKE DISTRICT

In Kirkland Lake area the principal mines are the Macassa, Kirkland Lake, Teck-Hughes, Lake Shore, Sylvanite, Wright-Hargreaves, and Toburn, all in Teck township. In Lebel township, adjoining Teck on the east, Bidgood Kirkland Gold Mines has been operating since 1934, and a few other properties have produced small quantities of gold. In Gauthier township Upper Canada Mines came into production in 1938.

The seven principal mines first mentioned are situated in the middle of a large mass of Timiskaming sediments. As at Porcupine the sediments are conglomerate and greywacke with some slate, closely folded and dipping at high angles. Where the orebodies occur the sediments are intruded by two igneous rocks, the older a diorite, the younger a reddish syenite porphyry composed of albite and anorthoclase phenocrysts in a feldspathic groundmass. These rocks occupy the greater part of the producing area. The syenite porphyry forms a large mass on the Wright-Hargreaves property, extending almost to the Lake Shore boundary. On the west it throws off long dykes that cut the diorite and sediments on the Lake Shore and Teck-Hughes properties.

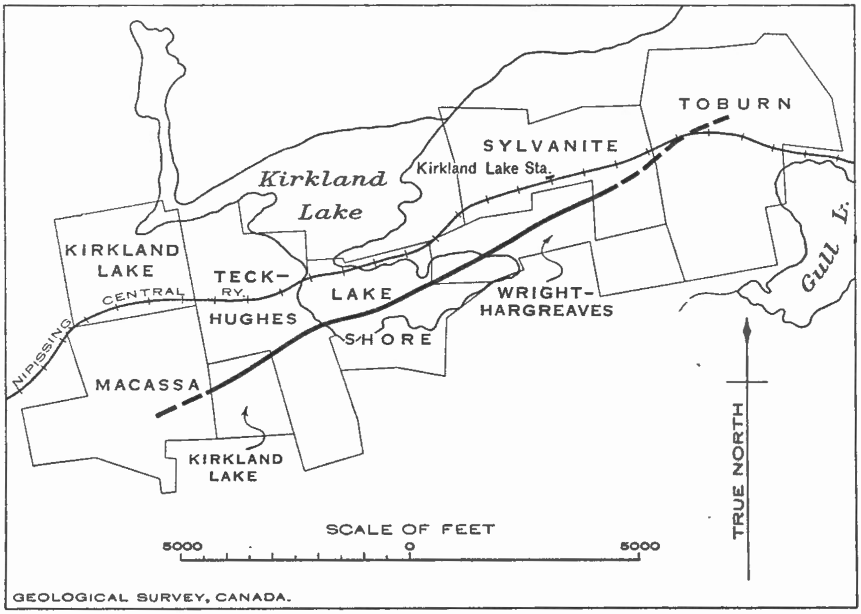

Figure 7. Position of principal mines, Kirkland Lake district, Ontario. Mineralized fault shown by heavy black line.

A large pre-mineral fault cuts all the rocks described, with a strike north 62 degrees east and a dip of 85 degrees south. The south side of the fault has been thrust upward about 2,000 feet. On the Kirkland Lake, Teck-Hughes, and western half of the Lake Shore properties, the greater part of the fault movement has been concentrated along one plane. To the east the fault is split into two faults 300 to 600 feet apart on the eastern part of the Lake Shore and on the Wright-Hargreaves properties. Still farther east, on the Toburn, the fault splits again into many small faults.

The ore has formed in the crushed and shattered zone of the fault. The width of this zone varies greatly. In places the walls of the fault zone are close together, and there the orebody is lean and narrow, as the rock was very completely crushed to a clayey gouge not readily replaced. Where the zone was wider, the intervening rock was brecciated rather than powdered, thus affording not only a good channel for the passage of solutions, but also material that was readily replaced. For the most part these brecciated zones are 5 to 10 feet wide, and yield ore of good grade. In a number of places the fault splits into two branches that unite again farther on, enclosing a horse of country rock. Such a horse, in many instances, was sufficiently brecciated to permit the entry of ore-bearing solutions, with consequent formation of great widths of ore. Rich bodies 50 feet or even more in width have been thus formed.

The nature of the country rock had a profound influence on ore formation. The syenite porphyry, a hard, brittle rock, shattered readily in faulting, but did not form schist, and, consequently, the veins in the porphyry are of good width and grade. The complex of porphyry dykes and diorite on the Teck-Hughes and western part of the Lake Shore properties shattered even more readily and widely, and consequently in this section the veins are widest and richest. Where the fault passes into other rock types, such as diorite or

Production Table for the Principal Mines of Kirkland Lake District

Year	Kirkland Lake		Lake Shore		Macassa		Sylvanite		Teck-Hughes		Tough-Oakes		Wright-Hargreaves	
	Tons milled	Gold, fine ozs.	Tons milled	Gold, fine ozs.	Tons milled	Gold, fine ozs.	Tons milled	Gold, fine ozs.	Tons milled	Gold, fine ozs.	Tons milled	Gold, fine ozs.	Tons milled	Gold, fine ozs.
1913	......	......	......	......	......	......	......	......	......	......	2,220	3,164	......	......
1914	......	......	......	......	......	......	......	......	......	......	3,734	5,524	......	......
1915	......	......	......	......	......	......	......	......	......	......	26,196	26,658	......	......
1916	......	......	......	......	......	......	......	......	......	......	39,865	33,991	......	......
1917	......	......	......	......	......	......	......	......	11,257	3,181	38,695	16,384	......	......
1918	......	......	16,749	20,031	......	......	......	......	14,774	3,869	22,000	6,620	......	......
1919	11,324	2,675	11,081	12,696	......	......	......	......	18,387	8,156	......	......	......	......
1920	40,812	13,795	19,779	24,292	......	......	......	......	30,646	11,910	......	......	......	......
1921	43,966	11,678	21,817	23,896	......	......	......	......	34,693	15,582	......	......	36,053	22,617
1922	37,489	10,814	24,279	22,737	......	......	......	......	41,194	28,780	16,108	5,144	66,181	36,748
1923	45,449	10,747	23,203	26,431	......	......	......	......	38,314	53,955	1,803	580	79,242	36,370
1924	8,091	2,236	56,168	53,053	......	......	......	......	44,209	49,350	8,438	2,281	84,487	52,465
1925	......	......	109,273	94,456	......	......	......	......	55,220	48,077	34,152	12,625	147,939	92,286
1926	10,829	6,112	171,197	133,893	......	......	......	......	80,074	77,266	43,871	14,819	153,392	103,793
1927	52,648	22,778	236,818	162,829	......	......	40,479	20,596	153,881	134,279	38,999	7,484	209,164	103,790
1928	57,883	19,962	279,661	196,533	......	......	69,791	35,452	317,213	238,888	14,396	3,967	256,331	88,580
1929	53,595	16,999	430,170	293,587	......	......	74,523	33,168	337,630	243,745	290,477	139,241	188,238	83,631
1930	52,106	25,764	550,501	377,831			81,213	38,303	338,555	260,775	Toburn		220,430	117,455
1931	52,628	28,315	816,580	533,757			91,621	43,437	444,410	294,422			266,352	140,520
1932	56,492	25,323	818,698	610,463			96,891	39,919	475,700	282,882	14,689	9,841	295,525	171,299
1933	49,487	18,465	808,917	499,800	8,101	3,683	96,937	44,608	474,700	220,036	36,913	23,020	285,465	177,190
1934	64,952	20,316	836,023	472,762	66,557	32,056	111,767	50,337	442,745	167,412	36,230	20,401	354,418	218,203
1935	71,920	22,051	836,322	461,019	68,627	30,272	152,281	54,356	417,917	138,987	35,360	20,200	361,149	213,471
1936	84,679	21,256	887,571	451,847	70,878	35,894	162,185	59,789	403,712	135,262	34,440	20,577	400,310	216,210
1937	84,886	35,666	900,321	443,160	90,617	41,762	174,566	63,393	412,430	124,999	37,465	26,243	436,500	224,092
1938	92,655	42,103	921,837	429,182	110,718	50,213	190,714	68,623	380,215	102,816	52,434	31,553	434,650	221,204
1939	99,401	47,323	856,586	368,320	148,085	63,886	201,331	68,249	379,175	94,775	55,272	33,506	438,710	225,907
1940	137,986	53,229	647,426	283,349	150,674	69,486	212,519	68,930	317,560	92,764	59,524	33,619	442,920	225,235
1941	136,613	48,767	530,368	205,334	142,332	65,375	197,293	67,160	258,100	65,714	60,715	28,422	411,760	208,937
1942	100,854	37,846	347,951	144,101	120,400	55,582	175,745	52,418	93,335	35,427	43,635	18,915	283,580	146,959
1943	83,987	30,863	293,398	133,906	103,259	42,854	148,190	52,515	100,705	32,456	40,905	15,798	225,710	113,343
1944	77,457	27,326	258,544	109,469	83,392	36,241	137,822	44,650	102,920	25,660	39,940	12,780	184,520	90,614
Totals	1,608,199	602,409	11,711,238	6,588,734	1,163,640	527,304	2,415,868	905,903	6,219,671	2,991,425	547,522	294,875	6,263,026	3,330,919

Notes: The Tough-Oakes property was operated in 1922–23 by Kirkland Lake Proprietary, Ltd.; in 1924–28 by Tough-Oakes Burnside Gold Mines, Ltd.; and in 1932–44 by Toburn Gold Mines.

sediments, shearing rather than shattering occurred. Such schistose fault gouge does not appear to have been favourable for passage of solutions or for replacement, because, although scattered nests of ore occur in it, they are not numerous or large enough to be profitably mined.

On the Toburn property to the east, where the fault breaks into a large number of smaller faults, many veins of rich ore up to 5 feet in width were found.

The ore consists mainly of mineralized porphyry with more or less quartz. In places quartz occurs as large masses nearly the full width of the vein, but more often it is found intersecting the porphyry in numerous thin strings and ribbons. Some calcite is present. The wall-rock is commonly greatly altered to a mass of sericite and carbonate, and analyses show pronounced additions of potash and carbonic acid, and a decrease in soda. Gold and gold tellurides are the principal constituents of value; 2 or 3 per cent of pyrite is commonly present, but does not appear to be highly auriferous. Tellurides are present in considerable variety and amount. Altaite (PbTe) is the most abundant; it is usuallly accompanied by free gold, and its presence in many cases indicates high-grade parts of the vein. Calaverite ($AuTe_2$) and petzite ($(AgAu)_2Te$) are not uncommon and hessite (Ag_2Te), coloradoite (HgTe), tetradymite ($Bi_2(TeS)_3$), and melonite ($NiTe_3$) have also been identified. Other minerals present in small quantity are chalcopyrite, galena, sphalerite, molybdenite, and graphite.

