GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES
AND TECHNICAL SURVEYS

ECONOMIC GEOLOGY
REPORT No. 20

MOLYBDENUM DEPOSITS OF CANADA

F. M. Vokes

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MOLYBDENUM DEPOSITS OF CANADA

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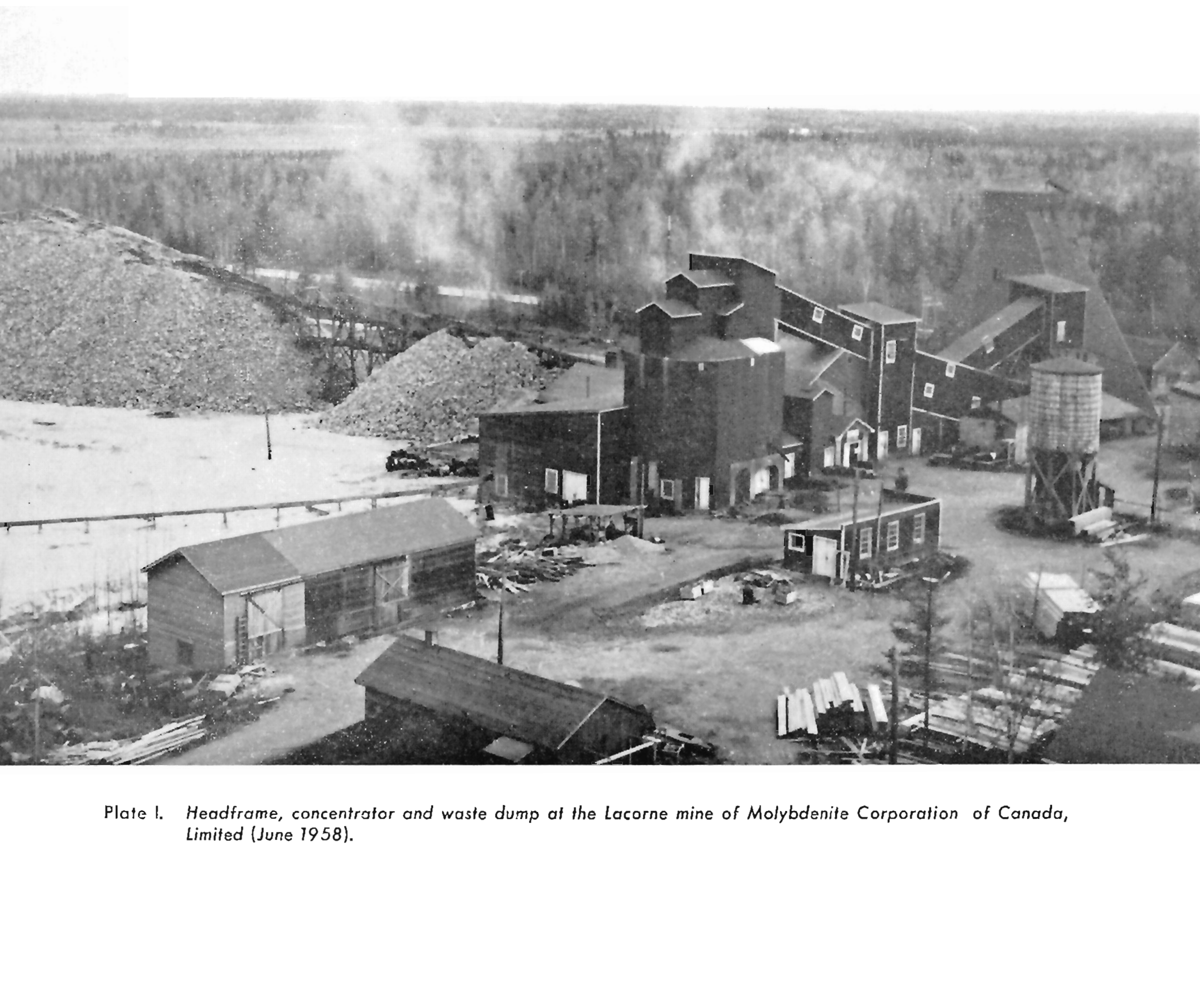

Plate I. *Headframe, concentrator and waste dump at the Lacorne mine of Molybdenite Corporation of Canada, Limited (June 1958).*

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By
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DEPARTMENT OF
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A French translation of this report is being prepared.
La version française de ce rapport est en voie de préparation.

PREFACE

The author of this report was on the staff of the Geological Survey for one year only, but during that time he visited most of the important molybdenum-bearing areas in Canada. Because of the growing interest in molybdenum deposits this report is published without further field work. This report is, however, made reasonably complete by including the description of many properties based partly or entirely on earlier reports.

An introductory section on production, consumption, and uses of molybdenum has been prepared by the Mineral Resources Division of this Department. The addition of this material and information supplied by officials of mining companies and provincial mining departments have enhanced the value of this report.

J. M. HARRISON,
Director, Geological Survey of Canada.

OTTAWA, January 5, 1960.

CONTENTS

CHAPTER I

CHAPTER IV

CHAPTER V

CHAPTER VI

Illustrations

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MOLYBDENUM DEPOSITS OF CANADA

Abstract

Interest in molybdenum is growing because of increased uses in high-temperature alloys. Many occurrences are known in Canada; several were mined during World Wars I and II. At other times the demand has been so small that most mines have closed. Canada now produces only about 1 per cent of the world's output, from a single mine—the Lacorne.

Molybdenite is the only primary molybdenum mineral known. It occurs most commonly in late products of magmatic fractionation, such as granites, syenites, and associated pegmatites and high-temperature veins. The Lacorne deposit consists of molybdenite in pegmatitic quartz veins in granodiorite. Deposits in pegmatites and aplites are probably the most abundant Canadian occurrences, but the distribution of molybdenite in most of them is erratic. Disseminations and impregnations appear to be one of the most favourable types of occurrence, at least for quantity, if not for grade. In other types molybdenite occurs in breccias, veins of base-metal sulphides, and in metasomatic deposits. Occurrences of more than one kind are commonly associated.

Most occurrences are in the Canadian Shield. An accompanying map shows the location of 282 occurrences, including areas containing two or more occurrences, distinguished according to types. Where possible, geological descriptions of occurrences and mines are based on the writer's own observations; descriptions of properties which the writer was unable to visit are quoted from earlier reports.

Résumé

L'emploi plus courant des alliages résistant à de hautes températures suscite un intérêt toujours plus vif dans notre pays. Parmi les nombreux gîtes connus de ce métal au Canada, plusieurs ont été exploités au cours de la Première et la Seconde Guerre mondiale. Pendant d'autres périodes, la demande a été si faible que la plupart des mines ont dû fermer. La seule mine active, celle de Lacorne, ne livre que 1 p. 100 environ du total de la production mondiale.

Le seul minerai primaire de molybdène qu'on connaisse est la molybdénite. Elle se présente le plus souvent dans des roches formées, en des temps récents, par ségrégations magmatiques, par exemple, les granites, les syénites et les pegmatites qui leur sont associées, ainsi que les filons de minéraux hypothermaux. La molybdénite de Lacorne est contenue dans la granodiorite à filons de quartz permatitique. Il est probable qu'au Canada la molybdénite se présente en plus grande quantité en gîtes contenus dans des pegmatites et des aplites, mais elle est de nature erratique dans la plupart des gîtes. Les gîtes d'imprégnations diffuses semblent être les plus favorables à sa présence, sinon en fait de teneur, du moins en fait de tonnage. Dans d'autres genres de gîtes, la molybdénite se présente en brèches, en filons de minerais sulfurés de métaux communs et en gîtes de substitution. Les venues de plus d'un genre sont le plus souvent associées.

La plupart des gîtes se trouvent dans le Bouclier canadien. La carte qui accompagne l'étude montre l'emplacement de 282 venues réparties suivant leurs genres et comprenant les régions qui en contiennent deux ou plusieurs. Les descriptions géologiques des gîtes et des mines sont fondées, autant que possible, sur les propres observations de l'auteur; les descriptions des mines que l'auteur n'a pu visiter sont tirées de rapports déjà publiés.

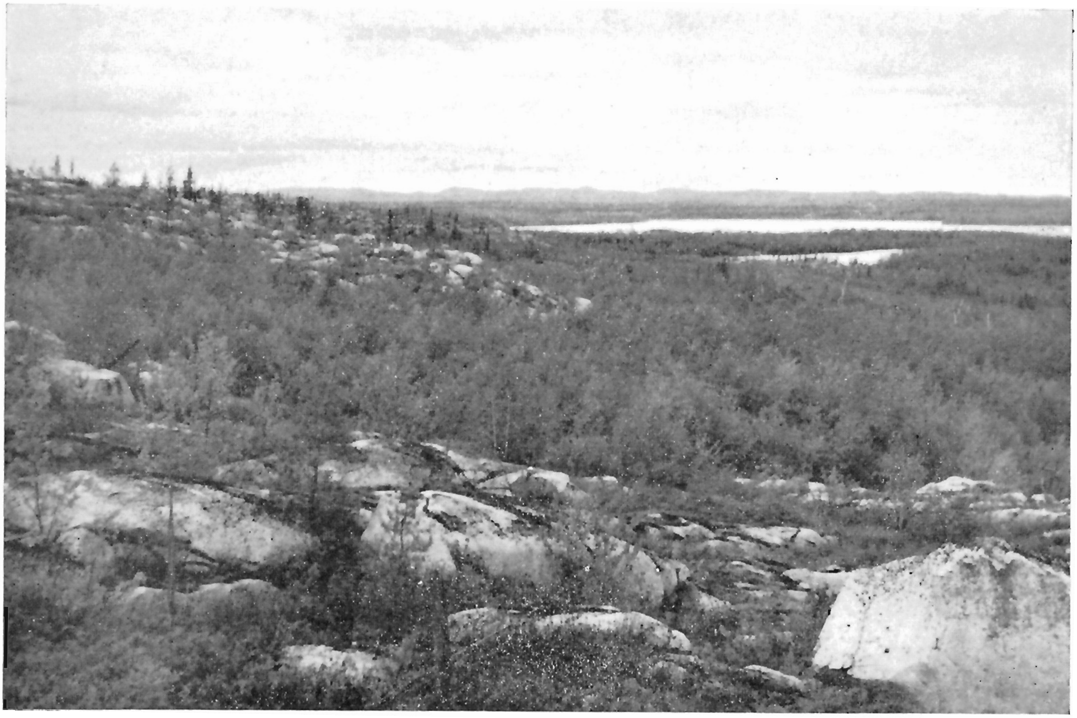

Plate II. *Indian Peninsula area, Preissac township, Quebec. View northwestward along the granite escarpment that overlooks lower ground occupied by schists of the Malartic group. The Preissac Molybdenite Mines orebody lies at the foot of the escarpment. Lac Fontbonne is in the distance.*

Plate III. *Hardy prospect, Glacier Gulch, Smithers, British Columbia. View up the gulch at a point about half-way between the valley floor and the glacier. Low-value molybdenite mineralization is widespread in the rocks (volcanics) beneath the ice-front.*

Plate IV. *Molybdenite-bearing, coarse pyroxene-albite rock, American Molybdenites Limited property, concession XV, lot 32, Monmouth township, Ontario. Shows pegmatitic segregations relatively enriched in albite.*

Chapter I

INTRODUCTION

The recently increased metallurgical use of molybdenum has led to an intensified search for deposits in Canada, as in other parts of the world. The history of the metal has been one of under-supply during wartime emergencies followed by a complete collapse of the Canadian market after the cessation of hostilities. The current increase in the use of molybdenum in high-temperature steels and other alloys may mean the beginning of a period of more constant and dependable demand under peacetime conditions, providing a surer basis for the development of a molybdenum-producing industry.

Canada is not lacking in molybdenum occurrences. About 700 are known—some for many years—but so far very few have proved to be of lasting economic importance.

This report records the results of a survey of Canadian occurrences and describes most of the known deposits. Information was gathered chiefly during 1958 while the writer was employed by the Geological Survey of Canada. The summer field season of that year was devoted to the study of some 30 to 35 different deposits in Quebec, Ontario, and British Columbia. This is a very small proportion of all the occurrences, and great use has been made of the various reports mentioned in the text. As this report was written during the winter of 1958-59 in Oslo, Norway, and no laboratory studies were made of any of the ores, it was not possible to deal extensively with the more theoretical aspects of molybdenite deposition.

Previous Work and Acknowledgments

Of the various monographs and reports on the geology of the molybdenite deposits of Canada or a particular province, the main ones, in chronological order, are those by T. L. Walker (1911)[1], Parsons (1917), Gwillim (1920), and Eardley-Wilmot (1925); the latter must now be regarded as a classic, and it contains much information that is still pertinent. Of the more recent literature, J. S. Stevenson's (1940) report is outstanding.

In addition to these topical reports, many descriptions of molybdenite-bearing areas and individual deposits have appeared in publications of the Geological Survey and the various provincial departments of mines, as well as scientific and technical journals and periodicals. All these sources have been consulted in compiling this report.

The writer is grateful to prospectors and company officials for information used in this report, and particularly for their help and hospitality in the field.

[1] Dates in parentheses are those of publications cited in the Bibliography.

Thanks are also due for information and courtesies received from Dr. M. Latulippe and Dr. J. Dugas of the Quebec Department of Mines, Dr. W. S. Savage of the Ontario Department of Mines, and Dr. S. S. Holland of the British Columbia Department of Mines.

Discovery and Early Development

The following account of the history of molybdenite is quoted from McInnis (1957, pp. 2-5):

> Centuries ago the Greeks and Romans used the term *molybdos* or *molybditis* to describe minerals that were soft and 'leadlike' in character. The terms were probably applied to the minerals now known as galena, graphite, and molybdenite. At a still later period, the word *molybdaena* was applied to graphite and the mineral molybdenite. In 1778, Karl Wilhelm Scheele, the celebrated Swedish chemist, demonstrated that molybdenite, unlike graphite, on treatment with nitric acid produced a "peculiar white earth" with acidic properties; he assigned the name "molybdic acid" to this substance. He also found that when the mineral was heated, sulfurous fumes were given off, and he concluded that molybdenite was a sulfide of molybdenum. Four years later (1782) J. J. Hjelm isolated the metal itself, which proved to be the new element, molybdenum.
>
> In 1893 the German chemists Sternberg and Deutsch produced a 96-percent-pure metal by reducing molybdate of lime with carbon and then separating the lime with hydrochloric acid. The impure metal was reported to have been used in experiments in an effort to utilize the metal in tool steel in place of tungsten. In 1894 the metal was first obtained by means of the electric furnace, but the high carbon content (9 percent) made it unsatisfactory for use. In the same year, Schneider & Co. produced molybdenum-bearing armorplate at its Creusot works in France. This was the first recorded report on the use of molybdenum as an alloying element in steel. A short time later, Henri Moissan, a French chemist, made extensive experiments in the reduction of molybdenum by means of the electric furnace and succeeded in obtaining 99.98-percent-pure metal. Moissan then devoted a considrable amount of study to its physical and chemical properties. He established its atomic weight and determined many other of its now known qualities. These experiments and results were successful enough to cause the metal to be considered commercially important for the first time.
>
> The first production of molybdenite was probably from the Knaben mine in the Knaben-Flekkefjord district, southern Norway, near the end of the 18th or the beginning of the 19th century. Its uses were evidently unimportant and small, for the mine had no important production until research during the last quarter of the 19th century stimulated interest in the mineral enough to cause it to be reopened about 1880; however, production was irregular and small until just before the end of the century, by which time the United States and Australia were also producing small quantities, but production in the United States was discontinued in 1905 and was not resumed until 1914.
>
> Although molybdenum had previous commercial applications in certain chemicals and dyes, the first record of its commercial use as an alloying element in steel was said to be in 1898, when the Sanderson Steel Co. began to market a molybdenum self-hardening tool steel, but production of the steel was discontinued before 1905. This use greatly stimulated interest in the metal as an alloying element, and metallurgists devoted considerable study to its use as an alloying element in high-speed steel. However, tools made from the molybdenum high-speed steels gave erratic performance, owing largely to lack of knowledge of the critical heat-treating range subsequently developed and demonstrated at Watertown Arsenal in 1930. This early failure gave molybdenum a bad reputation in the United States, and for the next decade there was very little development in the United States on the use of the metal as an alloying element.
>
> In 1907 Fink produced ductile molybdenum by compressing the hydrogen-reduced powder into bars that were then heated and hammered into rod or sheet. A few years later the metal was being produced in ductile form for commercial use.
>
> The difficulty of separating the mineral molybdenite from its ores was the subject of much study during the early years of the 20th century. Frank E. Elmore, one of the pioneers

of oil flotation, devised the Elmore vacuum process, based on liberation of dissolved air and gases by means of reduction of pressure, which enabled the bubbles to lift quite large masses of oil-coated minerals. This vacuum process was installed in several molybdenite mills in Norway, the first being at the Kvina mine in 1913; this was probably the beginning of oil flotation of molybdenite. Later research demonstrated that molybdenite was readily amenable to vastly improved flotation methods now universally practiced for concentrating the mineral from its ores.