The previous descriptions suggest that the Kirkland Lake ores are intermediate in type between the Porcupine ores and those of western Ontario and Manitoba. At Porcupine much of the gold occurs in auriferous pyrite, and large bodies of schist are so mineralized with the auriferous pyrite as to be commercial ore. In western Ontario there is little auriferous pyrite, and no mineralized schist of value, but the gold occurs free in quartz and commonly in rather coarse particles. At Kirkland Lake there is likewise little auriferous pyrite, and no schist ore of the Porcupine type, but the gold accompanies quartz, and is largely free. Unlike the ores of western Ontario, however, most of the gold is in very small particles, so that spectacular specimens are rare; and a good deal of it is present as telluride. As in western Ontario, however, the best orebodies are found where fault zones cut hard, brittle rocks. On the whole, the Kirkland Lake ores seem more analogous to the Howey orebody than to the ores of Porcupine district; but, unlike the western Ontario deposits, they have no demonstrable connexion with any known body of granite or other igneous rock. The general impression gained from a study of these ores is that they represent a lower temperature type of deposition than the usual deposit of western Ontario, and perhaps also than that of Porcupine.

Production figures for smaller properties that have operated or are operating in Teck, Lebel, and Gauthier townships are as follows:

Name	Period of operation	Tons milled	Gold, ozs.
Bidgood Kirkland	1934–44	427,944	113,640
Golden Gate	1936–42	92,679	26,451
Moffatt Hall	1934–35	16,388	4,768
Morris Kirkland	1936–41	127,253	16,669
Ontario Kirkland	1922	6,496	483
Upper Canada	1938–44	426,742	173,215

OTHER AREAS IN NORTHEASTERN ONTARIO

Gold deposits of sufficient merit to warrant development have been found in a number of other areas, the most important of which are those of Munro township, Hislop township, Lightning River, Larder Lake, Matachewan, West Shiningtree, and Boston Creek.

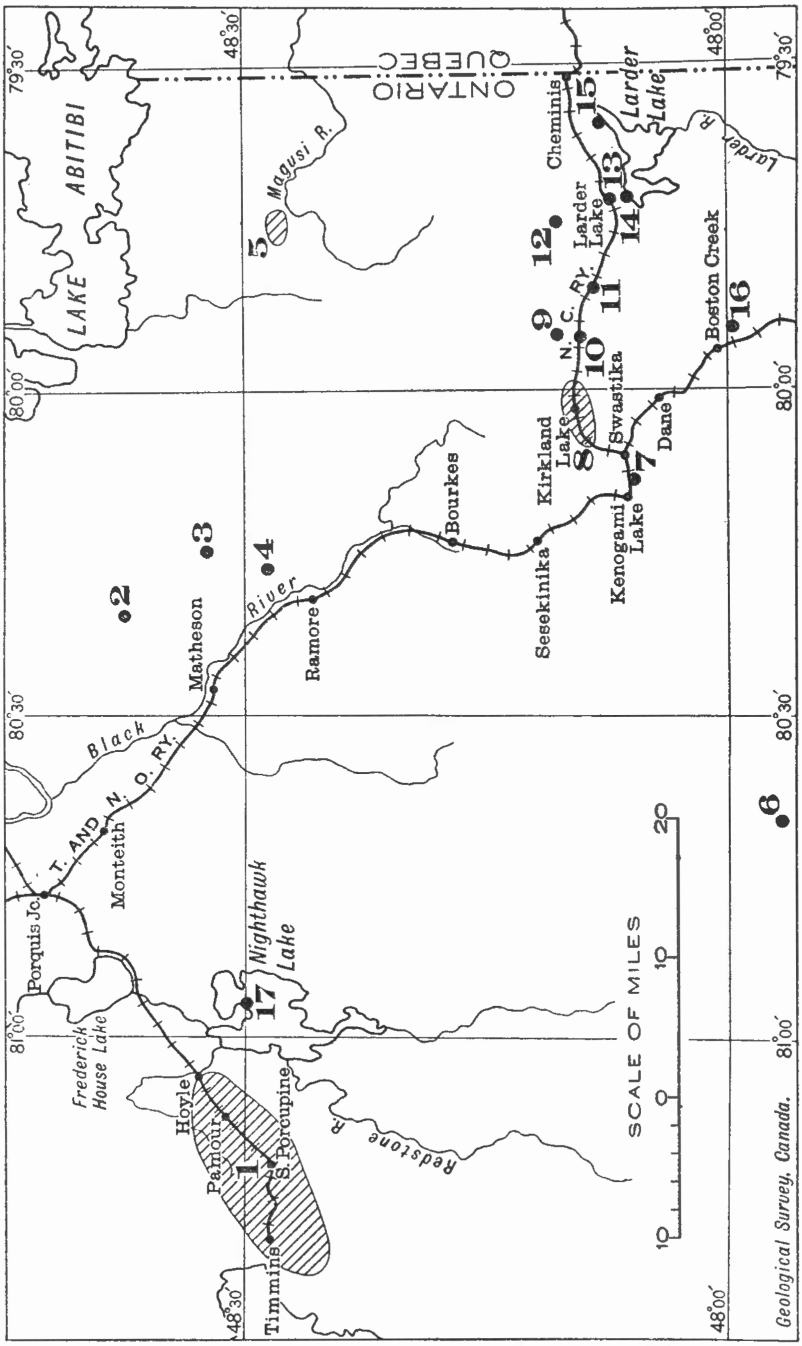

Figure 8. Index map of a part of northeastern Ontario, showing principal known occurrences of gold. 1, Porcupine district; 2, Hattie; 3, Croesus; 4, Ross mine (Hollinger); 5, Lightning River; 6, Matachewan (Ashley, Young-Davidson, Matachewan Consolidated); 7, Golden Gate; 8, Kirkland Lake district; 9, Bidgood Kirkland; 10, Morris Kirkland; 11, Upper Canada; 12, Argonaut; 13, Omega; 14, Laguerre; 15, Kerr Addison, Chesterville; 16, Barry Hollinger; 17, Night Hawk Peninsular.

Munro township is chiefly famous for the Croesus mine, a small deposit of what was probably the richest ore ever mined in Ontario; 765 pounds of ore taken from one place in the shaft yielded $47,000 worth of gold, or 2,274 ounces. The deposit was a quartz vein rich in native gold, with a little pyrite and arsenopyrite. The vein was about 200 feet long, and ranged from a few inches in width on the north to a few feet on the south, where it was cut off by a series of east-west faults. Mining was done in 1916-8, and again in 1923, with a total recovery of 9,748 ounces[1] of gold from 3,228 tons of ore. Other properties in the neighbourhood display rather small quartz veins carrying some visible gold, more or less pyrite, and galena in places. None has proved of commercial value.

A number of properties in Hislop, Guibord, and Playfair townships have been extensively prospected, but only one has as yet been brought into production. This is the Ross mine, in the north half of lot 1, con. II, Hislop tp. The mine is owned by Hollinger Consolidated Gold Mines, Limited.

A strong fault that strikes north and dips from 72 degrees west to vertical cuts much silicified and carbonated rhyolitic tuffs interstratified with some thin flows of acid lava. The fault appears to be normal, and there was movement on it before, during, and after ore deposition. The rock for at least 100 feet to the east and for several hundred feet west of the fault has been shattered into innumerable blocks of all sizes, and the whole mass is filled with a very complex network of quartz veins and veinlets. When E. S. Moore[2] examined the property in 1936 two orebodies were known, one to the east and the other west of the fault. The east orebody had a developed width of 75 feet and a length of 400 feet; it was bounded by the fault on the west and graded on the east into barren rock. The size of the west orebody was not stated, except that it had been crosscut on the 300-foot level for nearly 100 feet, and ended on the west in a dark, dense lava cut by small stringers of quartz.

The altered and mineralized tuff is highly impregnated with quartz, carbonate, mariposite, sericite, and pyrite, and is cut by quartz-carbonate veins up to 18 inches wide. The mariposite gives much of it a green colour. Values do not seem to be proportional either to the quartz or pyrite present, so that constant assaying is required to determine the ore. For production figures *See* table, page 59.

The Lightning River deposits occur in Harker and Holloway townships, south of Abitibi Lake. Although none of the properties has yet become a producer, the deposits are of interest because they resemble closely the Porcupine type. They are zones of shattering or shearing that have been invaded by auriferous solutions and mineralized with quartz, carbonate, auriferous pyrite, and a little free gold.

At Larder Lake the country rocks are altered along great shear zones to masses of ferruginous carbonate shot through with small quartz veins. These carbonate bodies contain scattered flakes of free gold, and in parts are rich in the precious metal. Exploratory operations were carried on for many years on these bodies, without success, until the rise in the price of gold in 1934 made it possible to attempt mining some of the parts of higher grade. The following production table shows the working properties and the grade of ore encountered:

Name	Period of operation	Tons milled	Gold, ozs.
Chesterville	1939–44	1,161,130	154,763
Kerr Addison	1938–44	3,473,332	593,103
Laguerre[3]	1937–39	40,514	7,568
Yama	1941–42	22,250	2,635

[1] Total production from the Croesus seems to have been more than this, presumably from gold recovered during the sinking of the shaft in 1915, a year for which no production figures are given. P. E. Hopkins, writing in 1919 (Ont. Bur. Mines Rept., vol. 28, pt. 2, p. 55) states that total production to the end of 1918 amounted to $259,953 in gold and a small amount of silver. With gold at the then value of $20.67 an ounce, this corresponds to 4,160 ounces more than the published returns for 1916–18, which were 8,456 ounces. It is definitely stated, also, that the rich pocket of ore in the shaft was found in 1915; this alone would account for 2,274 ounces.

[2] Moore, E. S.: Geology and Ore Deposits of the Ramore Area; Ont. Dept. Mines, Ann. Rept., vol. 45, pt. 6 (1936).

[3] Formerly the Harris-Maxwell, later Raven River Gold Mines.