Molybdenite is one of the most easily floated minerals, but when it constitutes only a very minor part of an ore, such as some copper ores, it is difficult to separate from copper sulphide minerals and other minerals.

Production, Consumption, Use, and other Economic Aspects

by R. J. Jones,
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World Mine Production

The United States demand for the additive metals—chromium, nickel, molybdenum, manganese, cobalt, tungsten, vanadium, and niobium—is great, because that country is the world's largest steel-producing nation. As the largest consumer of all these metals the United States must depend upon imports for its supply, except for molybdenum and vanadium of which it is the largest producer. More than 90 per cent of the world's output of molybdenum comes from the United States; more than two thirds of it from a single deposit at Climax, Colorado, and the remainder chiefly from the milling of porphyry-copper ores in Utah, Arizona, New Mexico and Nevada. The dominance of the Climax molybdenite mine in the United States is analogous to that of the Sudbury nickel mines in Canada. A difference of course is that the United States consumes about three quarters of its own molybdenum whereas Canada consumes only about 3 per cent of Canadian nickel.

Chile is second among molybdenum-producing countries. All of its output is a by-product of the mining of large porphyry-copper deposits. Chilean production is exported to Europe as molybdenite concentrate for conversion into primary products.

Canada, Japan, Yugoslavia and Norway are the only other producing nations of any consequence, and their production is small; Canada's is about 1 per cent of the world supply. Canadian production may increase at a moderate rate in future years with the development of production from the Gaspé copper deposit in Quebec and possibly from molybdenite deposits being explored in Quebec, Ontario and British Columbia.

Table I clearly illustrates the dominant position of the United States among the world's molybdenum-producing nations, and particularly, the important production of the Climax mine.

Table I

World Production of Molybdenum, Principal Producing Countries and Climax Mine

(Thousands of pounds of molybdenum contained in ores and concentrates)

Country	1950–54 (average)	1955	1956	1957	1958	1959
United States	45,301	61,781	57,462	60,753	41,069	50,956
Climax mine	(27,633)	(43,043)	(37,489)	(42,466)	(25,079)	(42,466)
Russia	e	e	e	9,300	9,300	9,900
Chile	3,058	2,817	3,122	2,998	2,972	3,785
China	e	e	e	e	2,200	3,300
Canada	249	833	842	785	888	851
Japan	238	439	534	600	683	815
Norway	271	379	366	397	481	480
World total*	55,800	75,000	70,300	76,200	57,700	70,300
% of world total from U.S.	78	82	82	80	71	72
% of world total from Climax mine	50	57	53	56	43	60
% of world total from Canada	0.4	1.1	1.2	1.0	1.5	1.2

[e] Estimate included in world total.

* Includes production from countries not listed here.

United States Production

The Climax deposit was explored in 1917. In 1918 a 250-ton-per-day mill was constructed and soon increased to 1,000 tons. In 1919, however, the cessation of hostilities in Europe and the resulting drop in demand for molybdenum caused the operation to be closed until 1924. Since then, the mine and mill have operated continually at an ever-increasing rate. In 1956, capacity was increased to 34,000 tons per day, making this the largest underground mine in North America. The company's production in recent years is shown in Table I.

In 1957 Climax produced and milled 10,552,000 tons of ore averaging 0.367 per cent molybdenum disulphide, a new record for ore production. Average daily tonnage mined and treated in the company's mill was about 34,400 tons. Because of reduced demand in 1958, due to lower steel production in the United States, only 6,363,000 tons of ore was produced and milled; mine output was reduced in the spring of 1958 and averaged 29,300 tons per operating day for the rest of the year. Although more than 100 million tons of ore had been mined at Climax to the end of 1957, proven ore reserves then were 418 million tons averaging 0.43 per cent molybdenum disulphide before dilution in mining. The full extent of the orebody has not yet been defined. At the end of 1958, ore reserves were calculated to be 472 million tons containing more than 2 billion pounds of molybdenum.

Most of the molybdenum sold in free world markets in competition with the Climax product is a by-product of copper mining. Production of by-product molybdenum declined in 1958 with curtailed copper production. Kennecott Copper Corporation is the second largest producer of molybdenum, with mines in Utah, New Mexico, and Chile. Production commenced in 1936 and has more or less kept pace with the copper output of the company. Recent production of molybdenite was:

1951—30,837,000 pounds
1952—34,480,000 pounds
1953—35,224,000 pounds
1954—28,200,000 pounds
1955—31,960,000 pounds
1956—32,538,000 pounds
1957—28,756,000 pounds
1958—23,626,000 pounds
1959—20,967,000 pounds

The above figures include production from Kennecott's wholly owned subsidiary—Braden Copper Company, Chile. Molybdenite from the Utah copper mine at Bingham was discarded with the tailings until 1936. Recoveries were rather low until additional equipment was installed to treat the underflow from the primary copper flotation cells. Molybdenite recovery commenced at the company's Chino copper mine in New Mexico in 1937.

The Morenci copper mine in Arizona, owned by Phelps Dodge Corporation, commenced production of molybdenite in 1948. At the time of writing, molybdenite was also being recovered at the copper mines of Miami Copper Company, Bagdad Copper Corporation, American Smelting and Refining Company, and San Manuel Copper Corporation—all in Arizona.

Chilean Production

In 1939, molybdenite was first recovered from the copper ores of the El Teniente mine of Braden Copper Company at Sewell; production was greatly increased in 1951 as a result of the installation of an improved selective flotation system. In 1958 the Anaconda Company also installed a molybdenite recovery unit at its large Chuquicamata copper property. Production in Chile will increase with the recovery of molybdenite from the copper ores of a subsidiary of the Anaconda Company—the El Salvador mine of Andes Copper Mining Company—where production was due to start in 1959 from an orebody estimated to contain 300 million tons averaging 1.6 per cent copper. The El Salvador concentrator is designed to handle up to 25,000 tons of ore per day.

Canadian Production

Prior to the discovery of the Climax mine in Colorado the Moss mine at Quyon in Onslow township, Quebec, was probably the world's largest producer of molybdenite; at least this was so during World War I. The end of the war and the commencement of Climax production caused this mine to close. Canadian production was intermittent between the two world wars.

Table II

Molybdenum Production of Canada[1]

Year	Pounds	Year	Pounds
1926	12,545	1947	455,117
1927	—	1948	182,857
1928	9,674	1949	—
1929–30	—	1950	62,130
1931	732	1951	228,958
1932–36	—	1952	303,578
1937–40	*	1953	194,344
1941	104,219	1954	451,450
1942	95,108	1955	833,506
1943	391,260	1956	842,263
1944	1,120,190	1957	783,739
1945	502,804	1958	888,264
1946	405,423	1959	748,566

[1] Producers' shipments of molybdenum ores and concentrates.

* Molybdenum content of molybdenite shipments for 1937-40 not known. Gross weight of shipments was: 1937—16,500 pounds; 1938—13,000 pounds; 1939—2,600 pounds; 1940—22,200 pounds.

Canadian production now comes from the mine of Molybdenite Corporation of Canada, Limited in western Quebec. This property was operated during World War II by a Crown company—Wartime Metals Corporation—which constructed a 275-ton mill. Production from May 1943 to July 1945 was 2,739,539 pounds of concentrate averaging 87 per cent molybdenite (MoS_2) and containing 1,429,711 pounds of molybdenum. As there were no Canadian plants equipped to convert molybdenite into primary products, the concentrates were shipped to Langeloth, Pennsylvania for treatment and returned to Canadian consumers. The property was returned to the present owner on July 15, 1945 and continued in production until December 1947 when operations were suspended. The company resumed test-milling early in 1951 and succeeded in producing a concentrate relatively free of bismuth and copper and containing more than 90 per cent molybdenite. By the end of 1951 it had increased the milling rate to about 280 tons per day.

During 1952, development indicated additional ore at greater depths. Production was suspended during 1953 to permit the opening of two new levels and the preparation of the mine for production at the rate of 500 tons per day with a milling rate of about 350 tons per day. To finance this expansion a contract was entered into with the Defense Materials Procurement Agency of the United States Government, whereby the Export-Import Bank agreed to advance $540,000 toward the expansion program in return for an option on 6 million pounds of molybdenite and upwards of 450,000 pounds of bismuth metal over a period of 6 years. Milling operations recommenced in March 1954, and in 1955 the mill capacity was increased to 560 tons a day. A roasting plant was installed at the property and production of technical molybdic oxide began in December 1956. In 1957 the company made its final ore payment on the loan from the Export-Import Bank. In early 1959 the roasting plant was shut down because of cost factors.

Canadian-produced molybdenite or technical molybdic oxide does not enter the United States market because of high tariff rates; it is mostly exported to Japan or European countries.

Consumption, Use, and Price

Although a small amount of molybdenite concentrates is added directly to a few steel-making operations, and some is purified to make molybdenum disulphide for lubricants, most of the production is roasted to technical-grade molybdic oxide (MoO_3). This is used as such or as a starting material in the manufacture of metal powder or addition agents such as calcium molybdate, ferromolybdenum, ammonium molybdate, etc.

The pattern of consumption of molybdenum in the United States may be illustrated as follows:

Use	1957 (%)	1956 (%)
Constructional low-alloy steel	50	49
Cast iron	12	11
Tool steels	9	11
Stainless steels	7	6
Steel castings	5	8
Gas-turbine steels and similar alloys	4	5
Rolling-mill rolls	2	2
Chemical manufacture (catalysts, fertilizers, lubricants, pigments, etc.)	7	5
Metallic molybdenum in all forms	4	3
	100	100

As indicated above, the iron and steel industry consumes about 90 per cent of the total molybdenum supply. Molybdenite is sometimes used as an addition to steel in the ladle if sulphur is also desired. Ferromolybdenum is generally used where a higher molybdenum content is required, as in cast iron and malleable steel castings. Molybdic oxide is, however, less costly and is generally used, particularly in the manufacture of constructional low-alloy steels. As in the manufacture of all additives, the specifications for impurities such as copper, phosphorus, tin, sulphur, silicon, and carbon are strict in all cases.

In the early 1920's the automotive industry became aware of the usefulness of molybdenum in low-alloy steels and the Society of Automotive Engineers adopted the 4,100 (chromium-molybdenum) series steels. This marked the beginning of ever-increasing uses of molybdenum—for prior to this development the metal was used mainly in competition with tungsten in high-speed tool steels. During World War II the shortage of alloying elements in the United States brought about the adoption of the so-called 'national emergency' steels (nickel, chromium, and molybdenum), which greatly increased the demand for molybdenum.

The approximate percentage consumption of molybdenum by the alloy steel and iron industries in the United States, according to eventual use, is as follows:

Use	Per cent
Automotive	28
Petroleum production	15
Tool steel	15
Process industries	11
Machine tool and heavy machinery	7
Power and electrical	5
Aircraft	5
Ordinance	4
Mining and earth-moving	4
Agriculture (including tractors)	3
Railroad	2
Marine and ship-building	1
	100

During both World War II and the Korean campaign, molybdenum largely replaced tungsten in certain high-speed and other tool steels. This was due primarily to the greater availability of molybdenum and the abnormally high price of tungsten. At the beginning of 1952 the price of scheelite in the free United Kingdom market was 485 shillings per long ton unit of WO_3, and at the beginning and the end of 1953 it was 360 shillings and 150 shillings respectively. In April 1958, it was about 85 shillings. It is not surprising, therefore, that the tool-steel manufacturers should concentrate on finding a replacement for tungsten, as its price reacts so much to any surge in demand.

The price of nickel and molybdenum concentrates from 1932 to 1959 has been plotted in Fig. 1. Nickel, although used in conjunction with molybdenum in many alloys, actively competes with molybdenum in other alloys and uses. It is remarkable how the prices for these two elements have kept pace with each other. Prior to December 1954 the price of molybdenum concentrates was based on the per-pound content of molybdenite; after that the cost was based on 'per pound of contained molybdenum plus cost of container'.

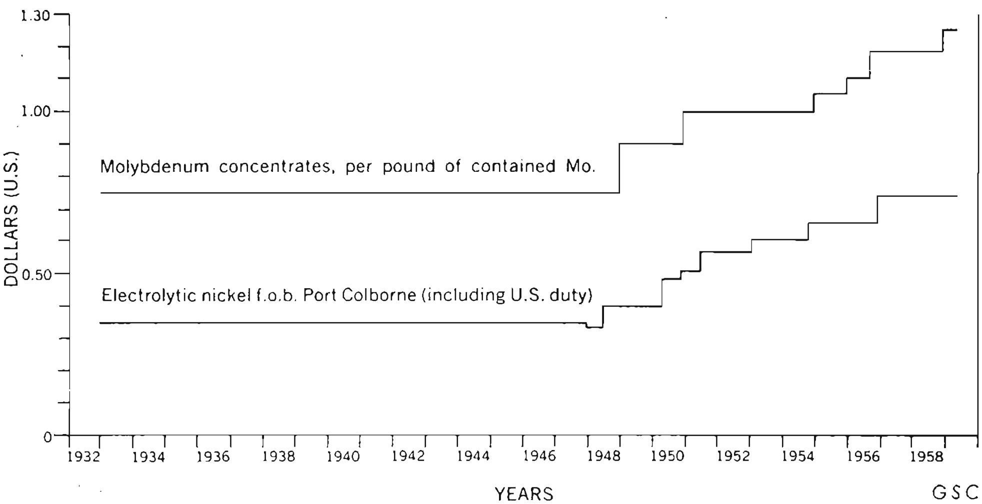

Figure 1. Comparative prices of nickel and molybdenum, 1932 to 1959.

Although the iron and steel industry accounts for 90 per cent of the total consumption of molybdenum, the other 10 per cent is used in many ways. The use of molybdenum disulphide as a lubricant is gaining in popularity. Molybdenite for this purpose is purified by refloating the concentrate and treating it with acid at an elevated temperature to decompose silicates and other impurities. The product is then washed and dried. The molybdenum disulphide is added to greases and oil dispersions and is also used by itself. Many major oil companies now sell branded chassis greases containing molybdenite for trucks, buses and taxis throughout the United States. The passenger-car market for these greases has just begun and should constitute a large outlet for molybdenite.

The use of molybdenum as a trace element is growing. Fertilizers containing the element are used in molybdenum-deficient areas of Australia, New Zealand, United States, Norway, Sweden, Denmark, and Canada. In the United States, soybean, peanut, alfalfa, clover, and pea seeds are treated to increase crop yields.

Molybdenum is used in pigments; one product—molybdenum orange, which is formed by the coprecipitation of lead chromate and lead molybdate—is widely used for automobile finishes. Molybdenum compounds such as silicides, borides, and carbides are being investigated for possible use as electrical heating-elements and cutting tools. Other compounds are used in the chemical industry as catalysts for oxidation-reduction reactions. The petroleum industry is the largest consumer of molybdenum catalysts, which are resistant to sulphur and other catalyst poisons in the manufacture of high-octane gasolines.

Many additional uses for pure molybdenum metal are being developed. During the past forty years or so, molybdenum wire has been used in electric lamps and electronic parts. Recent defence demands call for molybdenum metal and molybdenum-base alloys produced by improved methods of vacuum-arc melting and powder metallurgy. Research has indicated that the high-strength properties of molybdenum-base alloys, when properly protected from oxidation, are superior to those of certain other alloys at elevated temperatures. This research should also promote future civilian applications for molybdenum metal.

Table III is an estimate by American Metal Climax Inc. of the western world's industrial demand for molybdenum, excluding deliveries to the United States Government's strategic stockpile.

Table III

Demand for Molybdenum in Western Countries

Year	Millions of Pounds of Molybdenum		
	U.S.	Foreign	Total
1958	27	17	44
1957	35	26	61
1956	39	23	62
1955	37	19	56
1954	24	17	41
1953	30	12	42

Among the more important Canadian consumers of molybdenum are the following companies:

Atlas Steels Limited, Welland, Ontario
Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario
The Steel Company of Canada, Limited, Hamilton, Ontario
Sorel Industries Limited, Sorel, Quebec
Shawinigan Chemicals Limited, Shawinigan Falls, Quebec
Dominion Engineering Works Limited, Montreal, Quebec
Welland Electric Steel Foundry, Limited, Welland, Ontario
L'Air Liquide, Montreal, Quebec
Crane Limited, Montreal, Quebec
Eastern Electro-Casting Company Limited, Lachine, Quebec
Dominion Brake Shoe Company, Limited, Joliette, Quebec
Canadian Steel and Foundries Limited, Montreal, Quebec
Dominion Iron and Steel Limited, Sydney, Nova Scotia
Canada Electric Casting Limited, Orillia, Ontario
Canadian General Electric Company Limited, Toronto, Ontario
Dominion Colour Corporation Limited, New Toronto, Ontario
Canadian Knobel Diamond Tools Limited, New Toronto, Ontario

Table IV

Canadian Consumption of Molybdenum in Recent Years

Form	1958	1957	1956	1955
	(pounds of contained molybdenum)			
Molybdic oxide	298,078	326,420	535,546	470,996
Ferromolybdenum	183,161	322,366	255,919	125,609
Calcium molybdate	7,888	13,248	13,688	5,026
Sodium molybdate	24,983	24,109	33,021	22,380
Molybdenum metal	3,213	9,660	12,286	7,870
Molybdenum wire	1,801	2,617	3,558	2,180
Miscellaneous	—	—	1,450	—
Total	519,124	698,420	855,468	634,061

United States and Canadian Tariffs

Under the *Tariff Act* of 1922, the United States duty on molybdenum ores and concentrates was set at 35 cents per pound on the molybdenum content. This rate, equivalent at that time to almost 50 per cent ad valorem, remained in effect until June 30, 1956 when, as a result of the *Geneva General Agreement on Tariffs and Trade,* it dropped to 33 cents a pound and subsequently to 31½ cents on June 30, 1957 and to 30 cents on June 30, 1958.

Table V

Canadian Tariffs on Molybdenum Ores and Products

Paragraph No.	Product	British Preferential	Most Favoured Nation	General
208(g)	Calcium molybdate, molybdenum oxide, whether in powder, in lumps, or formed into briquettes by the use of a binding material, when for use in the manufacture of steel	Free	Free	5%
445(t)	Molybdenum rod and tubing for use in the manufacture of radio tubes and parts therefor (expires 30 June, 1963)	Free	Free	30%
445(g)	Molybdenum strip, when imported by manufacturers of radio tubes and parts therefor, for use exclusively in the manufacture of such articles in their own factories	Free	Free	30%
445(p)	Molybdenum wire and molybdenum when imported by manufacturers of radio tubes and parts therefor, for use exclusively in the manufacture of such articles in their own factories	Free	Free	30%
375(f)	Ferro-molybdenum used in the manufacture of iron or steel, n.o.p.	Free	5%	5%
329	Molybdenum ores and concentrates	Free	Free	Free

The duty on ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum is 25 cents a pound of contained molybdenum plus 7.5 per cent ad valorem.

History of Canadian Activities

The first reported discovery of molybdenite in Canada was made by Alexander Murray of the Geological Survey of Canada in 1852. The occurrence was in a granitic dyke on the west side of Terrace Cove, Lake Superior. About the same time he also noted the mineral in other localities, including the River Doré above Michipicoten Harbour, Ontario, and St. Jerome, Quebec. In 1863 the Geological Survey published a description of a molybdenite deposit on the north shore of the St. Lawrence River. A few years later several occurrences were noted in Nova Scotia.

Several records and descriptions of molybdenite deposits occurring over a wide area were published by the Geological Survey towards the end of the century. By that time the mineral had passed from the phase of scientific interest to one of commercial importance.

T. L. Walker's (1911) report was the first to deal with the mineral on a nation-wide scale. In it, 50 occurrences are described and 30 others are mentioned. Up to that time virtually no ore had been mined for commercial purposes, although a few small parcels of molybdenite had been sent to various museums and some had been used for experiments in concentration. Among the localities yielding such samples were the townships of Aldfield, Egan, and Romaine, Quebec.

The first record of commercial production was in 1902, when 3¼ tons of ore was shipped from the Horscroft mine in Victoria county, Ontario. In the following year, 85 tons of ore was shipped from the Chisholm mine in Sheffield township, Ontario. No shipments were recorded from 1903 until 1914, when increased use of the mineral by Germany aroused the interest of producers throughout the world, and Canada produced 15½ tons of selected ore. Most of this came from the Ross mine in Aldfield township, Quebec; the ore was concentrated at the Mines Branch, Ottawa.

Soon after the outbreak of war, the use and demand for molybdenum increased to such an extent that molybdenite became one of the essential war minerals. The Mines Branch, in the spring of 1915, offered its services to the Imperial Munitions Board, and a year later the Department of Mines was authorized by the Board to purchase molybdenite in Canada. Crude molybdenite and selected molybdenite ores were sent to Ottawa from all over Canada for concentration and sale in accordance with a schedule of prices laid down by the Board. As a result, methods of concentration were greatly improved and the experience gained by the Board was passed on to the producers, some of whom were enabled to erect their own concentrators. One of these companies—the Dominion Molybdenite Co., Ltd.—which was by far the largest producer in Canada during World War I, produced more than 80 per cent of the Canadian output after 1916.

For a period during its first year of operation, it was the world's largest individual producer (Eardley-Wilmot, 1925, pp. 23-24). During the war years, 1914-1918, a total of 857,000 pounds of molybdenite was produced from all Canadian sources. The industry collapsed at the end of the war when the demand ceased. In 1919 about 84,000 pounds was produced, and in the two succeeding years, production was only 250 and 40 pounds respectively, from material recovered during experiments at the Mines Branch, Ottawa.

Following the collapse of the molybdenum market there was very little prospecting and exploration for the metal. What activity there was, was mainly confined to reinvestigations of deposits worked during the war.

In 1915, claims were staked on showings of molybdenite in Lacorne township, Quebec, and in 1921 the Molybdenite Reduction Company was incorporated to take over and operate them. Shaft-sinking had started as early as 1917, and in 1927-28 the company deepened the shaft to 150 feet and started lateral work on the 100- and 150-foot levels. A 30-ton mill was erected in 1928-29, which in 1929 produced 17 tons of concentrate of which only 9.5 tons were sold. Early in 1930, Hollinger Consolidated Gold Mines, Ltd. took an option on the property, deepened the shaft to 275 feet, and started lateral work on the 250-foot level. Results were not encouraging and at the end of June, 1930, the company abandoned its option.

In 1931, about 1,200 pounds of molybdenite concentrates were produced at the Mines Branch from ore mined in Bagot township, Ontario, on the property of the Phoenix Molybdenite Corporation. This property was again active in 1934 when about 200 tons of ore yielded 1½ tons of concentrates, none of which was shipped. That year, too, a few hundred pounds of concentrates were sent out as samples from the old Chisholm mine in Sheffield township, Ontario. Exploration was recommenced north of Lake Abitibi, near Mace, Ontario, and in Quebec at the Bain mine, Masham township, and also west of Portneuf. In British Columbia, tunnelling was undertaken on the property of Martel Gold Mines, near Ashcroft. In the next two years the main activity was at the Phoenix property; by the end of 1936 a 25-ton mill had been erected there and a few tons of concentrates produced, but none was shipped. Exploration, including shaft-sinking and tunnelling, was continued in the Mace area, Ontario, and in Quebec at the Bain property and at a property near Portneuf. New areas of activity included the Joiner property near Wilberforce, Ontario, and Eardley township, Quebec.

A revival in prospecting for molybdenum began in 1937, the main attention being directed towards properties worked during World War I. The Phoenix Company was the only shipper. Nearly 5,000 tons of ore was mined, of which half was milled to produce 12½ tons of concentrates. Exploration that year ranged over the provinces of Quebec, Ontario, Manitoba, and British Columbia. Included in this activity was assessment work carried out by the Molybdenite Corporation of Canada on the property in Lacorne township, Quebec. Diamond-drilling was begun to investigate the vein system at depth. This resumption of activity at

Lacorne was to lead to the only lasting molybdenite-producing operation in Canada so far. In British Columbia prospecting took place in the region of Boss Mountain, east of Williams Lake.

This increased activity continued during the years immediately preceding World War II. The Phoenix property was taken over by the Zenith Molybdenite Corporation which shipped a few tons of concentrate to England. In 1938, Molybdenite Corporation of Canada began treatment, at its 30-ton pilot mill, of 2,500 tons of ore which had previously been mined and hoisted. The Moss mine near Quyon, Quebec—the old property of the former Dominion Molybdenite Company, Ltd.—was reopened in 1938 by the Quyon Molybdenite Company. Apart from these operations, some prospecting and exploration was continued in Ontario, Quebec, and British Columbia, none of which resulted in commercial production.

World War II occasioned a sharp increase in molybdenum mining and exploration in Canada. Commercial production started again in September 1939, and up to September 1, 1945, the total production amounted to 1,700 short tons of concentrates. Of this, 1,064 tons was produced during 1944.

The main source of supply—the Lacorne mine of Molybdenite Corporation of Canada—was taken over by the Wartime Metals Corporation in July 1942, and arrangements were made for Siscoe Gold Mines, Limited to operate the mine. The enlarged mill went into production in May 1943, and up to July 1945 when the original owners repurchased the property, about 200,000 tons of ore containing 0.7 per cent molybdenite was treated to produce concentrates containing 1,429,711 pounds of molybdenum.

Indian Molybdenum Limited, owned by Dome Mines, Limited, erected a 600-ton mill and operated a large low-grade deposit (about 0.45 per cent molybdenite) 20 miles northwest of the Lacorne mine. Production began in September 1943, and by the end of April 1944 when the mill was closed down, about 93,000 tons of ore had been treated and the concentrates shipped.

Quyon Molybdenite Company continued to operate the old Moss mine until May 1944; up to 1939 it had produced 80 per cent of Canada's output of molybdenum. This company treated about 150 tons of 0.2 per cent ore daily. The concentrates were converted to the oxide in a small roasting plant on the property.

During the war many other properties were investigated but none reached the production stage. The Zenith Company's property in Bagot township, Ontario, was extensively explored underground by the Wartime Metals Corporation during 1942-43. The results of the work were disappointing and only about 400 tons of ore was produced. This yielded 12½ tons of selected material which was subsequently treated at the Lacorne concentrator to produce 2,274 pounds of molybdenite concentrate.

Canadian molybdenite production since 1945 has been dominated by the Lacorne mine. After taking over from Wartime Metals Corporation, the Molybdenite Corporation of Canada operated the mine and plant until early 1948 when continuing losses forced its closure. From July 1945 to May 1948, 2,060,000 pounds of molybdenite concentrate was produced at the Lacorne mine.

In 1951, operations were resumed by the Molybdia Corporation, Limited, in which Molybdenite Corporation of Canada held a 50-per-cent interest. In 1953 the latter signed a contract with an agency of the United States Government to sell 6 million pounds of molybdenite and 450,000 pounds of bismuth over a period of 6 years. Molybdenite Corporation then reacquired the properties and started an expansion program to meet the terms of the contract. The mill resumed operations in March 1954. During 1957, 544 tons was milled daily; this was stepped up to 650 tons in 1958.

Although the Lacorne mine has been the only Canadian producer of molybdenite in the post-war period, prospecting and exploration has been widespread across Canada, with some encouraging results. Exploration, including diamond-drilling, by Preissac Molybdenite Mines Ltd. in the vicinity of the former Indian mine in Preissac township, Quebec, has revealed a mineable body of molybdenite ore down dip and along strike from the old mine workings. Ore reserves there are given as 1.3 million tons containing 0.5 per cent molybdenite.

In British Columbia, American Metal Climax Inc. have continued exploratory diamond-drilling of the molybdenite-bearing breccia zones in the neighbourhood of Takonkame (Boss) Mountain. One zone there has indicated 1.2 million tons of ore containing 0.76 per cent molybdenite.

In western Ontario, Pidgeon Molybdenite Mines, Limited, have investigated zones of molybdenite-bearing pegmatite, aplite, and quartz veins lying along the contact between a granitic intrusive and overlying sedimentary schists. Four lens-like bodies of mineable size have been indicated; they total about 280,000 tons of 0.6-per-cent ore.

In the Matachewan district of Ontario, an attempt has been made to rehabilitate a former small copper producer as a molybdenum-copper mine. At the time of writing the success of this project seemed to depend on the solution of metallurgical problems.

In addition to the above-mentioned operations, there has been considerable recent prospecting, exploration and investigation of known occurrences, covering areas from western Quebec to Yukon Territory.

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Chapter II

GEOCHEMISTRY

The information in this chapter has been taken from various textbooks and reports, chiefly those by Goldschmidt (1954, pp. 555-561), Sandell and Kuroda (1954), Rankama and Sahama (1950, pp. 625-631), and Krauskopf (1955).

Molybdenum (Mo) is an element having a widespread and rather uniform distribution in the rocks of the earth's crust. Sandell and Kuroda give the average Mo content of 135 granitic rocks as 1.1 ppm, of 37 basalts and diabases as 1.0 ppm, and of 21 gabbros as 0.6 ppm. According to these workers, ultramafic rocks tend to be poorer in Mo than mafic rocks; the average figure for 23 samples (including 9 serpentines) was 0.4 ppm. Sandell and Kuroda assigned an average value of 1 ± 0.5 ppm Mo to the rocks of the earth's crust.

Molybdenum in Meteorites

Molybdenum is present in meteorites and the amount in the sun's atmosphere has been measured. In meteorites the highest molybdenum content is in the metal phase and a submaximum is in the sulphide phase. From its distribution between the metal phase (8 ppm) and the silicate phase (0.6 ppm), Sandell and Kuroda concluded that Mo is more siderophile than Fe itself. Its chalcophilic character, though less strong than its siderophilic character, is pronounced, as shown by the average figure of 6 ppm Mo (3 samples) for the troilite phase of meteorites.

Molybdenum in Igneous Rocks

The rather uniform distribution of molybdenum among the common igneous rocks is attributed by Sandell and Kuroda to its ability to replace a number of elements in the lattices of rock-forming minerals. It is present in the feldspars, in biotite, amphiboles and pyroxenes and, especially, in magnetite and ilmenite. Substitution of Mo for Fe^{3+}, Ti, Al, and possibly Si, is indicated. These substitutions are in general agreement with the ionic radii of the elements involved.

In the upper lithosphere, molybdenum shows the property of becoming pronouncedly concentrated in the last differentiates during magmatic crystallization. The early magmatic nickeliferous sulphide ores contain Mo in low concentrations. On an average, magmatic sulphides contain 20 ppm Mo (Rankama and Sahama, 1950, quoting Noddack and Noddack, 1931). According to Landergren (1948) titaniferous iron ores are low in Mo (less than 30 ppm). In mafic rocks, Mo tends to vary with Ti, as was shown by Sandell and Kuroda for the basaltic flows of upper Michigan. This relation does not seem to hold for differentiates of those intrusives in which concentration of the alkalis can take place. Molybdenum is markedly bunched in the silicic or alkalic differentiates of mafic rocks.

Mo occurs in greater-than-average amount in rocks of alkalic affinities, such as syenites and trachytes. It is doubtless to be classed among the elements concentrated in alkalic differentiation. Considerable amounts of molybdenum are present in many of the granites that conclude the main stage of crystallization, mostly in the form of the disulphide molybdenite (MoS_2). According to Ramdohr (1940) however, molybdenite is rather scarce in igneous rocks as a whole, and figures given by Rankama and Sahama (1950, pp. 98, 101) seem to show that Mo is not very strongly concentrated in the sulphides of igneous rocks. It may therefore be concluded that molybdenum is oxyphile in the rocks of the earth's crust.

Molybdenum in the Processes of Weathering and Sedimentation

According to Goldschmidt (1954, p. 559) little is known of the fate of molybdenum in the sedimentary cycle. The bulk of molybdenum from primary igneous deposits undoubtedly goes into solution. Molybdenum has been found in sea water in amounts of about 0.001 to 0.005 ppm, a value that is probably subject to seasonal fluctuation. The soluble molybdates and colloidal compounds formed during weathering are transported in solution without being redeposited to any considerable extent in the zone of cementation.

The distribution of molybdenum between different types of soil minerals is still unknown, although its occurrence in soils is of some importance in agriculture. For instance, the cattle disease known as 'teart' is related to an excess of Mo in forage which occurs in neutral or alkaline soils with a high Mo content. The concentration of molybdenum in certain coal ashes is well known and very marked, being as high as 0.05 per cent. Concentration of molybdenum in forest litter has also been observed and may be due to processes similar to those that caused the concentration in coal ashes.

Precipitation of molybdenum takes place in ordinary hydrolysate sediments, especially in those minerals and rocks in which trivalent or quadrivalent manganese is being precipitated. Goldschmidt (1954, p. 560) consistently found notable amounts of Mo in manganese-dioxide minerals from sediments or other deposits in the zone of oxidation. The amounts ranged between several tenths of 1 per cent of Mo down to some hundredths of 1 per cent. Even the manganese-dioxide minerals from deep-sea sediments contain remarkable amounts of Mo originating from the content of the element in sea-water.

Under strongly oxidizing conditions in the sedimentary cycle, molybdenum as the molybdate ion becomes rather mobile and may migrate together with vanadium in porous sands and sandstones. Under strongly reducing conditions, for instance in water containing considerable amounts of H_2S, molybdenum is precipitated, presumably as MoS_2, and may collect in appreciable amounts in reduced sediments. A well-known example of this is furnished by the Permian copper shale of central Europe, which contains 100-200 ppm Mo over great distances—an amount sufficient to give a by-product recovery of molybdenum.

Molybdenum Content of Sedimentary Rocks

Sandell and Kuroda (1954) give the following summary regarding the concentration of molybdenum in various sedimentary rocks.

> Shales poor in organic matter contain about as much molybdenum as igneous rocks (average about 1 ppm). Carbonaceous and pyritic shales are likely to be much richer; contents of 100 ppm or more may be encountered. Limestones and dolomites usually contain less than 0.5 ppm Mo except when organic matter is present. Because of the variable amount of Mo in shales it is difficult to arrive at an average value for molybdenum in sedimentary rocks. The content may be appreciably higher than in igneous rocks because of the escape of molybdenum in hydrothermal solutions and volcanic emanations. Deep sea sediments contain an average of a few parts per million Mo.