In 1920 orebodies of a different type were found to the north and west of the carbonate bodies, on claims at first owned by Canadian Associated Goldfields and Crown Reserve Consolidated Mines, but now the property of Omega Gold Mines. The ores are lavas and tuff beds highly altered by thermal solutions to mixtures of calcite, quartz, and some albite or oligoclase, the whole coloured bright red in places with fine-grained hematite, and thickly sprinkled with auriferous pyrite and arsenopyrite. The orebody was a lens about 1,000 feet long, with a maximum width of 40 feet, but it was cut off below the 500-foot level by a fault. According to press reports, however, either its continuation or a new orebody has been found at the 1,175-foot level.

In 1927-8, Canadian Associated Goldfields milled 22,585 tons of this ore and recovered 2,517 ounces of gold. Since the property was taken over by Omega Gold Mines, 1,348,895 tons have been milled during the years 1936-44 inclusive, and 180,412 ounces of gold have been obtained.

At the Argonaut mine, about 6 miles northwest of Larder Lake, mining operations were carried on for many years on a vein largely of massive chalcopyrite with some quartz and calcite. The chalcopyrite carried high gold values, in places $200 a ton. The ore appears to have been deposited from solutions heated by a large dyke of quartz diorite. Near the dyke the vein changed in composition, and became a mass of high-temperature minerals such as magnetite, hornblende, and epidote, with some tourmaline and axinite. Because with increasing depth the dyke approached closer and closer to the vein, these changes eventually caused the mine to be abandoned in 1929. Since that time sporadic attempts have been made to renew operations, but only a few ounces of gold have been recovered. Total production from the opening of the mine in 1919 to the last attempt at mining in 1935 was 37,932 ounces of gold from 131,126 tons of ore. In addition, the ore yielded many thousands of dollars worth of copper.

At Matachewan two types of ore are known. In one, a body of syenite porphyry is sliced by numerous joints, and the joints are filled by narrow quartz veins carrying free gold. A large body of rock is thus converted into a low-grade ore averaging about one-tenth ounce a ton. The property, known as Young Davidson Mines, is being operated by Hollinger Consolidated Gold Mines. To the end of 1939, approximately, the ore was extracted by open-pit methods at the rate of about 1,000 tons a day, but underground operations are now being undertaken. In the years 1934-44 inclusive, 299,459 ounces of gold were extracted from 3,022,289 tons of ore.

The other type of ore, mined by Matachewan Consolidated Mines, consisted of volcanic tuff altered by pegmatite dykes to mixtures of calcite, sericite, and albite, and mineralized at the same time with auriferous pyrite. Steeply dipping pipes of ore lenticular in outcrop were thus formed. This ore was, however, largely exhausted about 1940, and Matachewan Consolidated has since been working ore, mainly, of the same type as that worked by Young Davidson. During the years 1934-1944 inclusive, this property has yielded 192,724 ounces of gold, from 1,674,640 tons of ore.

About 8 miles northwest of the last-mentioned field, the Ashley vein was discovered in 1930, in Bannockburn township close to the north boundary. According to H. C. Rickaby, the vein consists of a series of more or less connected lenses of quartz, rarely more than 2 feet wide, in Keewatin greenstones. The quartz vein material carries some orthoclase, and hence is closely allied to pegmatite. The other vein minerals include specularite, native gold, some telluride, pyrite, galena, and a little sphalerite and chalcopyrite. Mining operations were carried on during the years 1932-6 inclusive, and the plant was then closed. In that time 157,636 tons of ore were milled, and 50,099 ounces of gold obtained.

At Boston Creek, about 12 miles southeast of Kirkland Lake, considerable development work has been done on various properties since 1915, but no great amount of gold has been produced, except from the Barry-Hollinger mine, which operated from 1925-36 inclusive. The main vein, which was developed along a fault plane, had an average width of 6 to 14 feet, and a northeast strike. The ore was quartz, interlaminated in places with schist, and carrying a little pyrite, chalcopyrite, and visible gold. Values were higher in the quartz than in the schist, and appeared to accompany chalcopyrite rather than pyrite. Altogether, 68,883 ounces of gold were won at this mine from 266,239 tons of ore.

Gold tellurides are present in some of the other properties of this area, and in general the main values seem to occur as native gold and gold telluride rather than as auriferous sulphides.

A. G. Burrows and P. E. Hopkins state, "The gold generally occurs near these acid rocks (i.e., granite, syenite, and feldspar porphyry). The presence of a number of gold-bearing veins along the contact of the intrusive porphyry and older rocks at Boston Creek, as in many other parts of central Canada, and the frequent occurrence of auriferous quartz veinlets in the porphyry and granite, suggest the relationship between the intrusives and the veins. The relationship is more clearly shown in this area by the occurrence of gold in a pegmatitic vein in the granite on the Charest claim, McElroy Township."

West Shiningtree district (*See* Figure 5), about 60 miles almost due south of Porcupine district, has been prospected intermittently since the first discovery of gold in 1911. The veins, some of which have been traced over great lengths, are of quartz. The quartz contains a little albite and tourmaline in places, and chalcopyrite, molybdenite, sphalerite, and galena sparingly. Pyrite, the principal sulphide, is not abundant in the quartz, though more so in the wall-rock. Native gold is the principal constituent of value and spectacular specimens have been found from time to time. The deposits of West Shiningtree district thus more nearly resemble those of western Ontario than those of Porcupine and Kirkland Lake districts. The only property thus far brought into production in this district is Ronda Gold Mines, which operated for a few months in 1939, yielding 2,727 ounces of gold from 24,592 tons of ore.

Tyranite Mines, with claims straddling the boundary between Tyrrell and Knight townships, came into production in 1939, and was worked until August 1942. The output was 30,352 ounces of gold from 223,810 tons of ore. The writer has no information as to the geology.

Considerable attention has been directed of late to Swayze area (*See* Figure 5) about 80 miles southwest of Porcupine, where a number of discoveries have been made, chief of which is the Kenty, in the northeast corner of Swayze township. The discoveries lie within an area underlain by Keewatin lavas and associated sediments, which are cut by quartz-feldspar porphyries and diorites. All these rocks are traversed by quartz veins up to 10 feet in width, mineralized with tourmaline, specularite, calcite, galena, chalcopyrite, a little feldspar, and native gold. The wall-rocks are more or less replaced by ankerite and pyrite. Some spectacular showings of native gold have been discovered. Jerome Gold Mines, a property in Osway and Huffman townships, was worked from 1941-3, and recovered 56,879 ounces of gold from 335,060 tons of ore.

SUMMARY AND GENERALIZATIONS

The lode gold deposits of northeastern Ontario fall into at least two main types. The first includes the simple fissures and lodes, like those of western Ontario. These consist of high-temperature quartz with free gold, and small amounts of sulphides that carry little or no gold. The wall-rocks are slightly altered, if at all. Such veins may afford spectacular sections and samples, but rarely have been mined at a profit. The short-lived Croesus mine is the best known example of the type. It is noticeable that most of the deposits of this kind have been found around the outskirts of the northeastern Ontario area, as at West Shiningtree and Boston Creek.

The second type, found toward the centre of the northeastern Ontario area, is profoundly different from the first. The gold-bearing solutions appear to have been of much more complex composition, rich in carbonic acid, and probably carrying potash, lime, magnesia, and iron, as well as gold and sulphur. They vigorously attacked the country rocks over wide zones, altering them to aggregations of lime, iron, and magnesium carbonates; they converted the feldspars into sericite, leached out silica, and deposited gold, auriferous pyrite, and in places tellurides. These conditions obtain at Porcupine, Lightning River, Matachewan, Kirkland Lake, and Larder Lake.

The extensiveness of the action of the solutions was controlled, however, by the structure. The wide shear zones at Porcupine and the great fault zone at Kirkland Lake allowed the gold-bearing solutions to percolate readily through wide belts of country rock and exercise their alternative effects. In these places, therefore, great orebodies were formed. At Matachewan and Larder Lake structural conditions were far less favourable, and as a result the orebodies are smaller and of lower grade.

A further structural relationship is evident in this region, one which was pointed out in the previous edition of this report. This is the manner in which the gold deposits follow the synclines. Thus the deposits of Porcupine, Munro township, and Lightning River all lie in one syncline in the older rocks; and, it may be added, the Beattie property in Quebec, 30 miles farther east, lies in what appears to be the continuation of this syncline. The deposits of Matachewan, Kirkland Lake, and Larder Lake all lie in a second syncline, which extends eastward to include the Granada, Graham-Bousquet, Thompson-Cadillac, and O'Brien mines in Quebec. The deposits of Boston Creek fall into the next syncline to the south, and other veins have been found farther east along the synclinal axis. In western Ontario less is known about the structure, but it is known that the Red Lake deposits lie within a syncline. It is to be hoped that further data tending to prove or disprove this generalization will be accumulated.

Little is definitely known as to the origin of the gold-bearing solutions. The mineral associations of all the deposits indicate that they crystallized from heated solutions of high mineral content, and such solutions may reasonably be presumed to have originated from some body of cooling igneous rocks. At Matachewan it has been fairly well proved that the gold-bearing solutions originated from bodies of syenite porphyry; at Boston Creek that they emanated from syenite porphyry or granite; at the Argonaut mine that they were heated by a body of quartz diorite; but for the more important veins, those of Porcupine and Kirkland Lake, no connection with any known body of igneous rocks has yet been proved. The presence of high-temperature quartz containing liquid and gas inclusions, and the presence of such minerals as albite and tourmaline imply that such a connection must exist; but if so the intrusive supplying the solutions must lie deep beneath the surface, either not reaching the surface at all or reaching it so far away that its relationship to the deposits is unrecognizable.

SOUTHEASTERN ONTARIO

The first gold discovery in the Canadian Shield was made in southeastern Ontario in 1866, and further prospecting revealed veins throughout Peterborough, Hastings, Addington, and Frontenac counties, a distance of some 70 miles (*See* Figure 5). The rocks are ancient crystalline limestones, sedimentary gneisses, and some squeezed conglomerates, together with granites, diorites, and other igneous rocks of later age. Some ancient lavas also occur, supposed by some geologists to be equivalents of the Keewatin series farther north. The veins are found in any of these rocks, but seem to be more numerous near the contacts of diorite or granite, though later than both. They consist of quartz, accompanied in places by carbonates, and mineralized most commonly with visible gold and arsenopyrite, although in some deposits pyrite occurs instead. The Deloro deposit, in Hastings county, contained so much arsenopyrite that it was mined for arsenic as well as gold.

Most of the deposits were rather small and of low to medium grade. From the information available, it seems that they also became rapidly leaner with depth. A considerable amount of gold was taken from them, chiefly during the nineties and the first 3 or 4 years of the present century, when the costs of extraction were low. None of the deposits was worked for many years, but after the rise in the value of gold, in 1934, attention was once more attracted to them.

One or two descriptions of properties in this district may illuminate the preceding generalizations. The deposit at the Cordova mine in lot 20, con. 1, Belmont tp., was found in 1897. This mine was operated from 1898 to 1903, and again from 1912-17, and during those periods produced gold to the value of $334,943 from 86,379 tons of ore. The rock is a rather coarse-grained gabbro or diorite characterized by gneissic flow textures and rather great changes of composition from place to place. Shear zones cut the gabbro in a general east-west direction, dipping steeply south. Vein material was injected into these zones, forming in some places veins several feet wide, in other places aggregates of stringers separated by schistose country rock. The vein material is quartz associated with a brown-weathering carbonate, probably ankerite. In the wider veins the ankerite is intergrown with the quartz, but the narrower consist almost wholly of ankerite. Pyrite is the chief metallic mineral. The mine was dewatered shortly before the war and the new plant erected by the Consolidated Mining and Smelting Company. In 1939-40, 3,487 ounces of gold were obtained from the treatment of 33,434 tons of ore. Operations were stopped on July 30, 1940, and the plant was dismantled.

The Deloro mine, in lot 9, con. VIII, Marmora tp., operated from 1899 to 1903, and in that time recovered $181,907 in gold and $128,975 in arsenic. The country rock is a dark grey diorite, possibly a basic lava, cut by dykes of hornblende granite. Sheared zones cut through this complex almost due north and south, dipping steeply west. As at the Cordova mine, the veins were found in these sheared zones, and were rarely more than 3 or 4 feet wide. Vein material consisted of quartz associated with an iron-bearing carbonate, mineralized with arsenopyrite and small grains of free gold. The veins have been supposed to be closely related to pegmatite dykes emanating from the cooling granite of the neighbourhood.

OTHER TYPES OF DEPOSIT

In addition to the deposits already described, there are a few of distinctly later age near the north shore of Lake Huron. None of them has proved of much economic value as yet. It is altogether likely that some of the known deposits in districts already mentioned may be of the same age and origin as those about to be described, but if so, the lack of Huronian and younger rocks in those districts makes it impossible to determine their age. Along the north shore of Lake Huron, however, a comparatively complete Precambrian succession is developed, and, therefore, the age of any deposit can be fairly accurately determined. The following deposits, together with some of less importance, seem to have originated either from the Nipissing diabase or from the Killarney granite. Both intrusives are of late Precambrian age, younger than the Cobalt series and, presumably, very much younger than the deposits previously described.

Deposits Originating from the Nipissing Diabase

(*See* Figure 5)

The Crystal mine was discovered in 1888 on the east side of Wanapitei Lake, in Rathbun township, and was operated for some years with a small production. The deposit lies along the contact of a sill of Nipissing diabase with arkose and greywacke of the Cobalt series. In places the contact is marked by a crush breccia composed of diabase and sediments, and the sediments have steeper dips here than elsewhere. Both diabase and sediments are cut by numerous veins, most of them less than a foot wide. They consist of quartz and breunnerite, a pink or pale brown carbonate of magnesium, and iron; the breunnerite weathers to a characteristic deep bronze colour. This gangue is mineralized with pyrite containing a little copper, and with visible gold, in many places quite coarse. The sediments near the veins, over widths of about 6 inches, are bleached and mineralized with pyrite and breunnerite. As the veins cut the diabase, they are evidently younger than it; but their proximity to the diabase, and the lack of any other igneous rock from which they might be derived, strongly suggest that they were derived from it.

The Havilah mine in lot 12, con. III, Galbraith tp., was discovered in 1899 and has been worked at intervals. A high bluff of Nipissing diabase trends north-northwest, and the contact of the diabase with quartzites of the Bruce series (Lower Huronian) to the west lies at the foot of the bluff. The principal vein is in the diabase near the contact. It strikes north 75 degrees east, dips 80 degrees south, and has been traced about 1,300 feet. It is said to finger out where it enters the quartzite. The width varies from 18 inches to 7 feet. Three smaller veins more or less parallel to each other branch off from the north side of the main vein and swing around in an arc to rejoin the main vein some 450 feet farther on. This part of the mine is termed the ore chimney. The vein materials are quartz and a grey carbonate, probably breunnerite as it has the characteristic bronze weathering, together with a little chalcopyrite, pyrite, and visible gold. They enclose greenish streaks and bands of the schistose country rock. The average tenor of the ore appears to have been between 0·25 and 0·3 ounce to a ton, although parts of it ran much higher.

A number of smaller deposits of similar type have been found, such as: the Payton vein, on Whiskey Lake, a quartz vein mineralized with pyrite in the Bruce series; the McKenzie mine, about 5 miles east of Wanapitei Lake, located on quartz veins cutting greywacke of the Cobalt series near a mass of Nipissing diabase; and the Mount Aetna mine, in Davis township, which has quartz veins mineralized with pyrite, chalcopyrite, barite, and gold, cutting Cobalt conglomerate close to a mass of diabase.

The reasons for associating these ores with the diabase are as follows. The diabase magmas certainly contained some gold, because it occurs in Gowganda district in some of the cobalt-silver veins, now known to have been formed as differentiation products from the diabase magma. Secondly, the age of the gold veins is such as to indicate that they could have been derived from the diabase. They either cut the diabase or occur in late Precambrian sediments close to it. Finally, they are closely related in composition to other veins that carry little or no gold but have a fairly definite relation to the diabase. These are quartz veins mineralized more or less heavily with chalcopyrite, and containing usually some pyrite, siderite, or other carbonate, and barite. Occasionally, as stated, they carry some gold, but copper is the main constituent of value. Bruce Mines is the largest and best known of these deposits. The descriptions make it evident that except in the matter of gold values they are very similar to the gold veins; and as they are generally admitted to be derived from the diabases, it seems reasonable to conclude that the gold veins of this type were also derived from the diabase.

The gold content of the copper-nickel ores of Sudbury is very small, yet the large tonnages of these ores make their total contribution to the gold supply of some importance. Reports of the International Nickel Company indicate that, in the years 1938-39, 160,837 ounces of gold were recovered from the treatment of a little more than 13,000,000 tons of ore. The average tenor of the ores, in gold, is, therefore, about 0·24 pennyweight.

Veins Derived from the Killarney Granite

In the region immediately north of Lake Huron there are masses of granite much younger than most of the known granites of the Canadian Shield. They cut the Nipissing diabase, to which reference has just been made, and hence are among the youngest of the known Precambrian rocks. They are termed the Killarney granites, because first recognized near the village of that name on the north shore of Georgian Bay; and certain gold deposits appear to have been derived from them.

The Long Lake gold mine is about a mile south of Long Lake, or about 14 miles southwest of Sudbury (*See* Figure 5). It was worked from 1909 to 1916, and in that time produced more than $800,000 in gold. The known orebody ended against a fault, beyond which it could not be found. The geological relations are rather complex. A large body of Killarney granite almost surrounds a long tongue, about 2,000 feet wide, of the quartzite of the Bruce series. An irregular, linear body of diorite older than the granite likewise intrudes the quartzite tongue, and encloses or almost encloses a mass of quartzite, in which the orebody occurred. The orebody was merely a part of the quartzite impregnated with fine-grained pyrite and arsenopyrite carrying gold. It had no definite walls, but passed into country rock by gradual decrease in the amount of mineralization. Mining operations proved that it was a chimney-shaped mass, about 250 feet long and 150 feet wide, pitching steeply southwest. At a depth of 340 feet it was cut off by a fault, as already mentioned. This mine, under the name of Lebel Oro, was again operated from 1937 to 1939, production being from remnants of the orebody and the tailings from the former working. Gold in the amount of 14,708 ounces was recovered from 78,776 tons of ore and tailings. The orebody, the writer was informed by the management, is now exhausted.

Near Howry Creek (*See* Figure 5) gold was found in 1911-13 within an area about 6 miles long and 1 mile wide. The orebodies occur in sediments of the Cobalt series that have been much metamorphosed, supposedly by the heat of underlying masses of Killarney granite. Most of the deposits are veins up to 6 feet in width. They consist of quartz and the iron-magnesium-lime carbonate (ankerite), with varying amounts of arsenopyrite, pyrite, and gold. Some of the veins are nearly half arsenopyrite. Gold values are said to range from nil to 0·5 ounce a ton. None of the deposits has been mined. A second type of deposit, found only in one place in Howry Creek district, is a broad, sheared zone in conglomerate, impregnated with pyrite and ankerite, and thickly netted with veinlets like the larger veins in composition. The mineralized zone is 40 feet or more in width, and is said to be at least half a mile long; but values are lower than in the veins because of dilution by the interlaminated country rock.

The Shakespeare mine in lot 5, con. I, Shakespeare tp., was opened in 1903 and worked for 4 years. Somewhat more than $38,000 in gold was recovered. There appears to be a lode 40 feet wide with an ore zone on each side made up of quartz veins interlaminated with chlorite schist, and mineralized with native gold, pyrite, and some thin films of native copper. The body lies about half a mile from the Killarney granite.

All these deposits are supposed to have been derived from the Killarney granites for the following reasons. In all cases they lie in rocks of fairly late Precambrian age, and one of the Howry Creek veins cuts a dyke of Nipissing diabase. They are all fairly close to bodies of granite. They lack the chalcopyrite that commonly occurs in the veins derived from diabase, and instead, contain arsenopyrite. As the diabases are the only other late Precambrian intrusive from which orebodies might arise, it is concluded that these ores must have been derived from the Killarney granite.

QUEBEC

All of Quebec north of the St. Lawrence and Ottawa Rivers, except a narrow strip between Montreal and Quebec, is underlain by Precambrian rocks, in parts of which gold discoveries will doubtless be made from time to time. The district directly east of the Porcupine and Kirkland Lake fields, for about 100 miles east of the interprovincial boundary, has proved to be particularly favourable for gold deposition.