According to Krauskopf (1955, p. 452) molybdenum resembles vanadium in that its enrichment is greatest in asphalt and petroleum ash. Evidence has been presented for its special enrichment in sapropelite, but it is more consistently enriched than vanadium in all kinds of carbonaceous sediments. Doubt has been expressed that Mo is associated directly with organic matter in the rock as it exists today, but its orginal concentration may reasonably be linked with organic processes.

Krauskopf (1955, p. 454), suggests that coal ash and asphalt and petroleum ash are possible sources of molybdenum metal, and that the investigation of manganese-oxide sediments, black shales, and phosphorites containing organic matter might repay prospecting for molybdenum and other minor metals.

Mineralogy

The following information on the few minerals in which molybdenum is an important constituent is taken mainly from Palache, Berman and Frondel (1944, 1951).

Primary Minerals

Molybdenite (MoS_2) is the only primary mineral of molybdenum known in nature. It accounts for all the molybdenum produced in Canada and nearly all of that from the rest of the world. Theoretically molybdenite contains 59.94 weight per cent Mo and 40.06 weight per cent S; most analyses show no other constituents, the Mo and S being nearly in theoretical proportions. Germanium and rhenium are present as a trace or in small amounts in many molybdenites.

The mineral crystallizes in the hexagonal system, and the crystals are generally tabular in shape or short prisms, slightly tapering and horizontally striated. Molybdenite is commonly foliated, massive, or in scales; it is also very finely granular to amorphous. The colour is lead-grey and the lustre is metallic. The streak on porcelain is greenish—this may be used to distinguish it from graphite, a mineral that closely resembles molybdenite. On paper the streak is bluish grey.

Molybdenite occurs as an accessory mineral in certain granites and in pegmatites and aplites, in places in large amount. It is common in many veins of the deep-seated class, associated with scheelite, wolframite, topaz, and fluorite, and also in contact-metamorphic deposits with lime-silicates, scheelite, and chalcopyrite. In the zone of weathering, molybdenite alters to ferrimolybdite, powellite, and ilsemannite. Pseudomorphs of bismuthinite and powellite after molybdenite have been reported.

Secondary Minerals

Wulfenite ($PbMoO_4$) is a secondary mineral formed in the oxidized zone of deposits containing lead and molybdenum minerals. Next to molybdenite it is the most common mineral of molybdenum. It is generally associated with pyromorphite, vanadinite, mimetite, cerussite, limonite, wad, calcite, and altered or corroded galena. Less commonly it is found with hemimorphite, descloizite, anglesite, and crocoite. Wulfenite crystallizes in the tetragonal system. The crystals are commonly square tabular, but some are extremely thin. Less commonly they are octahedral in habit, and rarely prismatic. The mineral also occurs massively, and coarse to finely granular. The colour may be orange- to wax-yellow, yellowish grey, greyish white, siskin- and olive-green, brown, reddish brown, and even orange to bright red due to the presence of chromium. In composition, wulfenite is lead molybdate ($PbMoO_4$). Tungsten substitutes for molybdenum in at least one published analysis, indicating at least a partial series towards the isostructural compound stolzite ($PbWO_4$). However, tungsten is lacking in most reported analyses. Calcium substitutes for lead to at least a ratio of Ca:Pb = 1:1.7, indicating at least a partial series towards the isostructural mineral powellite (*see below*). Several varieties of wulfenite have been described. These include calcian, vanadian, and tungstenian varieties. Chillagite is a mineral from Queensland, Australia, containing W in substitution for Mo from a ratio of about 3:5 to slightly higher than 1:1.

Wulfenite is of no importance in Canada, although deposits containing this mineral have been worked in the United States.

Powellite, $Ca(MoW)O_4$, commonly forms by the alteration of molybdenite, but has been reported from only a few places in Canada, wholly from the uppermost, weathered zone of ore deposits. In the known occurrences it is of no consequence as an ore mineral, and it is doubtful whether, under Canadian conditions, it will anywhere be found in quantities of commercial importance. Powellite crystallizes in the tetragonal system and generally occurs as small dipyramids and thin tabular crystals. It may also be massive, with a foliated structure pseudomorphous after molybdenite, or in pulverulent to ochreous state. The colour is straw-yellow, brown, greenish yellow, pale greenish blue, and sometimes dirty-white to grey. Powellite fluoresces creamy-yellow to golden-yellow in ultra-violet light. Theoretically powellite has the formula $CaMoO_4$, but in nature tungsten substitutes for molybdenum up to a ratio of about Mo:W=9:1. A complete series apparently does not exist to scheelite ($CaWO_4$) in natural material. Powellite alters to ferrimolybdite. Its importance is in its being an indicator of the presence of molybdenum in the material, rather than in itself being a source of molybdenum.

Ferrimolybdite (molybdic ochre, molybdite), $Fe_2(MoO_4)_3 . 8H_2O$(?), is a secondary mineral formed by the alteration of molybdenite. It is common in the weathering zones of many Canadian molybdenite deposits and apparently forms in a very few years on broken ore. Palache, Berman and Frondel (1951, pp. 1096-1097) remark:

> The mineral long-known as molybdite was shown by Schaller in 1907 to be a hydrated ferric molybdate and not molybdic oxide as supposed. The name ferrimolybdite was later proposed for the species, in allusion to the composition, and the name molybdite, in lack of proved natural occurrences of MoO_3, is here relegated to the synonymy.

In Canadian publications, especially the older ones, the name molybdite is used more frequently than ferrimolybdite; both names appear in this report.

Ferrimolybdite occurs in massive form, as fibrous crusts, and as tufted or radial fibrous aggregates. It is also subfibrous and has an earthy powder or coating. The colour is canary-yellow, straw-yellow, or greenish yellow. In composition it is a hydrated ferric molybdate, probably $Fe_2(MoO_4)_3 . 8H_2O$. The water content is uncertain; most of the water is lost at temperatures below 125°C and dehydration is complete at 250°C.

Although of no importance as an ore-mineral of molybdenum, ferrimolybdite is a distinctive indicator of the presence of molybdenum in the material.

Ilsemannite (molybdenum blue), $Mo_3O_8.nH_2O$, is a secondary molybdenum mineral that has not been reported from Canada, and is of no importance as an ore of the metal. It is found associated with iron, aluminum, or magnesium sulphates, commonly colouring them blue. Ilsemannite is found only as earthy masses or crusts, and as a stain or disseminated pigment. Its colour is black, blue-black, or blue, becoming blue on exposure. The composition is uncertain; probably several different substances are involved in the natural occurrences.

Koechlinite, $(BiO)_2(MoO_4)$, is a rare secondary mineral formed during the weathering of veins containing bismuth and molybdenum. It has not been reported from Canada. The mineral occurs in thin, square to rectangular plates and laths, and in earthy and massive forms. Its colour is greenish yellow.

Lindgrenite, $Cu_3(MoO_4)_2(OH)_2$, is a secondary mineral found at Chuquicamata, Chile. Other basic copper molybdates have been reported, but their relation to lindgrenite is not known.

Chapter III

CLASSIFICATION OF DEPOSITS

The geochemical distribution of molybdenum is characterized by a preference for the late products of magmatic fractionation. Concentrations of molybdenum are found in association with granites, syenites, and their pegmatites, nearly always in the form of molybdenite. Molybdenum also occurs in the pneumatolytic products of magmas, especially when the pneumatolysis involves volatile fluorine compounds, as in the formation of granite-associated cassiterite deposits. Such deposits of molybdenite, some associated with bismuth minerals, are common in Precambrian granites. The molybdenite-bearing veins in these deposits are in places accompanied by typical 'greisen' rocks. Other molybdenite deposits associated with granites appear to have been formed from residual hydrothermal solutions rich in silica, as they are connected with extensive hydrothermal quartz veins, some of which grade into aplites or pegmatites. Again, molybdenite is a common mineral in contact zones, especially at the contacts of granites with limestones and related rocks.

The occurrence of molybdenum, however, is not restricted solely to such residual magmas as those of granites, syenites, or nepheline syenites. Small amounts of molybdenite are sometimes found in genetic relationship to basic gabbroic magmas such as norite, where it is a minor constituent of nickel-copper ores.

Secondary deposits are now of negligible importance in commerce. They fall into two classes: those formed by sedimentary processes, being laid down as part of the sedimentary rock in which they lie; and those formed as a result of the weathering of the primary molybdenum mineral—molybdenite. The source mineral in the sedimentary deposits is thought to be molybdenite. No secondary sulphides of molybdenum appear to be formed by weathering processes, the metal being contained in the complex oxidized minerals described previously.

The different types of molybdenite-bearing deposits have been classified in somewhat different ways by different authors. Stevenson (1940, pp. 2-3) makes a fivefold classification, based mainly on genetic considerations. His five classes are:

1. Silicified fracture-zones
2. Quartz veins
3. Pegmatites and aplites
4. High-temperature replacement deposits
   - (a) Bodies of lime-silicates, copper, iron, and molybdenum sulphides formed by replacement of limestones
   - (b) Bodies of quartz, feldspar, pyrrhotite, and molybdenite replacing schists
5. Certain disseminated copper deposits.

Vandervilt (1933) has proposed the following threefold classification in which Stevenson's first two classes are merged into one and his fourth class is omitted.

1. Pegmatite and aplite dykes
2. Quartz veins
3. Accessory mineral in gold and copper deposits.

Creasey (*see* McInnis, 1957, pp. 8-9) uses a classification that is based more on economic aspects, that is, it depends on the metal or metals obtainable from the deposits.

1. Deposits yielding molybdenum alone or as chief metal
2. Copper deposits yielding molybdenum as a by-product
3. Contact-metamorphic tungsten deposits yielding molybdenum as a by-product
4. Wulfenite-bearing base-metal deposits.

Charrin (1957) mentions the occurrence of molybdenum in the Mansfeld Shales (*see also* Chapter II). This type of deposit must be added to the classes set out above.

The classification used in this report is based on the information contained in the above-mentioned publications, and follows largely the classification used for uranium by Klepper and Wyant (1957).

Deposits Formed by Igneous and Metamorphic Processes

Syngenetic Deposits

In Acidic and Alkalic Igneous Rocks

Molybdenite is a common constituent of granites and other igneous rocks, occurring sparsely disseminated in them in a manner strongly suggesting that the sulphide is an original accessory mineral and has crystallized in situ. Of course, it is difficult in many cases to distinguish between a syngenetic and an epigenetic (introduced) dissemination, but the latter generally occurs in the vicinity of clearly epigenetic mineralization such as that which produces a vein. Syngenetic deposits of molybdenite of this type are very widespread but their tenor is generally so low that they are not of commercial interest. So far as is known they play no role in the present-day production of molybdenum.

Pegmatitic and Aplitic Deposits

Molybdenite is probably the most common sulphide mineral in pegmatites and related rocks, and in many cases there is every reason to suppose that they are a product of the original crystallization of the rock. On the other hand, pegmatite or aplite commonly forms later than the main intrusive mass. Therefore pegmatitic and aplitic deposits are a 'border-line' class that is difficult to assign to either the syngenetic or the epigenetic group. The tenor of pegmatitic molybdenite deposits is very erratic; the mineral tends to occur in lenses or pods. The grade in the pods may be high, but the pods are generally small and widely spaced so that the grade of the pegmatite as a whole is generally not economic. Most of the molybdenite in pegmatitic deposits occurs in large crystals or flakes; in places as radial clusters of smaller flakes. Molybdenite in aplite is normally of finer grain size, but it also commonly shows a rosette-like habit. Pegmatitic deposits of molybdenite are very common in Precambrian terrains, but with few exceptions, these are more of scientific than economic importance.

Epigenetic Deposits

Veins

Pegmatitic Quartz Veins

Veins of pegmatitic quartz with various amounts of feldspar and sericitic mica in places carry economic amounts of molybdenum and bismuth. These veins represent a transition from pegmatites to simple feldspar-free quartz veins. Beryl may be present in some examples, as in northwestern Quebec, again emphasizing the pegmatitic character of the veins. This type of deposit constitutes the orebodies at the only producing mine in Canada—at Lacorne, Quebec. At Climax, Colorado, around a central core of barren quartz formed by silicification of granitic rocks, molybdenite-bearing quartz veins—parts of which carry considerable orthoclase—form a closely spaced stock-work that constitutes the largest known molybdenum deposit in the world.

Simple Quartz Veins

Molybdenite-bearing veins of massive white quartz, without feldspar or primary mica, are widespread, but little molybdenite is obtained from them. The veins vary from a fraction of an inch to several feet wide. The mineral content varies widely; many veins consist only of quartz and molybdenite, whereas in others pyrite is common, and chalcopyrite, sphalerite, and galena may or may not be present. Most of the molybdenite is fairly fine grained and shows a tendency to concentrate along the vein walls or along joints and seams. In the Indian Peninsula area of Quebec, straight-walled quartz veins from 6 inches to 12 feet wide, cutting muscovite granite, carry spotty, uneconomic amounts of molybdenite. At Queston, New Mexico, economic amounts of molybdenite occur in veins and stringers in alaskite porphyry. The vein-filling is quartz and molybdenite with minor pyrite, chalcopyrite, fluorite, sericite, apatite, biotite, chlorite, and calcite. These molybdenite-bearing quartz veins in many ways resemble gold-quartz veins, and a transition between the two types is common.

Gold-bearing Veins

Molybdenite is a common accessory mineral in gold veins, especially in the Precambrian rocks of northern and northwestern Ontario and northwestern Quebec. As yet, these veins have not yielded any molybdenite to commerce.

Veins of Base-metal Sulphides

Transitions occur between molybdenite-bearing quartz veins with few accessory base-metal sulphides and veins that are dominantly composed of the latter minerals. The molybdenite is normally present as an accessory to the other sulphides, but in places it is abundant enough to be recovered. On the whole, this type of deposit does not yield any significant quantity of molybdenite.

Disseminations and Impregnations

Epigenetic disseminated molybdenite deposits are chiefly of two types: those that carry molybdenite alone or as the chief mineral, and those in which molybdenite occurs as a minor constituent in base-metal deposits—chiefly copper deposits. The first type is represented in Canada by the small orebody formerly worked at the Molly mine near Salmo, British Columbia, and by smaller occurrences that have not as yet played a commercial role. The second type is not common in Canada; it is chiefly represented by the so-called 'porphyry copper' deposits of southwestern United States and Mexico. Such deposits consist of large mineralized bodies of acidic hypabyssal intrusive rocks and parts of the surrounding country rocks. The chief minerals are chalcopyrite and chalcocite, with pyrite, and small amounts of other sulphides including molybdenite which is sometimes recovered as a by-product. The copper-to-molybdenum ratio mostly ranges from 50:1 to 150:1.

A third, but very minor type of disseminated molybdenite deposit is represented by certain small bodies of gneisses and feldspathic schists, very sparsely impregnated with the sulphide. None appears to be of economic importance.

Metasomatic Deposits

Many replacement bodies of lime-silicate minerals or 'skarn' carry low and erratic values in molybdenite. This type of deposit is common in the Cordilleran region of Canada in places where lime-bearing sedimentary rocks have been metasomatically altered in the neighbourhood of granitic intrusions, or under the influence of regional granitization. These bodies consist chiefly of garnet, diopside, and quartz. The metallic minerals vary considerably: some deposits carry only molybdenite; in others gold or tungsten is present and molybdenite is an accessory mineral; in yet others the principal metallic minerals are copper sulphides, with minor molybdenite. As sources of molybdenite, such deposits are of little importance.

A second type, which appears to be confined to the Grenville province in Quebec and Ontario, may, in the absence of definite evidence to the contrary, be classed as metasomatic. Such deposits are chiefly of diopsidic pyroxene, with or without feldspar, mica, and calcite, and many are heavily mineralized with pyrite and/or pyrrhotite, and molybdenite. Many of these 'pyroxenic' molybdenite deposits have been worked during wartime, but they appear to be too small and too erratic in grade to be of great economic importance.

Deposits Formed by Sedimentary Processes

So far very little is known about sedimentary deposits of molybdenum, and, certainly in North America, they play no role in commerce. However, the Mansfeld Kupferschiefer of central Europe has a sufficient molybdenum content to make possible the recovery of the metal as a by-product. Little is known of the mineralogical associations of these deposits, but presumably the metal is present as molybdenite.

Deposits Formed by Weathering Processes

Creasey (McInnis, 1957, p. 9) states:

> The oxidized parts of some lead-zinc deposits in arid and semi-arid regions of the world contain wulfenite, commonly associated with vanadium minerals, such as vanadinite and descloizite. The origin of these molybdenum and vanadium minerals is obscure. In most deposits the molybdenum and vanadium were apparently introduced after oxidation of the deposit because analyses of the primary vein minerals fail to reveal enough molybdenum and vanadium to account for that present in the oxidized portions of the veins. Adjacent vanadium- and molybdenum-bearing shales are commonly accepted as the source; but in some deposits, such as that in the Mammoth Mine, Arizona, such shales are not present. Production from this type of deposit has been small and is not likely to be significant in the future.

Chapter IV

WORLD RESOURCES

The molybdenum reserves of the world, except for the communist-controlled countries, have been estimated at 2,500 million pounds (Creasey *in* McInnis, 1957, p. 6). Of this, about 85 per cent occurs in four major deposits—three in the United States and one in Chile. Deposits within the United States alone—the three just mentioned plus other occurrences—account for about 90 per cent of the world's reserves. Commercial reserves of United States molybdenum are estimated to be 2,200 million pounds; additional potential reserves total about 850 million pounds. Creasey believes that future major discoveries of molybdenum ores will be of the porphyry-copper type, yielding molybdenite as a by-product.

Principal Foreign Deposits

The following brief descriptions of the geology of the principal producing molybdenite deposits of the non-communist world are drawn mainly from the chapter by Creasey (*in* McInnis, 1957, pp. 9-15), and from McInnis and Burke (1958).

United States

The Climax mine in Colorado and the Questa mine in New Mexico were the only United States mines operated chiefly for molybdenum in 1956. Their production comprised about 65 per cent of the United States total for that year; the rest was recovered as a by-product from nine copper-ore plants and one tungsten-ore operation.

The Climax deposit is about 100 miles west of Denver and 13 miles north of Leadville. The ore is mined by block caving and is taken directly to the mill through two main haulage levels.

The rocks in the vicinity of the Climax deposit are Palæozoic sedimentary rocks, Precambrian crystalline schists of the Idaho Springs formation, and Precambrian Silver Plume granite. These are cut by Tertiary dykes and stocks, and it is with one of these—the Climax porphyry stock—that the deposit is associated. The Climax stock consists of quartz monzonite; the stock does not outcrop in the area of the deposit but it has been well exposed in underground workings. The overlying rocks, chiefly Silver Plume granite, have been intensely silicified to form a dome-shaped cap or quartz rock, to which the ore is peripheral.

The wall-rocks and the Climax stock in the ore zone were closely fractured, presumably in Laramide or later time. Mineralization of these channels formed a close stock-work of veinlets that average $\frac{1}{8}$ to $\frac{1}{2}$ inch in width.

The rock between the veinlets in the ore zone was also intensely mineralized, presumably by diffusion through minute fractures and pore spaces. The three types of veins which have been recognized, and the minerals found in them, are as follows:

Molybdenite-quartz veins

quartz	sericite
molybdenite	orthoclase
pyrite	fluorite

Pyrite-topaz-quartz veins

quartz	galena
pyrite	sphalerite
topaz	rhodochrosite
hübnerite	sericite
chalcopyrite	fluorite

Sericite and topaz veins

sericite	kaolinite
topaz	montmorillonite

These minerals also occur in the altered wall-rocks.

The shape of the ore zone is irregular in three dimensions. In plan, the ore zone on the upper level is shaped like a doughnut, with the quartz rock in the centre; but on the lower levels, where the volume of quartz rock is less and more Climax porphyry is exposed, the ore zone loses its regularity.

The Questa mine, New Mexico, is a typical fissure-vein deposit, the only one of its kind in the United States known to have produced appreciable amounts of molybdenite. The tenor of the ore as mined varies between 2 and 15 per cent MoS_2.

In the vicinity of the deposit an albite granite invades Precambrian schist and a series of sedimentary and volcanic rocks of uncertain age. The veins are in the granite in a zone not more than 100 feet across, immediately below the contact with the schist, but small seams of molybdenite occur over a much greater width. The veins branch and die out in the overlying altered schist and shaly sedimentary rock. Production from the Questa Mine in 1956 decreased sharply from the previous year; no production was reported for the last two months of 1956.

The San Manuel deposit in Arizona, lies about 40 miles north of Tucson. It was discovered during World War II and has since been under continuous exploration and development. The first recovery of molybdenite concentrate from the dominantly copper ore was reported in April 1956. The average rate of ore production at the mine is about 35,000 tons a day.

San Manuel is a typical porphyry-copper deposit. The primary ore consists chiefly of pyrite, chalcopyrite, a small quantity of bornite, and even less molybdenite, in monzonite porphyry and adjacent rocks. There is some secondary enrichment; pyrite and chalcopyrite have been partly reduced by chalcocite. The molybdenite occurs with quartz in veinlets, some of which are younger and some older than quartz-chalcopyrite veinlets.

The Silver Bell deposit, Pima county, Arizona, is a small porphyry-copper property. Production began in 1954 at the rate of 18,000 tons of copper annually; daily ore-production is about 7,500 tons.

The disseminated ore is in two deposits—the Oxide and the El Tiro—about 2 miles apart. The deposits occur chiefly in alaskite, dacite porphyry, and monzonite. They appear to be genetically related to the monzonite, which is a stock and is the youngest of the intrusions. Primary mineralization introduced quartz, pyrite, and chalcopyrite, chiefly in narrow, parallel veins and veinlets. To a small extent, pyrite and chalcopyrite are disseminated between the veins. The veins range in width from paper thin to several inches, and in spacing from inches to several feet. The limits of the ore are controlled by the spacing of the veins. The molybdenite probably occurs with the chalcopyrite, chiefly in the veins and veinlets, and to a smaller extent disseminated in the ore between the veins.

The Utah Copper deposit at Bingham, Utah, is the largest porphyry-copper deposit in the United States, and the second largest producer of molybdenum. Utah Copper mills about 90,000 tons of ore a day that contains about 1 per cent copper and a small quantity of molybdenum.

The host rock is monzonite porphyry. The ore consists of quartz and sulphides in veinlets cutting the porphyry and disseminated between the veinlets. The most abundant minerals are chalcopyrite, chalcocite, covellite, bornite, pyrite, magnetite, and quartz. Molybdenum occurs in small amounts, chiefly in quartz veins.

Morenci is a disseminated-copper deposit in eastern Arizona, not far from the New Mexico border. Molybdenite has been recovered continuously since 1951.

The Morenci deposit is entirely within quartz-monzonite porphyry that has been intensely argillized and sericitized. Numerous large to small cracks break the rock into small, angular fragments. The veins and veinlets consist of quartz, pyrite, chalcopyrite, chalcocite, and small but variable amounts of molybdenite. The distribution of molybdenite in the ore is erratic and the average content is not known.

The Miami deposit, at the town of Miami in central Arizona, is a porphyry-copper deposit from which molybdenum has been recovered as a by-product since 1938.

The occurrence is similar to that of the other porphyry-copper mines; molybdenite occurs in quartz veins associated with pyrite and chalcopyrite and is disseminated to a small extent in the country rock between the veins.

Other porphyry-copper deposits producing molybdenite as a by-product are: The Bagdad Copper Corporation, Bagdad, Arizona; Chino Mines Division of Kennecott Copper Corporation, Grant county, New Mexico; and the Nevada Mines Division of Kennecott Copper Corporation, White Pine county, Nevada.

Pine Creek mine, Myo county, California, is situated near the crest of the Sierra Nevada, west of Bishop, California. It produced intermittently from 1917 to 1936 and continuously since 1939. Output in 1955 was at the rate of about 500 tons of ore per day.

The mine is near the north end on the west side of the Pine Creek pendant in a contact zone between marble and intrusive granite and quartz diorite. The contact zone consists mainly of garnet-diopside tactite but includes quartz and quartz-feldspar rocks. Thicker parts of the contact zone constitute the tungsten ore-bodies. The upper third of the ore zone contained about 0.6 per cent Mo, about 0.2 per cent Cu, and 0.45 per cent WO_3. The molybdenum content decreased with depth and is much less important in the lower workings. The lower tunnel level, which is 1,500 feet lower than the lowest working level of the mine, encountered tungsten ore carrying a small amount of molybdenite.

Chile

During 1956, the molybdenum production of Chile was 3.1 million pounds of contained metal, an increase of 11 per cent over the previous year. The total output was recovered as a by-product from the Braden Copper Company's El Teniente copper mine near Sewell.

The Braden deposit is of porphyry-copper ore. Lindgren and Bastin (1922) consider that it lies in and around an explosive volcanic vent cutting andesite porphyry and that the ore fluids followed paths through this vent. Their interpretation involves three periods of intrusion, three periods of hypogene metallization, uplift, erosion, and supergene enrichment.

Ore reserves are given as 220 million tons at 2.18 per cent copper with a small molybdenum content.

There is also a great potential molybdenum production from other porphyry-copper deposits in Chile, especially from Chuquicamata. Mining in this deposit is progressing from the oxidized ores—where recovery of small amounts of molybdenite is not feasible—to the primary sulphide ores. Molybdenite is known to occur in the sulphide ores, and the large ore reserves at Chuquicamata constitute a major resource of molybdenum.

In 1957, the Anaconda Company had planned to start by-product recovery of molybdenite from the ores at Chuquicamata and at El Salvador.

Japan

During 1956, molybdenum produced from several small mines totalled 534,000 pounds of contained metal. This output was about 22 per cent higher than that of the previous year but was not adequate to meet the country's rapidly growing needs. The deficit was met by imports from other countries, especially the United States.

Norway

In 1956, Norway produced 366,000 pounds of contained molybdenum in concentrates from the Knaben mine near Egersund in southwestern Norway. This mine is now the sole producer of molybdenum in Norway. Up to the end of 1950 it had produced about 9,900 tons of molybdenite concentrates, as compared with 1,100 for all other deposits.

At Knaben the molybdenite occurs in poorly defined veins and as disseminated flakes oriented parallel with the foliation of gneissic rocks. Associated introduced minerals include minor quantities of pyrite, other sulphides, silicates, tungstates, calcite, fluorite, apatite, and magnetite.

Early reports set the grade of the Knaben ore at 0.25 to 0.50 per cent MoS_2; more recent ones give it as 0.15 to 0.20 per cent. This probably indicates a diminishing grade over the period the deposit has been mined. This type of deposit rarely contains large measurable reserves; but possible ore reserves are large, though of low grade.

Mexico

Before 1947 Mexico produced substantial quantities of molybdenum, which from 1940-47 amounted to about 3 per cent of the world supply. In 1956, however, only 33,000 pounds of contained metal came from Mexican sources.

Past production came chiefly if not wholly from the Cananea deposits in Sonora Province. The most important of these are pipe-like bodies, of which the rich Colorada was outstanding. The cessation of molybdenum production from the Cananea area coincided roughly with the depletion of the Colorada pipe. The orebody has been likened in shape to a goblet, apexing at the 500-foot level to a quartz-sulphide ring 600 feet by 500 feet across. The ore ring converged into the stem of solid ore pipe at the 10th level and the base of the 'goblet' was pegmatitic quartz and phlogopite with sulphides. Stringers of quartz and sulphide penetrated the walls. The ore minerals were bornite, chalcopyrite, and molybdenite, with minor pyrite, tennantite, covellite, and chalcocite.

Korea

According to McInnis and Burke (1958, p. 867), the only other producer of molybdenum in the non-communist world in 1956 was the Republic of Korea with 31,000 tons.

U.S.S.R.

Creasey (McInnis, 1957, p. 14) gives the following information on the molybdenum situation in the U.S.S.R.

> The size and rate of growth of the molybdenum industry in Asia (including all of the Soviet Union) are unknown. The (U.S.) Bureau of Mines Minerals Yearbook for 1947 states that Soviet production was reported to have increased fourfold between 1940 and 1945 and that additional plans called for doubling the 1940 production by 1950. The Kounroud porphyry-copper deposit near Lake Balkhash is suspected to account for the bulk of the proposed increase in production and for the bulk of the known molybdenum reserves. The Tyrny-Auz tungsten-molybdenum deposit in the North Caucasus is the second largest known source, but the potential of this kind of deposit is small compared with that of the porphyry-copper deposits. Development was also underway on at least five other molybdenum deposits in the Soviet Union.

Chapter V

CANADIAN DEPOSITS

Representatives of most classes of molybdenum deposits formed by igneous or metamorphic processes are present in Canada, although very few are now of major importance. So far as is known, however, no sedimentary or secondary deposits have been found.

Syngenetic Deposits

Occurrences of molybdenite in igneous rocks, of apparently syngenetic origin, have been reported from a few places in Canada, but none is of present economic importance. Most of the occurrences are in granitic rocks, although Fairbairn (1937, p. 17) has reported molybdenite in syenite dykes from the Longlac area of Ontario.

At Pabineau (Pigeon) Lake, southwest of Bathurst, New Brunswick, molybdenite accompanied by beryl occurs disseminated in a fine-grained Devonian granite. According to Wright (1940a, p. 3), the molybdenite occurs as flakes and crystals, disseminated throughout the granite as well as along incipient joint planes and associated with stringers of bluish white quartz that cut the granite. Some of the molybdenite may have been introduced with the quartz veins, but the evidence seems to point to the disseminated crystals and flakes, at least, being of primary syngenetic origin.

Cairnes (1924, p. 163) reports molybdenite as a common accessory mineral in some of the batholithic rocks in the area of the Coquihalla Valley in British Columbia. The mineral is scattered throughout coarse granite within a few hundred feet of its contact with a belt of slates. Cairnes was of the opinion that the molybdenite "was introduced during the consolidation of (the) intrusive."

More important representatives of this class are probably the deposits of the old Moss mine near Quyon, Quebec. For a short period during World War I, this mine was the largest producer of molybdenite in the world. The mineral was won from irregular bodies of quartz-rich syenite which Wilson (1924) considered to be magmatic segregations formed during the cooling of the Onslow syenite. The ore consists of grey or greenish grey feldspar and quartz in which pyrite, pyrrhotite, fluorite, magnetite, and molybdenite occur, partly in disseminated form and partly in aggregates or zones. The normal grey phases of the ore generally possess a granular texture and medium grain, and resemble a granite in appearance. In places however, the rock is coarsely crystallized and pegmatitic. Wilson considered that as consolidation of the syenitic magma proceeded, molybdenum, iron, sulphur, fluorine and silica became more and

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more enriched in the parts remaining liquid, until at last, material of the composition of the ore masses became segregated at the points where consolidation last occurred. Wilson also points to the fact that molybdenite occurs as a normal accessory constituent of the Onslow syenite away from the ore masses. These observations are in keeping with the well-known geochemical association of molybdenum with alkaline rocks, and it seems that syenites and related rocks may be regarded as more promising potential sources of molybdenite than the more basic or acidic types.

Deposits in Pegmatite and Aplite

Pegmatitic types are probably the most numerous and widespread of molybdenite deposits in Canada, but so far none has proved of economic importance. Many of the occurrences are high grade but they are notoriously erratic in values and irregular in form, so that the tonnage of mineable-grade ore is very small in any one occurrence. In pegmatitic deposits the molybdenite tends to occur in large flakes and crystals, in keeping with the general coarse grain-size of this type of rock; in aplites on the other hand, the molybdenum mineral normally occurs as small, well-formed flakes, or as rosettes of radially arranged crystals. Molybdenite is generally the only sulphide mineral present; other sulphides occurring in minor quantities comprise bismuthinite, chalcopyrite, and pyrite.

An exception to this is the heavy pyrite-pyrrhotite association in the molybdenite-bearing granite pegmatites of the Grenville province in southern Ontario and southwestern Quebec. This type of deposition seems to be characteristic for the Grenville province as a whole, independent of the type of deposit, and is almost unique in Canada. Generally, however, metals other than molybdenite and iron are rare in this type of deposit in Canada.

Pegmatites carrying molybdenite have probably originated in at least two distinct ways: by injection of pegmatitic material, commonly of granite composition, into pre-existing rocks along zones of weakness; and by the formation of pegmatitic material in situ by a process of metamorphic segregation, commonly along zones of dilation or reduced pressure. There is insufficient evidence to determine if there is a significant mineralogical difference between these two types. Presumably the molybdenite in the second type of deposit was present in the rock from which the pegmatite formed, and was coarsened and concentrated together with the other pegmatitic minerals. At the property of the Acme Molybdenite Mining Company in Kensington township, Gatineau county, Quebec, molybdenite occurs erratically as large thin flakes and as coatings on the rock-forming minerals, in a coarse feldspar-biotite pegmatite in a country rock of coarse-grained biotite syenite. The field evidence suggests that the pegmatite formed by a process of metamorphic segregation; the constituents of the feldspar moved inwards towards a zone of dilation while the biotite was concentrated as a selvedge of coarsened flakes around the margins of the pegmatite (*see* p. 208).

Slipp (1951) and Cameron (1951) have described an occurrence of molybdenite in an injected quartz-orthoclase pegmatite on the Walker prospect at New Ross, Lunenburg county, Nova Scotia. Besides the quartz and feldspar, molybdenite, tourmaline, and copper sulphides are present. The molybdenite is regarded as having crystallized in situ in the pegmatite virtually contemporaneously with the quartz. Slipp suggests that the pegmatite was injected along lines of weakness in the country rocks, which there consist of granitized sediments.

In many areas, molybdenite deposits of different types occur in close proximity to one another. A common association, especially in the Precambrian Shield, is pegmatites, aplites, pegmatitic quartz veins, and quartz veins. This association illustrates the fact that molybdenum is always concentrated during the later stages of magmatic crystallization. These types of deposits are all formed towards the end of magmatic crystallization and normally occur in close proximity to each other. Indeed there is a gradual transition from pegmatites to barren quartz veins and it is often difficult to draw the dividing lines between the different types. For example several types occur close together in the Falcon Lake area of southeastern Manitoba (*see* Bruce, 1918, pp. 22-25). There, molybdenite deposits comprise (1) pegmatite dykes, (2) equigranular granitic dykes, and (3) quartz veins.