The largest producer at present is Noranda Mines, Rouyn township, a copper mine yielding much gold. Acid lavas and tuffs of the Keewatin series have been bent and shattered by intense drag-folding, and ore-bearing solutions entered the openings thus produced. Parts of the country rock were replaced by pyrite, pyrrhotite, and chalcopyrite, to form large lenses of copper ore carrying gold values up to 8 dwt. a ton in places. Other parts of the country rock were silicified, and much of the silicified material, which is used as a flux in the smelting operations, also carries gold values up to 5 dwt. a ton, or even more.

According to its annual reports, Noranda Mines produced 2,817,951 ounces of gold during the years 1927-39, inclusive. This figure may include some gold recovered from custom ore, and may, therefore, be a little high. During the years 1931-8 its annual production averaged 289,000 ounces, so that the value of the gold recovered was approximately half that of the total metal sales. Production figures were not published during the war.

The other sulphide deposits of Rouyn district, Quebec, namely, Amulet, Waite-Ackerman-Montgomery, and Aldermac, carry only low gold values. The Aldermac mine contained more than 2,000,000 tons of ore with an average gold content of 40 to 50 cents a ton. Amulet orebodies have an average gold content of about 1 dwt. a ton. These figures, though only rough approximations, will serve to give some idea of the probable gold recoveries from the mining of these bodies.

Thirty-five properties producing gold as their main product have operated in western Quebec, most of them in the Rouyn-Harricanaw belt. Mill records indicate that most of the ore treated would have been unprofitable at the old value of gold. The ores are of many types, intensely interesting in their variety of composition, their modes of origin, and their relations to rock structure. Only a few can be classified as veins; most of them are replacements of the country rocks.

Arntfield Gold Mines lies in the southwestern part of Beauchastel township, just northeast of Lake Renaud. The rock is a light-coloured trachyte of Keewatin age, composed mainly of albite-oligoclase now much replaced by secondary micas. In places this rock is sliced by numerous small joints, most of which run east and west. These are filled with quartz and calcite, accompanied in places by much albite and some hematite. The ore solutions have altered the surrounding trachyte profoundly, introducing much dusty hematite that has given it a red colour, and have mineralized it with auriferous pyrite.

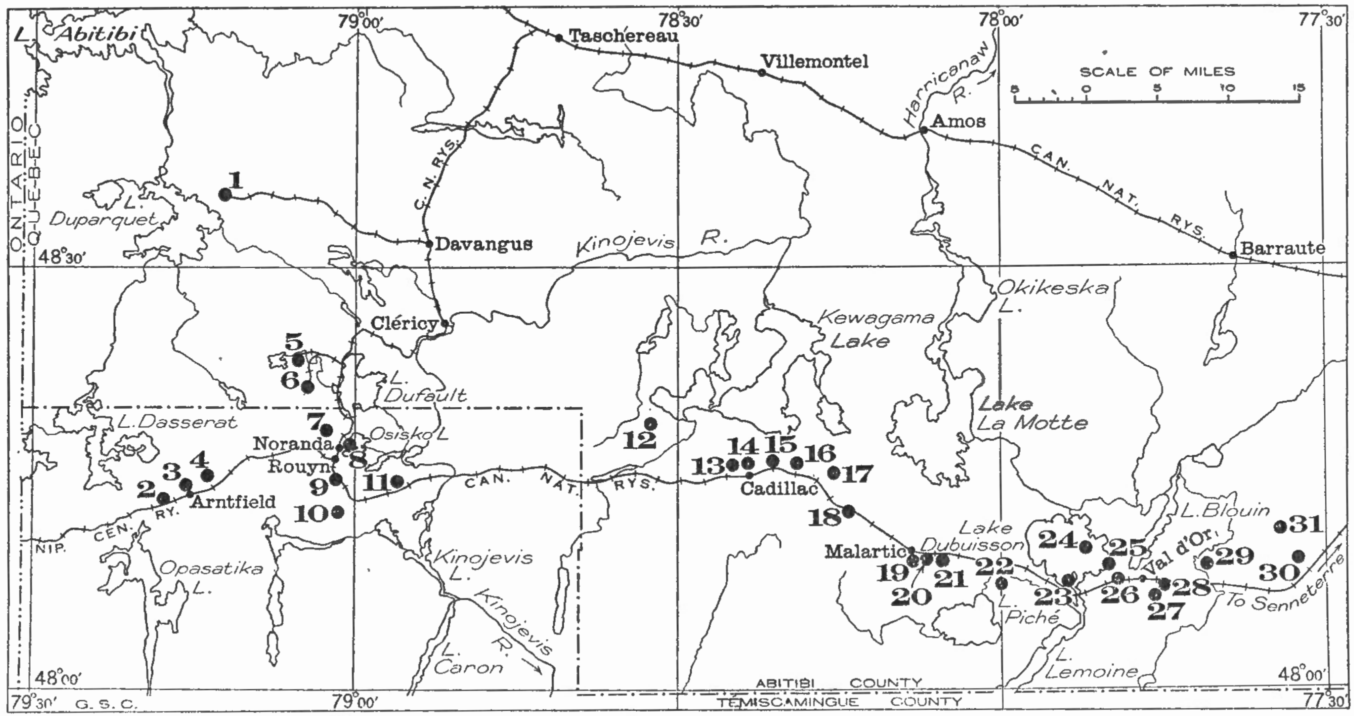

Figure 9. Index map of a part of western Quebec, showing principal known occurrences of gold. 1, Beattie; 2, Lake Fortune; 3, Arntfield, Francoeur; 4, Aldermac (copper-gold); 5, Waite (copper-zinc-gold); 6, Amulet (copper-zinc-gold); 7, Powell-Rouyn; 8, Noranda (copper-gold); 9, Stadacona; 10, Granada; 11. McWatters; 12, Mooshla; 13, Thompson-Cadillac; 14, O'Brien; 15, Central Cadillac; 16, Amm; 17, Lapa-Cadillac; 18, Pan-Canadian; 19, Canadian Malartic; 20, Sladen Malartic; 21, East Malartic; 22. Malartic Goldfields; 23, Shawkey; 24, Siscoe; 25, Sullivan Consolidated; 26, Greene-Stabell; 27, Lamaque; 28, Sigma; 29, Payore Holdings; 30, Cournor; 31, Perron.

According to S. E. Malouf[1], development has proved that these altered and mineralized parts of the rock occur chiefly along zones of faulting and shear that strike in a general way east and dip north. The sheared zones bend and roll, both on the strike and down the dip, so that dips range from 50 degrees north to as little as 20 degrees. On the concave sides of these rolls the rock has been shattered and jointed up to widths of 75 feet in places; and these jointed parts constitute the orebodies. Grade on the whole is low; mill records indicate that it averages about one-tenth ounce a ton.

Francoeur Gold Mines adjoins the Arntfield on the west. The character of the ore and conditions of its occurrence are similar.

Beattie Gold Mines, in Duparquet township, is a very large replacement deposit mined on a large scale. A wide band of rhyolite and rhyolite tuff along the north side of a mass of red feldspar porphyry is thoroughly altered and uniformly mineralized with very fine-grained, auriferous pyrite. The mineralized mass is bounded on the north by a wide east-west fault through which the mineralizing solutions may have entered. At the surface the mineralized mass is about 1,200 feet long and 110 feet wide; at the 500-foot level, about the same length and 84 feet wide. Rock alterations accompanying mineralization consist chiefly of addition of carbonates, formation of sericite in large amounts, and disappearance of most of the original rock minerals except part of the quartz. Mill records indicate the average grade to be about one-ninth ounce of gold a ton. Milling was suspended in September 1944.

Powell-Rouyn Gold Mines is established on the first discovery in Rouyn township, the Powell vein. The vein, which fills a fault fissure, has been traced on the surface for some 3,600 feet on an average strike of north 30 degrees west. For about 600 feet of this distance it traverses a body of granite, within which it has its greatest width, ranging from 2 to 12 feet; the proportion of auriferous pyrite is also greatest in this section. To the north and south the vein traverses Keewatin lavas, and with the exception of a few sections is narrow and poorly mineralized. The vein material, together with the adjoining silicified country rock, is being mined and shipped to Noranda for use as siliceous flux.

McWatters Gold Mines[2], discovered in 1932, is in Rouyn township 4½ miles east-southeast of Rouyn. The orebodies lie in a strong shear zone that strikes east-northeast and dips steeply north, cutting through a body of conglomeratic tuff. They are rather irregular, discontinuous lenses of black quartz and tourmaline, carrying in places spectacular shows of native gold; the schist of the walls is much tourmalinized and carbonated, and mineralized with pyrite and arsenopyrite. Discontinuity between the different orebodies has been a difficulty in mining; but this, for the present at least, appears to have been overcome.

Granada Gold Mines, in the southwestern quarter of Rouyn township, operated during the years 1930-5 and produced 51,286 ounces of gold. The deposit was a quartz vein carrying native gold, cutting the Timiskaming conglomerate not far south of its contact with Keewatin lavas. A little tourmaline or hornblende accompanied the quartz. The quartz was much fractured by planes of slip containing films of chlorite. Native gold was commonly deposited in these slip planes.

A chain of important deposits runs easterly through the middle of Bousquet and Cadillac townships, turning southeast into Malartic township. It may prove to extend west into Joannès township. These deposits are closely related to a large fault termed the Cadillac "break," marked by a zone of soft, contorted mica and chlorite schist up to 200 feet in width. The fault, which

[1] Malouf, S. E.: Geology of Arntfield Gold Mines, Limited; Can. Min. Jour., vol. 59, pp. 427–34 (1938).
[2] Hawley, J. E.: McWatters Mine Gold Belt; Ann. Rept. Que. Bur. of Mines for 1933, pt. C.

is practically vertical, parallels the strike of the strata or cuts it at a very small angle. The orebodies do not occur in the fault itself, as the dense schist is not favourable either to the movement of solutions or to formation of fissures, but are found in subsidiary fractures, usually south of the "break", where there are hard or brittle rocks that fracture rather than shear. The "break" follows closely a band of greenstone, and lies close to the north side of it in Cadillac township. This greenstone has proved a particularly favourable horizon for orebodies, and has been termed the "Cadillac belt" of greenstone. Orebodies have also been found in conglomerate and quartz albitite. The common greywacke of the region is not a favourable host for ore.

Although the Cadillac "break" has been traced west almost to the western side of Bousquet township, only one producing mine, the Mic-Mac, has been developed to date in that township. In Cadillac township, however, six mines along the "break" have been brought into production, namely, the Thompson Cadillac, O'Brien, Central Cadillac, Amm, Lapa-Cadillac, and Pan-Canadian. The ores of these six mines are closely alike in character, as will presently be described, and hence presumably arose from a common source. Near Lapa-Cadillac mine, in the eastern part of Cadillac township, the Cadillac greenstone belt changes strike from east to east-southeast, and between Lapa-Cadillac and Pan-Canadian it is violently drag-folded. It is not known definitely whether the Cadillac "break" was drag-folded along with the strata, but similar wide and strong shear zones are found in the greenstone belt wherever it has been explored to the east.

A gap of nearly 8 miles separates the Pan-Canadian property from the next producing mine on the Cadillac belt of greenstone, the East Malartic property; and 3 miles east of it, in turn, is Malartic Goldfields, the most easterly mine yet developed on the belt. Just south of the belt, to the west of the East Malartic property, lie the Canadian Malartic and Sladen Malartic mines. These appear to lie on a west-striking branch of the principal shear zone, which, as mentioned, follows the greenstone belt on an east-southeast strike. The four deposits not only exhibit marked similarities, but as a group are quite different from the deposits of Cadillac township; and it is, therefore, concluded that they arose from another source.

The orebodies of Cadillac township are quartz veins that in places, as in the O'Brien mine, carry spectacular shoots of native gold. The veins usually average less than 4 feet in width, though widths up to 15 feet were encountered in the O'Brien. The productive veins are generally flanked by bands of altered rock from 1 to 10 feet wide; these carry gold values and materially increase the mineable widths. The altered zones are cut by numerous little veins of quartz; presumably the solutions causing alteration were supplied through these fissures. Only the productive veins are flanked by such zones of alteration; the non-productive veins of the district, of which there are many, have not affected the surrounding rock.

The quartz of the veins is commonly dark grey or bluish grey, and much of it resembles a dense, vitreous quartzite. Besides native gold, it carries some arsenopyrite and very small amounts of pyrite, pyrrhotite, chalcopyrite, and galena. The altered country rock alongside is largely ferruginous carbonate with much brown biotite in places; in other places chlorite or sericite takes the place of the biotite. Small amounts of albite, tourmaline, and other minerals are nearly always present. This altered rock is heavily mineralized with tiny needles of auriferous arsenopyrite, and with lesser amounts of pyrite and pyrrhotite. Neither of the latter carries important amounts of gold as a rule, though exceptions have been found. The bullion from these mines contains very little silver; it averages, roughly, about one part by weight of silver to ten parts of gold.

These orebodies are closely associated, areally, with small bodies of albitite and quartz albitite. Some of the albitites are rich in tourmaline, and many veins carry albite; albite and tourmaline are almost invariably present in the altered wall-rocks. The tourmaline, albite, biotite, pyrrhotite, and arsenopyrite of the deposits all point to their being formed at moderately high temperatures. The evidence, discussed in detail in Memoir 206 of the Geological Survey, Canada, suggests rather strongly that both the albitites and the veins are emanations from some common body of magma.

The second group of mines, which may be termed the Fournière group, differ from those in Cadillac in having no arsenopyrite or tourmaline, and very rarely any pyrrhotite. Native gold, instead of being coarse and spectacular, is generally so finely divided as to be invisible to the unaided eye. The principal sulphide is pyrite, accompanied by small amounts of galena, sphalerite, and chalcopyrite, and by at least two tellurides, sylvanite and petzite. Unlike the rich and relatively small veins of Cadillac township, the deposits typically are low grade and adapted to fairly large-scale mining. The bullion from these ores is all very high in silver, some of it carrying approximately half as much silver, by weight, as gold.

Along with these similarities, there exist considerable differences. In the Canadian Malartic and Sladen Malartic mines the rocks are ancient greywackes, which have been much drag-folded and intruded by bodies of syenite porphyry. Near contacts the greywacke, and to a lesser extent the porphyry, have been silicified and mineralized with fine-grained pyrite and native gold. All stages of silicification are present, from the unaltered country rock to rock completely converted into fine-grained quartz. The pyrite does not seem to be auriferous, but all the values come from the finely divided native gold. The better values are commonly in the more highly silicified parts of the rock, but not invariably, so that practically all rock must be assayed to make certain that no ore is overlooked.

In the Canadian Malartic mine, also, pegmatitic veins carrying gold have been found within the porphyry mass. They are commonly much richer than the average siliceous ore, hence serve as valuable "sweeteners". These veins consist of quartz intergrown in places with pink albite, and contain a large variety of other minerals, such as biotite, muscovite, fluorite, rutile, tourmaline, molybdenite, pyrite, chalcopyrite, and native gold. The occurrence of such veins suggests that the gold deposits originated in part from the known bodies of porphyry, and perhaps in part from similar bodies consolidating at greater depths.

In the East Malartic and Malartic Goldfields properties the schistose lavas of the Cadillac belt of greenstone contain discontinuous, steeply dipping sheets of a dark green, crystalline, altered rock known locally as diorite. Whether this rock is an intrusive or has been formed by recrystallization of the surrounding schists is not yet definitely known. It is cut by many small veins of quartz and ferruginous carbonate, which carry native gold, and is mineralized with much fine-grained pyrite, accompanied locally by chalcopyrite or arsenopyrite. These bodies constitute the ore. In addition, some silicified syenite porphyry carrying sufficient gold to be ore is found on both properties.

To the east of the properties just described, in Dubuisson, Bourlamaque, Senneville, Pascalis, and Louvicourt townships, a large mass of granodiorite has intruded the Keewatin lavas. The body, which is rather irregular in shape, is about 14 miles long in an east-west direction, and has a maximum width of $6\frac{1}{2}$ miles. A large group of producing mines is closely associated, areally, with this mass. Some of them lie within the granodiorite itself, others in the lavas not far from its margin. Some of the most important are situated in or close to small satellitic intrusions of the granodiorite. This group of mines includes the Siscoe, Sullivan Consolidated, Greene-Stabell, Lamaque, Sigma, Cournor (formerly Bussières), Perron, and Payore Holdings. Shawkey Gold Mines also lies in the vicinity, and is probably a part of the group. In addition to the producers mentioned, there are many promising prospects.

Siscoe Gold Mines,[1] a consistent producer since 1929, is on Siscoe Island, Lake de Montigny, Dubuisson township. The north end of the island is underlain by greatly altered granodiorite, part of a small boss satellitic to the main mass farther east. It is in contact on the south with Keewatin lavas, and the contact strikes north 65 degrees west and dips 80 to 85 degrees north. Stresses tending to move the lavas eastward and up, relative to the granodiorite, have caused faulting along the contact, and have produced a zone of schist ranging from 30 to 200 feet in width. Tension cracks running off this fault have provided fissures that later became filled with ore; most of these were formed in the granodiorite. Considerable ore is also found in the main fault.

The material of the main fault, known locally as the "K" zone, is schist. Chlorite, actinolite, and sericite schists are found, but talc schist and massive talc rock predominate. Strange as it seems, lenses of ore have been found in this material; they range from 25 to 350 feet in length, and from 3 to 10 feet in width. Their material is of three types: (1) Granular, white quartz banded with chlorite and carrying visible gold and 2 or 3 per cent of pyrite, pyrrhotite, and chalcopyrite. (2) Talc-chlorite and talc-actinolite schist containing fine visible gold and 2 to 5 per cent of sulphides. Irregular threads and stringers of quartz run through it, and it is much altered to carbonate in places. (3) Green talc filling fractures and carrying minutely disseminated gold. All three types commonly occur in the same lens and grade into one another. Thus the ore at the ends of a lens may be of type (3); nearer the middle, of type (2); and the middle of the lens like type (1).

The tension cracks in the granodiorite north of the main fault have been filled with quartz associated with calcite and some tourmaline. Native gold occurs irregularly through the quartz, both as small specks and in coarse, spectacular masses. Some of these pockets, when mined, have been found to contain up to 1,000 ounces of gold. Very little sulphide is found in the vein material.

One of these veins, known as "C" vein, was unusual in the amount of tourmaline present. The quartz of the original vein filling was sliced parallel to the strike by shearing stresses, and the fissures so formed were filled with black tourmaline and a little quartz. In places the tourmaline formed plates up to an inch thick. It was mined for lengths up to 400 feet, and to a depth of 450 feet, and, although not more than 2 or 3 feet in average width, it produced gold valued at some $800,000.

The veins found in the greenstone south of the main fault are white, sugary quartz with some sulphides and visible gold, but in general appear to be lower in grade than those in the granodiorite. Little mining has been done on them.

Lamaque Gold Mines[2], Quebec's largest producer aside from Noranda, is in Bourlamaque township, about 1 mile from the west boundary and 3½ miles from the north boundary. At this point there is a small plug or pipe of granodiorite, the length of which ranges from one level to another, between 500 and 800 feet, the width from 350 to 400 feet. It strikes north 70 degrees west and dips about 70 degrees north. The centre of the pipe consists of albite granodiorite, which material passes, outward, into quartz diorite porphyry and then into ordinary diorite. Contacts between the different phases are in places sharp, in others gradational, a fact suggesting that the three rock types were differentiated from a common magma, but that movements during consolidation caused some injection of still liquid parts into the parts solidified.

[1] Backman, O. L.: Geology of Siscoe Gold Mine; Can. Min. Jour., vol. 57, pp. 467–75 (1936).
[2] Wilson, H. S.: The geology of the Lamaque Mine; Can. Min. Jour., vol. 57, pp. 511–6 (1936).

The pipe is cut by numerous small thrust faults, ranging in strike from east-southeast to northeast and in dip from 30 to 70 degrees south. Except in two cases, these faults do not cut completely through the pipe, but originate within it and pass out of the north or hanging-wall side into the country rocks, which are mainly Keewatin lavas. They die out again up the dip by development of tension cracks on the foot-wall side. It seems that these extraordinary faults must have been produced by upward movement of residual parts of the magma in the final stages of consolidation, thus compelling enlargement of the upper part of the pipe.

The faults and the associated tension cracks are filled with vein materials carrying native gold and tellurides, and in places the altered wall-rocks also carry commercial values. Vein materials are chiefly quartz and tourmaline, and these vary in relative proportion from nearly pure quartz to nearly pure tourmaline. Other minerals present in minor quantities are ankerite, calcite, scheelite, fluorite, pyrite, and, rarely, chalcopyrite. There have been several periods of movement, during which the vein materials have been fractured, and new vein materials introduced. The distribution of the gold in the veins is dependent on the extent of the later fracturing; it does not vary with the character or width of the vein filling.