In the typical pegmatite dykes, according to Bruce, the molybdenite occurs as crystals varying in size from a fraction of an inch to 2 inches in diameter, the larger crystals being found in the dykes close to the edge of the main granite area. However, in these dykes the total amount of molybdenite present is no greater, and is possibly even less, than in those farther from the intrusion.

In Newfoundland, the most promising deposits of molybdenite so far discovered occur in aplite and related rocks. In the Rencontre East area, occurrences are confined to the southern border of a Palæozoic batholith of granite and alaskite, at or near its contact with Ordovician volcanic rocks. The distribution of molybdenite shows a close correlation with the distribution of the aplitic phase of the batholith. At the Ackley City deposit, an ore zone in the form of a lens, 140 feet long and 40 feet wide, consists of numerous patches of a greisen-like type of alteration, with quartz, muscovite, molybdenite, fluorite, and chlorite distributed through the aplite. Biotite, magnetite, hematite, pyrite, chalcopyrite, pyrrhotite, and sphalerite are minor associates.

On the property of Pidgeon Molybdenum Mines near Sioux Lookout, Ontario, the southern contact zone of a granitic stock contains irregular dykes of aplite that are cut by quartz and pegmatite stringers. The largest concentrations of molybdenite are associated with the quartz and pegmatite, although much of the aplite contains disseminated molybdenite. There appears to be an almost continuous gradation from veins of almost pure quartz containing only one or two feldspar crystals, to coarse, feldspar-rich pegmatite. The latter type normally holds greenish yellow sericitic muscovite, with which large amounts of molybdenite are normally associated. The pegmatites are commonly zoned, with the feldspar occurring predominantly along both walls, and the cores consisting of almost pure quartz. Molybdenite is also concentrated preferentially along the pegmatite walls, and for an inch or so into the enclosing aplite. These deposits clearly show the tendency for the molybdenite in the pegmatite to occur as large irregular flakes, whereas in the aplite, it occurs as small, well-formed crystals and rosettes.

As would be expected from their nature and mode of origin, pegmatitic and associated types of molybdenite deposits are closely related to the margins of the igneous masses in which they originate. They generally occur in the border zones of the intrusives themselves, but are also present in the invaded rocks. The junctions between areas of granite or other igneous rocks and the enclosing sedimentary or volcanic rocks are the most favourable areas for prospecting for deposits of molybdenite, not only of the pegmatite-aplite types, but also of the pegmatitic quartz-vein type (*see below*).

Pegmatitic and aplitic types of molybdenite deposits are widespread in Canada, many representatives occurring in the rocks of both the Precambrian Shield and the Appalachian region. These types are relatively much less common in the Cordilleran region.

Particular concentrations of pegmatites carrying molybdenite occur in the Yellowknife area of the Northwest Territories, in the Lake Athabasca region of Saskatchewan, in southeastern Manitoba, northwestern Ontario, the Grenville province, and certain restricted areas in Nova Scotia and Newfoundland. Though so widespread, pegmatitic molybdenite deposits have so far proved of little commercial importance and there seems little chance that they will ever be commercially significant.

Epigenetic Deposits

Vein deposits containing molybdenite are common and widespread in Canada, and to this class belong the only deposits now being worked for the mineral. For the purposes of description and classification, vein deposits are here divided into different types, but the types intergrade and in many cases it is difficult to place a given deposit in any particular class. So far as possible, the transitional types are mentioned.

Pegmatitic Quartz Veins

The association of pegmatitic quartz veins with pegmatites and aplites, and their normal localization along the border zones of igneous intrusions have already been stated. These relations are very well illustrated in the pegmatitic quartz-vein deposits of the Preissac-Lacorne area of northwestern Quebec, which are by far the most commercially important representatives of this class so far discovered in Canada. Indeed, they include (at the time of writing) the most important deposits of any class in the country. At the Lacorne mine of Molybdenite Corporation of Canada, pegmatitic quartz veins are yielding more than 1 million pounds of MoS_2 concentrates annually, and in the Indian Peninsula area, Preissac Molybdenite Mines Limited have indicated more than 1 million tons of ore with an average content of 0.53 per cent MoS_2.

At the Lacorne mine, the pegmatitic quartz veins which carry the molybdenite occur in and northwest of a large sill or stock of biotite granodiorite which is enclosed in biotite schists of sedimentary origin. Three age groups of veins have been recognized, of which only the intermediate age group has yielded any significant quantities of molybdenite ore. This group includes two sets of veins different in trend but similar in appearance; one set is slightly richer in quartz and contains more of the rare minerals commonly found in the pegmatites (e.g. beryl), and less molybdenite. The so-called 'easterly' veins occur both in the granodiorite and the schist, whereas the 'northerly' veins are confined to the granodiorite stock.

The two sets of veins contain somewhat different mineral assemblages but in common they carry feldspar and muscovite. Some of the easterly veins in schist carry notable amounts of green or blue-green beryl, mostly in a zone along the foot-wall.

Molybdenite is generally associated with greenish sericitic muscovite in irregular patches within the quartz. Other minerals include tourmaline and pyrite, and rare chalcopyrite, bismuthinite, native bismuth, fluorite, apatite, and scheelite.

The contact zone of the Preissac-Lacorne batholith in the Indian Peninsula area of Preissac township, Quebec shows a considerable concentration of molybdenite-bearing quartz and pegmatitic quartz veins. Simple quartz-molybdenite veins also occur in the muscovite granite of the batholith away from the contact zone, and in places molybdenite is scattered sparsely in the granite itself, but these two types of occurrence are of little economic importance compared with the pegmatitic quartz veins and bodies along the contact zone. Norman (1944, pp. 6-7) described a solid vein of quartz containing 5 per cent red feldspar in scattered bunches of coarse crystals. The vein was visible in the crosscut at the bottom of the inclined shaft on the old Indian molybdenite mine. It is intersected by slip-planes roughly parallel with the foot-wall, and muscovite and fine-grained molybdenite occur along these slip-plane surfaces—in some of them, in conspicuous amounts. Other veins show little indication of deformation; these contain white microcline feldspar and hexagonal plates of molybdenite. Molybdenite also occurs to some extent in disseminated flakes in the granite remote from the veins.

From the Tidewater Molybdenum property, at the head of Alice Arm, British Columbia, Stevenson (1940, pp. 61-67) has described molybdenite-bearing lenses and veins of quartz that become more and more pegmatitic in character (due to increasing feldspar content) as they are traced nearer to the intrusive rocks, both horizontally and vertically. The increase in feldspar content is accompanied by a decrease in the molybdenite content of these deposits. This transition again illustrates the difficulty of placing any one deposit into a particular class.

Stevenson (1940, pp. 20-28) has also described the Anticlimax property to the west of the North Thompson River, 60 miles north of Kamloops. There, says Stevenson, the mineral assemblage is definitely high-temperature and closely related to the formation of pegmatites. Medium-grained molybdenite is evenly disseminated in pegmatitic quartz and feldspar and in watery quartz that is itself undoubtedly of pegmatitic origin. Small amounts of molybdenite occur in other places in narrow quartz veins and stringers, together with small amounts of pyrite, sphalerite, and fluorite.

Other pegmatitic quartz deposits containing molybdenite have been reported from western Ontario and Nova Scotia, but none appears to be of possible economic importance.

Quartz Veins

Epigenetic veins consisting essentially of quartz and molybdenite are very widespread in Canada and representatives are known from all the geological provinces in which deposits of molybdenum occur. So far no deposit of this type has yielded significant quantities of molybdenum, and it seems improbable that any will. Normally these quartz-molybdenite veins carry very small amounts of other sulphides, but there are transitions to these quartz veins that carry large amounts of base-metal sulphides as well as molybdenite (*see below*). Small amounts of pyrite commonly accompany the molybdenite, and chalcopyrite and/or bismuth minerals may or may not be present. In other veins the molybdenite is accompanied by tungsten and/or tin minerals. Yet again, the presence of gold in some quartz-molybdenite veins indicates a transition to the gold-quartz veins that carry minor molybdenite as an accessory mineral.

It has already been mentioned that molybdenite-bearing quartz veins occur in close proximity to pegmatitic deposits in the Falcon Lake area of southeastern Manitoba. According to Bruce (1918, p. 23), the molybdenite in the quartz veins is present as flakes in veinlets traversing the quartz. The molybdenite veinlets are probably a little younger than the quartz veins they cut. Native bismuth appears to be the only other metallic mineral accompanying the molybdenite, and this only rarely.

At Burnt Hill Brook, New Brunswick, quartz veins cut dark slates of probable Cambro-Silurian age at a short distance from their contact with an intrusive granite batholith. The veins are developed parallel with both the strike of the schistosity in the sediments and with joint planes in the rocks. Those parallel with the joint planes are much better defined and regular and some can be traced for several hundred feet before they pinch out. Most of the veins are less than a foot wide. Brock (1912, pp. 13-15) observed the following minerals in the veins, in addition to quartz: brown mica, feldspar, topaz, fluorite, wolframite, molybdenite, pyrrhotite, chalcopyrite, and cassiterite. These deposits were worked for some time for tungsten, but no attempt was made to save the molybdenite.

Another Appalachian occurrence of this type is that near Beauceville in the eastern townships of Quebec. MacKay (1921, pp. 84-85) describes the deposit as consisting of "flakes, films, and small pockets of molybdenite scattered throughout a quartz vein developed at the contact of a muscovite granite and a serpentinized peridotite." The width of the vein rarely exceeded a foot, and varied greatly along strike. As with most deposits in this class, an attempt to mine it proved uneconomical, due to the low overall molybdenite content and the small width.

The quartz veins in the muscovite granite of the Preissac-Lacorne batholith on Indian Peninsula, Quebec, hold small erratic amounts of molybdenite, with practically no other metallic minerals. The veins are generally lenticular in plan, having maximum widths between 1 foot and 12 feet, with corresponding lengths of twenty to several hundred feet. They occur in swarms of parallel veins having a southeasterly strike, commonly arranged *en échelon*. The molybdenite occurs erratically in the quartz of the veins as nearly perfect hexagonal flakes from 1 to 5 mm in diameter. Compared with the pegmatitic quartz deposits at the contact of the batholith, these quartz veins are of little potential economic importance.

Molybdenite-bearing quartz-veins are particularly widespread in the Cordilleran region of Canada. The deposits on the Stella property, near Endako, British Columbia, consist of a series of discontinuous quartz veins and zones of silicification following fractures or joints in the Topley granite (*see* Armstrong, 1949, pp. 192-193). The veins range in width from an inch or so up to perhaps 2 feet, and in length from a few feet up to perhaps 10 feet. They strike mainly east, and most dip flatly to the south. The Stella veins are characteristically composed of fine-grained, white sugary quartz in which very fine grained molybdenite occurs in 'ribbons' parallel with the vein walls.

In the Highland Valley area of British Columbia, development of the large low-grade copper deposits is revealing a fairly constant, though small molybdenite content which may be recoverable as a by-product when the ores are worked for their copper content. However, quartz veins carrying molybdenite had been known from the old Tamarack property in this area long before the exploration of the copper deposits. There, molybdenite occurs as coarse-grained foliated masses in the veins, which also hold variable quantities of chalcopyrite and bornite. Thus the mineralization in the quartz veins is identical with that in the large low-grade disseminated deposits, except that the molybdenum-copper ratio appears to be reversed. However in spite of their relatively low molybdenum content, the disseminated deposits would appear to be of much greater potential economic worth than the relatively rich, narrow, and erratic quartz-vein deposits.

Another example of the close spatial relationship between molybdenite-bearing quartz veins and a disseminated deposit of probable economic value is the Takomkane Mountain area east of Williams Lake, British Columbia. There, a zone of quartz veins lies close to, and with the same strike as zones of quartz-filled breccia, of which one at least has been shown to contain ore of mineable grade. The quartz-vein zone consists of a series of *en échelon* veins and lenses, some showing spectacular quantities of molybdenite. The mineral occurs along both walls of the veins as bladed aggregates, ¼ to ½ inch in diameter. It appears to be the only sulphide accompanying the quartz.

With increasing content of base-metal sulphides, these quartz-vein deposits grade into dominantly sulphide veins and it is often rather difficult to establish a significant class-boundary. However, before describing some of the features of these base-metal - molybdenum veins, mention must be made of the following type of deposit in which the filling consists mainly of quartz and molybdenite.

Breccia and Stock-work Deposits

Few of these deposits have been found in Canada, but of these, at least one appears to be of possible economic worth. In principle, they consist of a breccia or shatter zone in the country rock that has been later sealed by quartz, or quartz and feldspar, and carries molybdenite, and in places small quantities of pyrite and bismuth or tungsten minerals.

At Takomkane Mountain in British Columbia, three elongated zones of breccia in quartz diorite, varying in width between 50 and 100 feet, strike parallel with one another and dip very steeply. The breccia has been sealed with white vein quartz and small amounts of orthoclase. The metallic mineral is mainly molybdenite, with minor amounts of pyrite, magnetite, and chalcopyrite. The breccia fragments have apparently had an influence on the precipitation and crystallization of the molybdenite, as it typically occurs as a fine-grained rim around the fragments. Kaolinization of the original feldspar of the quartz diorite has apparently preceded or accompanied the deposition of the quartz and molybdenite, and a certain amount of silicification of the breccia fragments and the surrounding quartz diorite has taken place.

At Net Lake, just north of Timagami, Ontario, an irregular quartz-filled breccia carries apparently small amounts of molybdenite with few other sulphide minerals, apart from very minor chalcopyrite. The breccia is in a dark green, medium-grained, basic igneous rock. The breccia fragments are very angular and sharply defined and do not appear to have suffered any marked alteration—in contrast with the fragments in the breccias on Takomkane Mountain. The breccia occurs in irregular areas and as breccia veins, and away from it occur narrow fissure-filled veins of quartz with notable amounts of molybdenite. The molybdenite content of the breccia as a whole appears to be very low, perhaps about 0.1 per cent.

In British Columbia a third example of this type is of a slightly different character. At the Hardy prospect on Hudson Bay Mountain near Smithers, molybdenite occurs in thin veinlets of sugary quartz occupying joints and fractures in Mesozoic volcanic rocks, and as thin films and coatings on fractures, without other minerals. It has been traced over a very large area, although the shape of the mineralized body is still unknown. Molybdenite occurs abundantly in the veinlets, which average about ½ inch thick, but its total content in the rocks of the mineralized area does not appear to reach ore grade. Accompanying minerals are pyrite and very minor powellite. Small but fairly consistent tungsten values occur in all samples assayed so far, but it is not known whether any tungsten-bearing mineral other than powellite is present.

Gold-quartz Veins

Molybdenite is a minor constituent of many gold-bearing quartz veins and replacement zones in Manitoba, northern Ontario and northwestern Quebec. So far as is known, no attempt has been made to recover molybdenite from any gold ore. This type of deposit must so far be regarded merely as another type of deposit in which molybdenite appears. The mineralogy of the gold-quartz veins is often complex, and in addition to gold and molybdenite, they carry such minerals as pyrite, base-metal sulphides, tellurides, specularite, and scheelite.

Veins of Base-metal Sulphides

As previously mentioned there is every transition from simple quartz veins carrying molybdenite and only minor amounts of other sulphides, to veins consisting mainly of base-metal sulphides with only small or accessory quantities of molybdenite. This group therefore encompasses a great many types of veins of varying morphology and mineralogy. In general it can be said that very few deposits of this type have given any promise of yielding economic quantities of molybdenum either alone or in conjunction with the other metals present. Several have been explored and even worked for short periods, but none has given rise to steady production.

The Victoria mine on Rocher Déboulé Mountain near Hazelton, British Columbia, was worked intermittently during the period 1926-1940. It yielded about 1,600 pounds of molybdenite in addition to gold, silver, and cobalt. More recent development has taken place to investigate its uranium content. The ore shoots consist of quartz replacements and fillings in a fissured zone in grey granodiorite. Other vein-forming minerals are feldspar and hornblende. The metallic minerals include arsenopyrite, cobaltite, cobalt-nickel sulpharsenides, molybdenite, chalcopyrite, sphalerite, uraninite, and native gold. The molybdenite occurs in thin films and as small nodules. The molybdenum contents of samples taken by Kindle and Stevenson (*see* Kindle, 1954, pp. 84-89) contained around 0.8 - 0.9 per cent Mo.

At the Rocher Déboulé mine in the same area, the deposits are fissure-filled veins that formed along strongly faulted zones (Kindle, 1954, pp. 57-63) in granodiorite. The gangue is predominantly quartz and hornblende, with minor calcite, siderite, chlorite, titanite, tourmaline, and rutile. Chalcopyrite is the most common ore mineral, with, in addition, various amounts of magnetite, pyrrhotite, pyrite, scheelite, cobaltite, arsenopyrite, molybdenite, tetrahedrite, smaltite-chloanthite, glaucodot, and a little uraninite.