Alteration of the country rocks consists of the replacement of the original minerals by mixtures of albite, ankerite, and quartz, with more or less pyrite and tiny needles of tourmaline. Most of the pyrite seems to have formed from the original iron of the rock. Where alteration has been extreme, pyrite is so abundant as to suggest that some has been introduced; and in such cases some fuchsite is usually also present. The latter types of altered rock commonly carry high gold values.

Sigma Mines adjoins the Lamaque property on the north. The latest published description, so far as the writer is aware, is that written in 1934 by L. V. Bell, and at that time development was not far advanced. According to Bell, the rocks are moderately acid Keewatin lavas and volcanic breccias, intruded by extensive and irregular masses of a diorite porphyry rather difficult to distinguish from some varieties of the lavas. All these rocks are cut by dykes of andesite porphyry. When the above report was written, the known orebodies consisted of two veins about 190 feet apart, both striking north 80 degrees east and dipping about 75 degrees south, and a zone of lenses and veinlets forming a sort of stockwork about 100 feet north of the north vein. The south or main vein is a series of lenses, with a maximum width of 20 feet, and up to the end of March 1935 had been traced more than 1,200 feet. The north vein is 4 or 5 feet wide, but made ore for only about 400 feet along the strike. The fracture zone is about 30 feet in width. Vein material is quartz and tourmaline, mineralized with pyrite, a little chalcopyrite, and native gold.

At the writer's request, the management of Sigma Mines generously supplied the following additional information.

"Developments at Sigma up to 1940 have disclosed the presence of six zones (including the two mentioned by L. V. Bell in 1934), which strike roughly east and west and dip from 65 to 85 degrees south. All of these zones form ore over varying proportions of their length and closely conform to the description of the south dipping veins mentioned by Bell. In addition, two zones have been developed which dip north at 45 degrees and lie between adjacent south dipping veins. Important orebodies occur at the upper junction of the north and south dipping veins (one of these orebodies being described as a 'stockwork' lying north of the 'north vein' by Bell in 1934).

"In addition to the above occurrences, and closely associated with them, diagonal or oblique veins occur between adjacent veins of the south dipping series. These veins make ore over only a part of their length and appear to be limited in vertical extent.

"More important than the oblique veins are horizontal narrow veins that offshoot from both the north and south dipping zones. These veins may occur in either or both walls and may extend up to 100 feet from the main vein for distances up to 300 feet along the strike. In some cases these veins extend the entire width between adjacent steep breaks. These veins have proved important with regards to both tonnage and grade.

"The outside dimensions of the area in which development work is being carried on are 1,000 feet across the general strike by 3,800 feet along the general strike. The shaft is now down to 2,115 feet, although practically no development work has been carried out below the 975-foot level."

Good descriptions are not available for most of the other properties associated with the Bourlamaque batholith, but they appear to be mostly of the same general type as those described, i.e., quartz-tourmaline veins filling more or less irregular and lenticular fractures.

Exceptions must be made, however, of the Shawkey and Greene-Stabell ores. The Shawkey mine, formerly the Martin, is on the south shore of Lake de Montigny, and somewhat farther away from the granodiorite than most of the other mines. Its orebody is a vein, with a maximum width of about 11 feet, including subsidiary stringers. The ore is chiefly white, sugary quartz with a little calcite and pyrite. Tourmaline is absent, but the wall-rocks have been altered to calcite close to the vein, and albitized farther away. The altered zones are only an inch or two in width.

The Greene-Stabell property is in Dubuisson township about a mile southwest of the end of Blouin Lake. The orebody was a narrow vein of quartz heavily impregnated with pyrrhotite and auriferous chalcopyrite. The mineable shoot had a length of 200 to 300 feet and a width of 3 or 4 feet. Operations began in 1933 and ceased in 1936.

Two areas lie outside of the main belt described in the preceding pages. One, Guillet Lake area, is about 60 miles south of Rouyn, or 50 miles east of Haileybury. Belleterre Quebec Mines is situated there (*See* Figure 5). The other, Currie township, in which the Lake Rose Mines lies, is about 65 miles north and 20 miles east of the village of Senneterre.

Belleterre Mines, controlled by McIntyre Porcupine Mines, lies north and northwest of Guillet Lake, Guillet township. No good description has been published, so far as the writer is aware, since 1935. At that time the orebodies consisted of two good-sized veins of quartz in Keewatin greenstones. The first discovery was a vein of very dark, gold-bearing quartz, ranging in width from a few inches to 8 feet. The other main vein is white or greyish quartz carrying abundant tiny specks of native gold, but otherwise sparsely mineralized. Its widths vary from 2 to 19 feet. According to press reports, a third vein has been found, carrying good values.

Lake Rose property, in Currie township, was likewise described in 1935. The orebodies are of two kinds: (*a*) veins of white quartz, rather sparingly mineralized, but locally carrying rather spectacular shows of gold; and (*b*) sheared zones filled with stringers of grey quartz well mineralized with chalcopyrite and pyrrhotite, and carrying one-half ounce or more of gold a ton. Both types are rather narrow, 2 to 3 feet. Both cut a quartz diorite body and the surrounding Keewatin lavas, but are said to be less persistent, and to carry smaller values, in the diorite.

Production figures for the gold mines of western Quebec are given in the following table, to the end of 1944 or for the period of operation, as the case may be.

Name	Period of operation	Tons milled	Gold, ozs.
Amm	1938–40	74,237	9,334
Arntfield	1935–42	529,480	55,493
Beattie	1933–44	5,632,579	646,451
Belleterre Quebec	1936–44	699,240	231,048
Bussières (later Cournor, which see)	1932–35	100,949	15,711
Canadian Malartic	1935–44	2,467,537	288,610
Central Cadillac	1939–43	201,684	30,924
Cere. Gustav	1944	300	2,060
Cournor	1937–42	325,976	63,001
East Malartic	1938–44	2,532,201	395,282
Francoeur	1938–44	420,763	71,078
Granada	1930–35	181,679	51,286
Greene-Stabell	1933–36	69,996	14,950
Halliwell	1938	2,718	1,165
Lake Rose	1938–39	5,374	3,421
Lamaque	1935–44	3,090,451	944,686
Lapa-Cadillac	1938–43	380,544	47,271
Malartic Gold Fields	1940–44	1,057,278	213,200
McWatters	1934–44	365,242	107,620
Mic-Mac	1942–44	391,242	50,692
Mooshla	1939–40	4,901	4,203
O'Brien[1]	1931–44	607,711	289,714
O'Neil Thompson	1936	2,700	79
Pan-Canadian	1938	5,837	1,072
Pandora Cadillac	1940–42	122,367	18,026
Payore Holdings	1938	4,812	466
Perron	1934–44	1,094,425	319,666
Pershing Manitou	1941–42	225	15
Poulos, Thos.	1943	1,200	2,850
Powell Rouyn	1937	1,657,223	219,726
Senator Rouyn	1940–44	415,765	74,941
Shawkey	1936–38	137,978	25,391
Sigma	1937–44	2,314,092	472,008
Siscoe	1929–44	2,698,952	781,891
Sladen Malartic	1938–44	1,466,437	150,286
Stadacona Rouyn	1936–44	1,131,608	167,091
Sullivan Consolidated	1934–44	1,045,443	292,293
Thompson Cadillac	1936–39	172,935	15,039
West Malartic	1942–44	232,615	28,895
Wood Cadillac	1939–42	179,400	27,435

SUMMARY AND GENERALIZATIONS

It is evident from the previous descriptions that most of the gold ores of Quebec are high-temperature types, characterized by such minerals as hematite, albite, tourmaline, and ankerite. This strongly suggests that the gold-bearing solutions originated from igneous sources at no great depth below the present surface; and the numerous and widely different types of ore, together with the great distance over which the bodies are spaced, further suggest that there were several such sources differing in composition, and possibly very different in age. In at least two areas, namely, the mines of Cadillac township, and the deposits surrounding the Bourlamaque batholith, the ores are so similar in type to one another, and so closely associated with certain igneous rocks, that their origin can hardly be doubted. In Cadillac township, it has been shown, the igneous rock is albitite and quartz albitite, and it and the veins appear to have originated from a common source. The Bourlamaque deposits are so closely associated with the granodiorite batholith of the same name that a genetic connection seems indubitable. In the Canadian Malartic mine auriferous pegmatites are found within a mass of syenite porphyry, and there is little reason to doubt that they were differentiated from it. Thus at least three probable igneous sources of gold ores are identified, and others undoubtedly exist.

[1] In addition, O'Brien Gold Mines yielded 3,238 ounces of gold during 1928–30. Tonnage figures not available.

The descriptions likewise emphasize again the importance of structure plus physically favourable rock in localizing ore deposits. Faults are particularly prominent in this way; most of the gold deposits are localized in and near faults where these cut hard, brittle rocks that fracture rather than shear. Tension cracks produced in the walls during fault movement, and later filled with ore, have likewise made important contributions to the ore supply in the mines of Bourlamaque area. This is true at Siscoe, Lamaque, and Sigma, and probably in other cases also. Drag-folds are another structure particularly favourable to ore formation. Apparently the drag-folding produced openings of various sorts through which ore-bearing solutions could rise. The orebodies at Noranda, Pandora mine, Canadian Malartic mine, and Sigma and Lamaque mines, are all closely associated with drag-folds.

GENERAL SUMMARY OF CONDITIONS IN THE CANADIAN SHIELD

Preceding descriptions make it evident that there were at least two periods during which gold was deposited in the Canadian Shield. The first, so far as known, and as yet by far the most important, was that great interval of folding, mountain building, and granite intrusion that separated earlier from later Precambrian time. Later in the Precambrian, folding and mountain building, accompanied by intrusion of granites and diabases, took place in local areas and possibly at different times. One of these districts is a belt along the north shore of Lake Huron, where deposits related to the late Precambrian intrusives have yielded a little gold. A second district, of which not much is yet positively known, but which promises to be of vast importance, is the Yellowknife district of the Northwest Territories where, it has been established with some certainty, great gold deposits have originated from the late Precambrian granites. Their discovery greatly brightens the outlook for the economic possibilities of the yet little known northern parts of the Shield that are so largely underlain by granites.

The rocks in which the gold deposits are found consist, as the descriptions show, mainly of ancient lavas and sediments. In a few instances deposits have been found within small bodies of intrusive granite, syenite, or porphyry. Some instances are also known of veins in larger granite masses, but in such cases the veins are confined to the edges of such masses.