Farther south in British Columbia, the Golconda mine at Olalla just north of Keremeos, was worked intermittently between 1918-1930 and yielded about 1,770 pounds of molybdenite, in addition to gold, silver, and copper. The deposits on this property are thin quartz veins and replacements in a northwest-trending zone of shears and fissures in a biotite pyroxenite. The veins are discontinuous lens-shaped sheets of white quartz, surrounded by mineralized crushed pyroxenite. In width the whole zone varies between 6 inches and about 5 feet. The main introduced sulphides are pyrite, chalcopyrite, and molybdenite. Galena, in minor quantities, occurs intimately associated with the chalcopyrite. The molybdenite is everywhere extremely finely divided, pulverulent or amorphous. It occurs in irregular patches in the vein quartz, but mainly as fine coatings on fractures and along the margins of the quartz veins. Its mode of occurrence suggests that it was deposited later than the other sulphides.

More recently, attempts have been made to produce copper and molybdenum concentrates from a deposit of this type at the Ryan Lake mine near Matachewan, northern Ontario. Molybdenite and chalcopyrite occur in lenticular quartz veins and badly crushed and fractured serpentinite and porphyry along east-west-trending shear zones. Apart from a little pyrite, molybdenite and chalcopyrite are the only metallic minerals present.

Vein deposits consisting predominantly of base-metal sulphides, with relatively less molybdenite, are not so common as the foregoing, and very few have yielded noteworthy amounts of molybdenite. However, in the Grenville province of the Precambrian Shield, especially in Brougham and Griffith townships of Ontario, small deposits of this type were exploited during World War I. At the Spain mine, relatively narrow veins of pyrite, pyrrhotite, and molybdenite occurred filling almost vertical joint-fissures and other fractures in pyroxene-feldspar gneisses. The walls of these veins were lined with thin quartz-feldspar pegmatites and the sulphides appeared to have filled in the centres of the openings at a later time. The veins worked at the Spain mine were apparently never more than a foot wide, but a concentration of them occurred over a relatively small area, so that they could be mined together in a single open-cut. The veins apparently filled tension openings striking at a high angle to the direction of the regional lineation. At the Ross and O'Brien properties to the east, pyrite-pyrrhotite-molybdenite veins occurred parallel with the banding of the enclosing gneisses. They also were apparently narrow and did not yield important quantities of molybdenite.

Small amounts of molybdenite have often been reported from large sulphide veins and other epigenetic bodies that have been worked for their copper, lead, zinc, or other base-metal content. So far as is known there has been no by-product recovery of molybdenum from these ores and its presence must be regarded as of scientific interest only.

Disseminated Deposits

Epigenetic disseminations of molybdenite, with or without other metallic minerals, have been reported from many places in Canada. Some of these, mostly in the Cordilleran region, have in the past yielded small quantities of molybdenum, and yet others are under active exploration to determine their workability. It would seem that, tonnage-wise at least, this type of deposit is one of the most promising economically.

The molybdenum content of disseminated deposits is commonly very low, but the large tonnages involved, and the common presence of one or more other metals of economic interest, suggest that in the future large amounts of molybdenum may be derived from them. In the United States, similar deposits are yielding very significant quantities of molybdenum as a by-product of copper-mining operations. Canada has at least two representatives of this class—one in the east and one in the west. In the Gaspé Peninsula, Quebec, molybdenite is an accessory mineral in the large-tonnage copper ores at the property of Gaspé Copper Mines, Limited. The mining and beneficiation of these copper ores started in 1955 and it would seem to be only a matter of time before molybdenite is recovered as a by-product.

In the west, in the Highland Valley area of British Columbia, large-tonnage, low-grade disseminated copper ores are presently being explored and developed by several companies. Most of these ores contain small percentages of molybdenite, and should the copper-producing operations become firmly established, the mineral could be recovered as a by-product in not inconsiderable quantities. On the Jersey zone of Bethlehem Copper Company, Limited, molybdenite occurs in very finely divided form in altered quartz diorite, together with chalcopyrite, bornite, and pyrite. It commonly forms thin films along fracture planes and joints, but also occurs within the body of the rock itself.

Recently, several other molybdenite-bearing deposits of the disseminated type have been investigated and explored to various extents. The minerals associated with the molybdenite vary from deposit to deposit. The old workings on the Regnessy Metals property, near Michipicoten, Ontario, were rehabilitated in 1957 and a program of exploration was started by International Ranwick Limited. The ore minerals there are disseminated in a shattered granite contact zone; they include beryl and molybdenite.

Near North Barrière Lake in central British Columbia, a recently investigated low-grade dissemination of molybdenite in granite proved to be below commercial scale.

At the Index property near Lillooet, British Columbia, molybdenite with low values in uranium occurs disseminated in a body of granite. The ore is said to be free from copper, tin, tungsten, or bismuth (Drysdale, 1917, p. 54). In parts, very high grade ore was found; during the first world war, 8½ tons of 15-per-cent-MoS_2 ore was shipped from the property.

Another relatively high grade disseminated molybdenite deposit in granite occurs in the Salmo area of British Columbia. At the Molly mine, a small body of this type was worked during the period 1914 to 1917. It yielded some 25,000 pounds of molybdenite concentrates. Molybdenite occurred with erratic quantities of pyrrhotite in a sheeted zone in granite near its contact with overlying, hornfelsed argillites. The orebody appears to have been in the form of a steeply plunging 'strip' or 'ribbon' controlled by the intersection of certain prominent fracture or joint planes with the sheeting. In such disseminated ores it is not always easy to decide whether the ore minerals are syngenetic (primary) or epigenetic (introduced). In the case of the Molly mine it seems clear that the sulphides were introduced after the consolidation of the granite, assuring their epigenetic nature.

Besides those occurring in igneous rocks, epigenetic molybdenite-bearing disseminated deposits have been reported from several localities in schists, gneisses, and other metamorphic rocks.

In the extreme northeastern corner of Alberta, disseminated deposits of molybdenite and radioactive minerals have recently been found by geologists of the Research Council of Alberta (Godfrey, 1958). At one of the main localities the molybdenite appears to be concentrated in a band of biotite schist. Elsewhere, molybdenite is scattered through gneiss and quartzite. In the same general area, molybdenite was also noted in quartz veins and pegmatites, and these may have been the original sources for the disseminations in the metamorphic rocks.

In the northern part of Yukon Territory, Gabrielse (1957, p. 10) has reported disseminated molybdenite together with wolframite, pyrite, and arsenopyrite, in an area of low-grade metamorphic rocks underlain by granite.

The occurrence of disseminated molybdenite in a sedimentary rock has so far been reported from only one place in Canada. From a locality near Mine Centre, a station on the Canadian National railway line 50 miles east of Fort Frances, Parsons (1918, p. 18) reported the presence of molybdenite with pyrite in a conglomerate. The occurrence is of mineralogical interest only.

Metasomatic Deposits

Deposits of molybdenite occur in rocks of apparent metasomatic origin in many parts of Canada. The manner of occurrence of some suggests a genetic connection between the metasomatism of the rock and the metallization; in others it seems that pre-existing bodies of rock of metasomatic origin have acted as hosts for later metallization. Both types are considered together, as in many deposits there is insufficient evidence to determine which of the two processes operated.

Metasomatic molybdenite deposits in Canada can be divided into two distinct classes, differing in petrography, mineralogy, shape, and mode of occurrence. Each class, with some exceptions, has a well-defined distribution.

The first class may be termed the 'skarn'-type deposits, consisting of mineralized bodies of skarn or tactite, developed from limestones and impure calcareous rocks, chiefly under conditions of contact metamorphism. The chief rock-forming minerals in these deposits are garnet (grossularite) and diopside, together with various quantities of quartz, and minor amounts of typical contact-metamorphic minerals such as wollastonite, sphene, and apatite. The metallic mineralization varies somewhat: molybdenite alone; molybdenite-tungsten minerals; minor molybdenite in copper ores; and minor molybdenite in gold ores. This type of metasomatic deposit is confined, almost without exception, to the Cordilleran region of Canada where it is widely developed.

In the Yukon Territory the copper ores of the Whitehorse area carry chalcopyrite and bornite, with lesser magnetite, small amounts of molybdenite, and some free gold in a gangue of calcite, garnet, augite, epidote, tremolite, and actinolite. Similar associations are met in the contact-metamorphic copper ores of Texada Island, British Columbia. Neither of these areas has produced any molybdenite.

From Champion Creek in the Tulameen Valley, British Columbia, Camsell (1913, pp. 170-171) has described molybdenite occurring as small flakes and scales scattered plentifully throughout a gangue of quartz, garnet, epidote, hornblende and pyroxene.

> The associated minerals indicate that the rock in which the molybdenite occurs was originally a limestone which, on intrusion of . . . . . granodiorite, had its constituents altered from carbonates to silicates by a process of metasomatic replacement, the molybdenite being introduced into the limestone along with the silica which went to form the lime silicates.

At the Kenallan property southeast of Kamloops, British Columbia, bands of lime-silicate rock, up to 4 feet thick, occur interbedded with crystalline limestone and fine-grained argillaceous hornfels. The main rock-forming minerals in these 'skarn' bands are red-brown garnet and green diopside. Quartz veins cross lime-silicate rocks, indicating a later age. The metallic sulphides in the Kenallan occurrences are molybdenite and chalcopyrite.

At the French mine near Hedley, British Columbia, a flat-lying layer of brown contact skarn is being worked for its gold content. Other minerals include molybdenite, bornite, chalcopyrite, pyrrhotite, chalcocite, covellite, safflorite, cobaltite, native bismuth, and tellurides. None of the minerals is abundant; the molybdenite content is minor and erratic. In the contact-metamorphic orebodies of the Emerald mine near Salmo, British Columbia, which until recently were worked for tungsten, molybdenite is present but none has been recovered.

On the whole, the prospects for commercial production of molybdenite concentrates from the contact-metamorphic ores of the Cordilleran region do not appear to be promising, although by-product recovery may be possible in some instances.

The second type of molybdenite deposits of apparently metasomatic origin is confined almost solely to the Grenville province of the Canadian Shield in southeastern Ontario and southwestern Quebec. A typical deposit of this type comprises a body of pyroxenite containing erratically distributed pyrite and/or pyrrhotite, and molybdenite—the latter generally in large conspicuous flakes and crystals. Other base-metal sulphides are normally lacking, except for a small amount of chalcopyrite.

The pyroxenite consists mainly of a green or dark green diopsidic pyroxene, together with more or less scapolite, plagioclase, and brown mica. The mode of origin of these bodies of pyroxene has not yet been determined—it is one of the major petrological problems of Grenville geology. The pyroxenites were originally regarded simply as intrusive bodies, akin to the large intrusive masses of pyroxenite found in most fold-mountain regions. This concept was later discarded, chiefly by Wilson, in favour of the hypothesis of in situ metamorphism of dolomitic limestone. Wilson (1924, pp. 32-35) gave the following reasons for believing the "metamorphic pyroxenite" to have formed "by the interaction of siliceous emanations from the igneous intrusives of the basal complex on the Grenville limestone."

1. The pyroxenite is generally included in or adjoins the Grenville limestone.
2. The pyroxenite and Grenville limestone resemble one another in that they both contain inclusions of pegmatite and are interstratified in places with quartzite.
3. In some localities the pyroxenite forms a contact zone between limestone and pegmatite.
4. The high lime-content of the pyroxenite—up to 24 per cent—is far in excess of the lime content of normal igneous rocks.
5. The numerous lime-silicate minerals associated with the pyroxenite belong to the mineral types generally found in contact-metamorphic deposits.

On the other hand, H. S. Spence (unpublished report) is of the opinion that in practically all instances, contact metamorphism of original sedimentary limestone played no role.

> Contact metamorphism of the amount of dolomitic limestone required to form some of the larger pyroxenite bodies would have demanded intrusives of at least comparable size, and major granite or pegmatite intrusions are rarely found in direct association with the pyroxenites. Where they do so occur they were intruded *after* the formation of the latter was complete.

Spence distinguished two types of pyroxenite bodies. In places, both types occur in fairly close proximity, but generally, each tends to favour its own local geological environment. The types are:

1. Those emplaced in or adjacent to crystalline limestone. These are fine to medium grained, with numerous cavities filled with coarsely crystalline calcite which was one of the best minerals to form and which was deposited from solution. "It represents," said Spence, "residual carbonate derived from assimilated sediments, after the Ca/Mg needs for the formation of the pyroxene had been satisfied." Such pyroxenites are characterized by their usually pale grey-green colour, which is probably due to a bleaching effect exerted by post-emplacement flow of hydrothermal solutions through them.

2. The other type, abundant in the Grenville, is found in gneissic or other crystalline metasediments. According to Spence, these pyroxenites show linear dyke-like or vein-like forms and have sharp contacts with their wall-rocks. Most have been emplaced conformably in their wall-rocks, but occasionally are found transgressing. In places, tongues or offshoots branch into the wall-rocks. They thus have every appearance of being injected basic pegmatites. Calcite-filled cavities are unimportant. Instead, the commonly abundant calcite tends to occur

as the filling of long, wide fracture openings that parallel the vein walls. Texture may vary from fairly fine to very coarse, and colour from pale greyish green to blackish green. The dyke-like forms of such pyroxenites and the pegmatite-like zoning of their component minerals strongly suggest that they represent the filling of large, open fractures and that their material was digested or dissolved dolomitic rock which was converted into pyroxene and introduced either as a 'magma', or deposited from solution, in these openings. The excess Ca, plus Co_2 liberated from the digested dolomite, was reconstituted as calcite, which crystallized in cavities and fractures, or combined with magmatic phosphorus and fluorine to form apatite and phlogopite mica.

"Thus," said Spence, "both types of pyroxenites would appear to have been formed by similar agencies, the differences in their configuration and character being dictated by the nature of the rock in which they were emplaced."

Whatever mode of origin may ultimately be proposed and proved for the Grenville pyroxenites, the main point for the purpose of this report is that, in a belt extending from southern Gatineau and Pontiac counties in Quebec through Renfrew and Haliburton counties in Ontario, many of them are host rocks for a very characteristic iron-sulphur-molybdenum metallization.

This metallization is present in other host rocks in the Grenville, as already described, and it is not at all proven that there is any genetic connection between the pyroxenites and the sulphide minerals. Indeed, the opposite is probably the case. The iron and molybdenum sulphides occur in breccia fillings in the pyroxenites, filling fractures as veins, and generally showing an undoubtedly epigenetic character to them. Thus the position of the sulphide-bearing pyroxenites in the general scheme of classification is by no means clear. Until further evidence is forthcoming they may be left in the metasomatic class.

The pyroxenitic deposits occur in great numbers in the Grenville province, especially in Haliburton and Renfrew counties in Ontario and in Pontiac and Gatineau counties in Quebec. At the present time none is being worked and the deposits do not appear to have a large economic potential, if any. In the past, however, under conditions of wartime emergency, pyroxenitic deposits yielded several hundred thousand pounds of molybdenite concentrates.

One of the most recently investigated deposits of this type is the Kirkham property of Quebec Metallurgical Industries, Limited, in Clarendon township, Pontiac county, Quebec. The main zone on the property is a lenticular body of pyroxenite, 300 feet long with an average width of 20 feet and a dip length of at least 200 feet. The body overlies a pegmatite dyke and is overlain by a zone of hornblende gneiss and limestone. The pyroxenite is medium to coarse grained and consists mostly of diopside. It shows a distinct chilled margin against the underlying pegmatite. The sulphides—pyrrhotite, pyrite, molybdenite, and minor chalcopyrite—occur in fracture and breccia zones, as well as replacing the pyroxenite. The molybdenite, which is largely in coarse flakes and plates, follows the heavy pyrrhotite mineralization. Radioactive minerals occur in one or two places associated with late crosscutting fractures.

In Bagot township, Renfrew county, Ontario, a considerable amount of molybdenite has been produced intermittently over a number of years from pyroxenite orebodies on the property of Zenith Molybdenite Corporation, Limited. The most important molybdenite-bearing zones are in tabular to lens-shaped bodies of pyroxenite occurring along or near the contact between gneissic granite and included bands of metasedimentary rocks (crystalline limestone, biotite gneiss, hybrid gneiss). According to Satterly (1945, p. 75), who considered the pyroxenites to be metamorphic, the best molybdenum mineralization so far discovered is mostly along the contacts between the pyroxenite and hybrid gneiss.

The molybdenite occurs in the pyroxenite as disseminated flakes up to 2 inches across, and as bunches, seams, or bands, commonly associated with irregular stringers of pyrite. Most of the ore is composed of pyroxene, calcite, quartz, and molybdenite.

The two deposits described above may be taken as typical of the Grenville pyroxenitic molybdenite occurrences, although others differ in some respects.

Miscellaneous Deposits

Molybdenite has been reported from deposits that do not fit easily into the above classification. On the whole such occurrences are of mineralogical importance only.

At the L. H. group near Malakwa, 36 miles west of Revelstoke, British Columbia, molybdenite occurs as paper-thin films on shears and shear zones cutting pink granite. The highest assay obtained was 0.4 per cent MoS_2 (Stevenson, 1940, p. 67).