The Canadian Shield has an area of about 1,825,000 square miles, the greater part of which is underlain by granites and remnants of early Precambrian sediments and lavas. As yet only the southern end where access is easy, and a little of the extreme western edge, has been prospected in any degree of detail, so that the area still has large possibilities for the prospector. At the same time it should not be assumed that the unknown northerly parts of the Shield are likely to be as productive as the southern, because the widely scattered traverses that have been made across them have shown that immense areas are underlain by granites; and past experience indicates that such areas are almost certainly barren of gold deposits. On the other hand, those who made these traverses did not distinguish, in mapping, gneisses of sedimentary origin from those of igneous origin, so that it may prove that the apparently granite areas are less extensive than they seem at present.

It may be assumed, therefore, with reasonable safety that the northern part of the Shield still affords much space for future prospecting; and the discovery that the gold deposits of Yellowknife district are related to the late Precambrian granites excites the hope that similar granites may be found in other northern parts of the Shield. If they are, the writer sees no reason why gold deposits should not be found around their margins, even where the older rocks are the earlier granites.

It is probable that the remainder of the Shield will be prospected mainly by aeroplane. Many useful observations can be made from the air alone, such as distinguishing granite areas from those of lavas or sediments, detecting large rusty areas that may indicate extensive mineralization, and recognizing large elements of structure, either folds or faults. On the ground the relations described in the preceding pages should be kept in mind. Preliminary evidences of mineralization may be rusty areas or zones, silicified zones or sericitized zones; scattered boulders of ore or vein material; or quartz veins. As the best and largest deposits occur in the the shattered zones of brittle rocks, any strong shear zone in which evidences of mineralization occur should be followed to determine whether it cuts a brittle rock such as porphyry, rhyolite, and so on. The neighbourhood of contacts between granite masses and older rocks should be carefully examined, especially if the granite masses are small. If veins are found running from the granite masses into older rocks, they are likely to be richest close to the contact. Replacement deposits carrying auriferous sulphides are to be sought for in preference to quartz veins containing visible gold, as they are more apt to form large bodies and to be more uniform in tenor.

DEPOSITS OF SOUTHERN QUEBEC AND NEW BRUNSWICK

Throughout the Eastern Townships of Quebec, and particularly on Chaudière River and its tributaries, between Valley Junction and Beauceville, placer gold was mined throughout the latter half of last century, especially between 1875 and 1885; and sporadic attempts to continue operations were made until a few years ago. Many of the nuggets obtained were rough and angular and others still clung to bits of the quartz matrix from which they were derived, thus suggesting that they had not travelled far from their point of origin. Evidently, therefore, the placers were derived from quartz veins in the vicinity. The heavy cover of glacial drift makes prospecting difficult, yet many veins throughout the Eastern Townships were sampled and assayed, with discouraging results. Apparently some or many of the veins contain free gold,[1] in some cases fairly coarse; but no vein so far discovered is large enough or rich enough to mine. The veins are of two general types. Those of the first type consist of barren quartz and are extremely numerous, particularly throughout Notre Dame Hills. Those of the second type consist of quartz accompanied by some or all of the sulphides, pyrite, marcasite, arsenopyrite, chalcopyrite, galena, and sphalerite. Assays made in past years indicate that the clear quartz veins contain no gold, but that the quartz-sulphide veins generally show at least traces.

No gold deposits have yet been found in New Brunswick, but the presence in the western part of several large bodies of granite as well as some smaller ones suggests that deposits may occur in their vicinity. The heavy cover of glacial drift over the great part of the province is, however, a great hindrance to prospecting.

DEPOSITS OF NOVA SCOTIA

The Gold-bearing series of Nova Scotia is a monotonous succession of quartzites and slates, folded into long east-west anticlines and synclines. It is considered to be Precambrian by some geologists, Cambrian by others. The first school base their opinion on the resemblance of the series to a definitely Precambrian series in Newfoundland; the second school point to the fact that the Gold-bearing series appears to grade without any visible break into fossiliferous Palæozoic rocks. The Gold-bearing series is invaded by numerous large and small masses of granite, of Devonian age. Granites of two ages are present.

[1]Geol. Surv., Canada, Ann. Rept., vol. X, pt. J (1889).

The Gold-bearing series is more than 30,000 feet thick, occupies that half of the province lying along the Atlantic Coast, and extends the full length of Nova Scotia Peninsula. The beds commonly dip at high angles, and the anticlines are more or less regularly spaced about 3 miles apart. Many of them are of great length; some have been traced for 100 miles. The anticlines plunge east and west at low angles, so as to form a series of domes, the crests of which may be 10 to 25 miles apart on any one anticline. Towards the west end of the province the folds become broader and less tightly compressed than in the eastern part, a change that has seriously affected gold deposition.

Fairly important amounts of gold have been produced from more than a score of fields, and of these all but four or five occur in the eastern part of the province, east of the great granite mass that comes down to the Atlantic Coast at Halifax. The others are fairly closely grouped, in the northeastern part of Queens and the adjoining part of Lunenburg counties. No deposits of importance have been found in the western fifth of the province.

The gold occurs in quartz veins, most of which lie in thin slate beds between bands of quartzite. The veins are found near the crests of plunging anticlines, and in many instances pass completely across a crest from one limb to the other. Because of their habit of thus straddling the anticlines, they are termed saddle veins. In some anticlines a whole series of parallel saddles is developed, many of which, mining operations have shown, do not come to the surface. Many veins appear to have been formed before the folding processes were completed, because the vein matter is wrinkled and thickened at the noses of the anticlines, as if dragged between the quartzite walls. The corrugations in many cases are quite large and are then known as barrels.

As a general rule the veins are limited to those parts of an anticline or dome in which the strata have a pronounced curvature. Thus little or no vein material is found on the flanks, where the beds maintain a uniform dip in depth, or at the summits of anticlines that have broad, flat tops. This is the reason that veins are few and poor in the western part of the province, where folds are broad and open. The best veins are found at the crests of fairly sharp folds, in which the two limbs enclose an angle of 45 degrees or less. In such anticlines the veins form saddles curving around the crests and extending down the limbs until the strata cease to bend. In short domes, veins may run completely round the dome. In broad anticlines, there may be no quartz at the crest, but some may be developed at a distance from the axis where the beds bend from their nearly horizontal position on the axis to the normal steep dip of the limbs. In some districts vein formation is closely connected with subordinate flexures on the limbs of a fold. In others the anticlinal axis itself is curved or bent, and where this occurs veins are more numerous on the convex side.

All these facts indicate an intimate connection between folding and vein formation. The accepted theory is that the slipping of one bed over another during folding produced openings along the bedding planes, which were widest where curvature was sharpest. As the slipping was concentrated in the beds of easily deformed slate, the openings were formed in the slate. Into these openings the vein matter was introduced by solutions.

The principal gangue mineral is quartz, but calcite and sulphides occur locally, usually in subordinate amount. Pyrite and arsenopyrite are the principal sulphides, but galena, sphalerite, pyrrhotite, and chalcopyrite are also found. Auriferous stibnite is mined at West Gore, chiefly for the antimony. In some instances the sulphides are distributed more or less evenly throughout the quartz, but more generally they are concentrated along the walls and in the wall-rock for a few inches from the vein. Films and fragments of the slate walls form a minor part of the vein matter. The chief constituent of economic value is native gold, much of which is very coarse; but some gold is intimately combined with the sulphides, from which it cannot be separated by amalgamation.

For the most part the veins rarely exceed 2 feet in width, and many that have been worked are less than 1 foot. In places, however, especially where a vein has been thickened by corrugation near the apex of a fold, the width greatly exceeds this figure. The quartz in many of the narrow veins was very rich, carrying 2 to 3 ounces in gold a ton.

Some of the wider beds of slate carry several quartz veins, which may be so small that they cannot profitably be separated from the slate. Such "belts," as they are locally termed, attain widths of 10 to 20 feet. Some of them are sufficiently rich to be worked as a whole and furnish large bodies of low-grade ore.

The veins of Nova Scotia are far from being exhausted. In the early days of mining prospectors were granted only claims of very small size, commonly lengths of 150 feet along the vein, but in one instance as little as 20 feet. This resulted in multiplication of the number of owners, most of them without funds sufficient to carry on extensive operations. The usual practice was, therefore, to sink an inclined shaft for a short distance, following the vein, and stope out the ore most readily won, after which the workings were allowed to slump and fill. Large numbers of these shafts now dot the mining areas and practically all the ore near the surface has been removed.

In these circumstances, mining, if attempted now, is carried on under á heavy handicap. Although the veins, as described above, are very uniform in strike and dip, so that their continuations on both horizontal and vertical planes can be closely estimated, the vein material is unfortunately not all ore. Commercial values are confined to shoots of various size, which rake at various angles, usually about 45 degrees, to the east or west. The shoots are rarely more than a few hundred feet in length, along their axes. Consequently, the miner, having perhaps sunk a shaft on a known vein, must drift along it to find an ore-shoot; and then, while mining the shoot, must continue drifting and crosscutting to locate another shoot before the first is exhausted. Such underground prospecting generally eats up all the profits obtained from mining the rich shoots, and it is very hard to find ore fast enough to supply the demands even of a 50- or 75-ton mill.

Proponents of gold mining in Nova Scotia have maintained at times that by sinking a shaft on the crest of an anticline where gold had been found, many veins would be discovered that do not outcrop. Cheap modern methods of mining, they urged, should make it possible to develop the deposits at a good profit. In 1937 one of the large Canadian mining companies made a thorough test of this theory, by sinking to 500 feet on the crest of an anticline that had produced considerable gold, and cutting exploratory drifts and cross-cuts from the bottom. Results, however, did not vindicate the theory. Although sufficient ore was found to repay, perhaps, the expense of the operation, veins were not found in large numbers, and most of those discovered were barren.

The following table showing the production of the various operating mines in 1940 will illustrate the scale of operations and the grade of the ore obtained. By the end of 1944 all these properties, except the Queens Mines, had ceased operations.

Name	Tons treated	Gold, fine ozs.
Consol. Mining and Smelting	12,984	6,465
Guysborough Mines	32,172	7,344
Killag	565	268
Queens Mines	2,185	885
Rehabilitation project	4,094	210
Seal Harbour	88,602	4,173
Other mines	....	2,874

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