On the Sterling group, 34 miles north of Revelstoke, molybdenite, pyrite and pyrrhotite occur disseminated in bodies of massive, siliceous rock (orthoclase-albite-quartz), that appear to be replacing quartz-muscovite schist and phyllite. Samples of this material assayed from zero to 0.6 per cent MoS_2. (Stevenson, 1940, p. 70).

Distribution of Deposits

It has already been noted that molybdenum is distributed fairly evenly in the rocks of the earth's crust. The average content of molybdenum in these rocks is 1 ppm or 1 gram per ton. This means that molybdenum has the same order of abundance as tungsten, tantalum, and antimony. It is much less abundant than the following common metals of commerce (after Goldschmidt, 1954, pp. 74-75):

nickel	100 ppm
zinc	80 ppm
copper	70 ppm
cobalt	40 ppm
lead	16 ppm
uranium	4 ppm

On the other hand molybdenum is much more abundant than gold (0.001 ppm) and silver (0.02 ppm).

The average content of molybdenum in the earth's crust has however little significance when it comes to estimating the amounts available for exploitation. By far the greatest amount is dispersed within the rock-forming minerals of the crust and can never be profitably recovered. The exploitable deposits of molybdenum, as with most metals, contain an almost infinitesimal proportion of the total contained in the earth's crust.

Although these exploitable deposits are of no significance when discussing the geochemistry of the element, they are obviously of prime importance in the present context. A measure of the availability of any metal is given by the number of times it must be concentrated above its average abundance in the crust in order to produce a workable deposit. This has been termed the 'clarke of concentration' of the element. In the case of molybdenum, we may reckon, for Canadian conditions, that 0.3 per cent is the minimum workable grade, thus the clarke of concentration of molybdenum is $\frac{0.3}{0.001}$ or 300. This figure may be compared with those for some of the common metals in the tabulation below (after Mason, 1958, p. 48):

copper	140
nickel	175
zinc	300
tin	250
lead	2,500
uranium	500

Thus it can be seen that although lead is about 16 times as abundant in the earth's crust as molybdenum, it is not until it has been concentrated about 8 times as much that it forms workable deposits. Other factors play a part in determining the availability of an element. It is the nature of molybdenum to prefer the common rock-forming minerals, i.e. it is said to have a 'lithophile character'. Thus, although molybdenite is a relatively common mineral in some granites, it represents a very small proportion of the total molybdenum in the earth's crust. On the other hand, copper deposits are relatively very abundant. Not only is the clarke of concentration of copper only half that of molybdenum, but copper has a pronounced 'chalcophile character'—it prefers to enter into mineral combinations with sulphur. Thus copper, in the form of sulphides, is much more commonly met in the rocks exposed at the surface of the earth and is much more available to industry.

Geographical Distribution

Altogether, about 700 occurrences of the mineral molybdenite—the only economic molybdenum mineral in Canada—have been recorded. A map compiled by the writer (GSC Map 1045A-M3) gives this number as "nearly 800" but a more accurate estimate places it closer to 700. These deposits are distributed between the different geological regions of the country as follows:

Canadian Shield	62 per cent
Cordilleran region	30 per cent
Appalachian region	8 per cent

By provinces, the distribution is:

Yukon	4
British Columbia	200
Northwest Territories	15
Alberta	4
Saskatchewan	11
Manitoba	23
Ontario	260
Quebec	140
New Brunswick	10
Nova Scotia	8
Newfoundland	24
	699

Metallogenic Provinces

It has been recognized for some time that specific regions of the earth's crust (metallogenic provinces) are characterized by concentrations of certain metals or groups of metals. Similarly there have also been periods in the earth's history (metallogenic epochs) when metallization appears to have been at a maximum. In a recent treatise on this subject Turneaure (1955) uses the term "metallogenic province" in a broad sense to refer to "strongly mineralized areas or regions containing ore deposits of a specific type, or groups of deposits that possess features suggesting a genetic relationship."

The molybdenum deposits of Canada are in many instances grouped together into what may be termed metallogenic provinces for molybdenum. These provinces are illustrated to some extent on Map 1045A-M3 (in pocket).

The main molybdenum provinces in Canada are:

(*a*) the western Cordillera;

(*b*) the Canadian Shield, especially from southeastern Manitoba, through Ontario, to southwestern Quebec; and

(*c*) the Appalachian region in New Brunswick, Nova Scotia and Newfoundland.

Within these major provinces, the molybdenum deposits show distinct groupings into smaller subprovinces, many of which have characteristic types of deposits and geological associations. Some can be related to a particular source rock, e.g. to a certain granitic batholith like the Preissac-Lacorne batholith of northwestern Quebec. Others may be linked with a definite geological subprovince.

In the Cordilleran region several subprovinces may be recognized. In northwestern British Columbia, relative concentrations of molybdenum deposits occur in the Stewart, Terrace-Cedarvale, and Hazelton-Smithers areas. These are mainly vein deposits related to granitic rocks of the Coast intrusions. Farther south in the province, on Vancouver Island and the adjoining islands and coast, other concentrations of deposits in and along the western margin of these intrusions suggest that they may be regarded as a geological unit favourable to the occurrence of molybdenum.

Molybdenum deposits are fairly widespread in the south-central interior of British Columbia, though very few are of apparent economic importance. Certain local concentrations of deposits occur in association with bodies of deep-seated igneous rocks, such as the Guichon Creek batholith, in such a manner as to suggest that there is a genetic connection. One of the largest known deposits of molybdenite in British Columbia lies rather isolated from other deposits and is not related to any detectable subprovince. On the other hand, the surrounding country is relatively little known geologically and it is possible that other deposits may be found in connection with the rather large quartz-diorite batholith in which the known deposit occurs.

On the whole, the subprovinces in British Columbia tend to include deposits of more than one type. For example, there is a well-defined subprovince in the Salmo area south of Nelson in which representatives of the quartz-vein type, the metasomatic type and the disseminated type all occur in rather close proximity. These deposits are spatially related to granitic (Nelson) intrusions and it would seem that they were the source rocks for the molybdenite mineralization, regardless of type.

The whole Cordilleran region in general may be regarded as a favourable molybdenum province within which the deposits are localized close to the margins of large intrusions that range in composition from granite to quartz diorite.

The Canadian Shield as a whole may also be regarded as a favourable molybdenum province. The distribution of known deposits to a certain extent reflects the state of exploration of the area, relative accessibility, etc., but enough is known to delimit certain areas as subprovinces in which the molybdenum concentration is relatively high. In the northwest there is a marked grouping of pegmatitic deposits of molybdenum in the area northeast of Yellowknife, Northwest Territories. These are mostly small, and the molybdenum occurs as an accessory mineral in pegmatites containing tantalite-columbite, beryl, or lithium minerals. Similarly the area immediately north of Lake Athabasca—on both sides of the Alberta-Saskatchewan border—constitutes a little subprovince characterized by the association of uranium and molybdenum. On the Alberta side the deposits consist of disseminations in metamorphic rocks and pegmatites; on the Saskatchewan side they are mainly veins and pegmatitic deposits. The mineralogy of many of them is complex, and in general, the molybdenite must be regarded as accessory to the uranium. On the Alberta side the former is perhaps of greater relative importance.

In Manitoba the deposits are more widespread and are mainly of the pegmatitic and quartz-vein types. There is a minor concentration in the Wekusko Lake area northeast of The Pas, but the most important subprovince is in the southeastern corner of Manitoba in the Falcon Lake area where quartz-vein and pegmatite deposits occur close to one another.

The southeastern Manitoba occurrences are in effect the westerly end of a broad Precambrian molybdenum subprovince that stretches across northwestern and northern Ontario to about the longitude of Hornepayne. Within this subprovince the molybdenum occurrences are fairly evenly scattered, with few areas in which they are more concentrated than elsewhere. Deposits of all types occur, the dominant ones being quartz veins, pegmatite-aplite and, in the western part, gold-quartz veins. The distribution of these deposits with respect to the major rock units of the Shield is very interesting. With few exceptions, the molybdenum deposits occur within or close to the borders of the large areas of supracrustal sedimentary and volcanic rocks lying in the largely granitic basement. Few deposits occur in the basement away from the supracrustal areas. In general, the molybdenite deposits, especially the pegmatitic, pegmatitic-quartz, and quartz-vein types, favour the rocks on each side of the margin of acidic intrusions.

In the Algoma district a small local concentration of molybdenite deposits is found in the area northeast of Michipicoten Harbour. Active exploration is proceeding on at least two of these.

Another marked molybdenum subprovince stretches from about the longitude of Timmins across northern Ontario into northwestern Quebec, as far as about longitude 77°W. This subprovince corresponds closely to the large area of supracrustal rocks forming the gold-bearing belt of Porcupine, Kirkland Lake, Rouyn, Malartic and Val d'Or. Many of the occurrences reported from this area are of accessory molybdenite in gold deposits, but quartz veins carrying little but molybdenite are also common. In the Preissac-Lacorne area of northwestern Quebec is the greatest concentration of molybdenite deposits so far found in Canada. Pegmatites, pegmatitic quartz veins, and quartz veins are all present, and molybdenum, with subsidiary bismuth, is the sole recoverable product. The deposits are related very strikingly to the marginal zones of the large Preissac-Lacorne batholith and its satellitic stocks and bosses.

The Grenville geological province in southeastern Ontario and southwestern Quebec shows a remarkable concentration of deposits carrying molybdenite. The chief mineralization is very characteristic—the molybdenite is accompanied by unusually large amounts of pyrite and/or pyrrhotite. Chalcopyrite and uranium minerals are present in variable but minor quantities. Deposits of the pegmatitic, pyroxenitic, and sulphide-vein types are all present, and in many places these types occur within short distances of one another. Nonetheless the uniformity of the mineralization in all types indicates a common origin. Most characteristic of the Grenville province is the pyroxenitic type. Pyroxenites carrying molybdenite occur in a belt extending from the Haliburton area, through Renfrew county, Ontario, into Pontiac and Gatineau counties, Quebec. Outside this belt the Grenville pyroxenites are apparently unmineralized. This fact, plus the uniformity of the mineralization in otherwise dissimilar types of deposits, suggests that the iron-molybdenum-sulphur metallization genetically has little connection with the formation of the Grenville pyroxenites, but has favoured them as host rocks within the above-delimited belt only.

H. S. Spence (unpublished report) suggests that this molybdenum belt in the Grenville is due to the fact that "only that portion of the granitic magma underlying (it) was significantly rich in molybdenum." He also mentions that pyroxenites themselves are uncommon west of the belt, so that the favourable host rock is less abundant outside it. These two factors—a suitable (still hypothetical) source and suitable host rocks—may have combined to localize the molybdenum-bearing belt in the Grenville province. Just which factor is more important is hard to evaluate, but perhaps the source is more fundamental as molybdenum deposits of types other than pyroxenitic are present in the belt.

The known geochemical characteristics of molybdenum may provide a clue to its origin in this region. It has been shown that the element is more abundant in alkaline rocks than in granites, generally regarded as the source of molybdenum deposits.

Within the Grenville belt some of the largest molybdenite deposits worked were spatially, and it appears genetically, associated with large intrusions of syenite and quartz syenite, i.e. at the Moss mine in Onslow township, Quebec. In the literature on the various pyroxenitic deposits, the term granite-syenite gneiss is commonly used to describe the wall-rocks. Farther west, in Haliburton county for instance, alkaline rocks (nepheline syenite) are present in large quantities.

More systematic work is needed before the connection between the molybdenum mineralization and alkaline rocks of the Grenville province can be established, but there may be a link between a late stage of alkaline igneous or metamorphic activity and the undoubtedly late molybdenum-iron-sulphur mineralization.

Molybdenite deposits are scattered in the Appalachian region and no definite subprovinces can be recognized. The deposits, mainly of pegmatitic-aplitic and quartz-vein types, are very closely related to the margins of the Palæozoic granites. This relation is strikingly shown in what is probably the most promising part of the region—near Rencontre East in Newfoundland.

Structural Associations

By far the most important structural associations are contacts between bodies of igneous rocks and the surrounding metasedimentary rocks. Because of the relationship of the more important types of molybdenum deposits to the cooling history of batholithic igneous rocks, it is natural that most are found chiefly towards the margins, especially the upper margins, of the batholiths and for a short distance out into the enclosing metasedimentary rocks. This holds good for deposits of the pegmatitic, pegmatitic-quartz-vein and quartz-vein types. Certain disseminated deposits are also related to the upper margins of igneous bodies, e.g. at the Molly mine near Nelson, British Columbia. Others that are also closely related to the margins of igneous rocks are the 'skarn'-type metasomatic deposits of the Cordilleran region, although these appear to be less important economically.

Relatively few molybdenum deposits in Canada show evidence of being related to fault or fracture systems. Important exceptions nevertheless exist—for instance the Boss Mountain property east of Williams Lake, British Columbia; these deposits occur in elongated breccia-zones that seem to be parallel with some of the major regional faults of the area. Even here, however, the breccia zones appear to be related to the roof of the quartz-diorite batholith in which they occur.

Age of Mineralization

The age of any mineral deposit may be estimated by the relation of the deposit to the rocks in which it occurs. Syngenetic deposits, whether of igneous or sedimentary origin, are of the same age as the rocks in which they occur, whereas epigenetic deposits are, by definition, younger—how much younger can however rarely be determined. As many molybdenum deposits appear to be directly associated with certain bodies of igneous rock, the two may be presumed to have originated at about the same time. Thus the mineralization may be dated in a broad way even where precise dating is impossible.

In the Cordilleran region the deposits are believed to be genetically related to Mesozoic and perhaps Tertiary, igneous intrusions. These intrusions comprise many phases injected at different times during the general period, and it is not always possible to tell how much and what kind of metallization, if any, accompanied each phase.

Precambrian time may be regarded as the vast interval between 500 million and nearly 5,000 million years ago. During such a great interval many periods of igneous intrusion and metallization may have taken place, and in such a geologically complex area as the Canadian Shield it is most difficult to recognize logical sequences or to correlate one area with another. The age of the orogeny and igneous activity within the Superior province of the Canadian Shield has been estimated at about 2,200 million years, and perhaps this is also the approximate age of the metalliferous deposits of the province. Superior province contains most of the molybdenite deposits of the Shield, except for those in the Grenville province. The Grenville province orogeny is considered to be somewhat younger—perhaps it occurred 800 million to 1,100 million years ago—and perhaps this is also the order of the age of the characteristic molybdenite-bearing metallization.

In the Appalachian region the molybdenum deposits almost certainly are genetically related to the widespread granites of Devonian age, which means that they are probably of the order of 200 million years old.

A more direct method of dating mineral deposits is by the new and still experimental method of determining the age of crystallization of radioactive minerals by the amount of decay that has taken place. In addition to the well-recognized methods, including the strontium/rubidium and potassium/argon methods, a new method is being developed to determine the age of molybdenites.

This method is based on rhenium content (Herr and Merz, 1955). The isotope Re^{187} decays to form an isotope of osmium (Os^{187}). The value of the half-life* of this process is still somewhat uncertain, and in this uncertainty lies the present weakness of the Re/Os method. Herr and Merz (1958) have assigned a value of 6.2×10^{10} (i.e. 62 billion) years for this half-life. Using this figure and analyses of the rhenium and osmium contents they (p. 233) give a series of ages for molybdenites from various localities. Among these is one from "Preissac, Lacorne, Canada" with an age of 9.68×10^{8} (i.e. 968 million) years. If this is at all near the truth, it places the Preissac-Lacorne mineralization at about the middle of the Proterozoic (Late Precambrian).

Origin of Mineralization

The origin of the various types of molybdenum deposits has been touched on several times in the foregoing discussion. The main points are summarized here.

The close association of deposits of the pegmatitic, pegmatitic-quartz-vein, and quartz-vein types with igneous intrusions, particularly acid intrusions, is strong evidence for regarding that the two have a common origin. The metal appears to have concentrated in the last crystallizing fractions of the intrusions, with the deposits forming at or near the margins of the igneous bodies.

Although granites constitute the statistically most important igneous bodies associated with molybdenite deposits, other rock types play a not inconsiderable role. Granodiorites and quartz diorites for instance are important in the Cordilleran region. In southeastern Quebec and the Grenville province generally, molybdenite deposits are markedly associated with syenites and quartz syenites. Moreover, many of the granites related to molybdenite elsewhere are rich in alkali-feldspar and biotite, so that the association of molybdenum with alkali metals (as noted in Chapter II) may be more general than has yet been proven. This is one of the most interesting problems awaiting solution as regards the general associations of molybdenite deposits—one that might greatly aid intelligent prospecting.

The metasomatic occurrences of molybdenum, apart from the disputed Grenville pyroxenite type, again show the connection between the metal and acidic igneous bodies.

Thomson (1918) proposed a common pegmatitic origin for the molybdenite in three of the types of deposits found in the Grenville province—the deposits in syenite at the Moss mine, the pyroxenitic types, and the pegmatitic types. As he said, there can be little doubt about the origin of molybdenite in pegmatites, if it can be shown that this is syngenetic and has not been introduced into the pegmatites after their crystallization. So far there is nothing to indicate that the latter is the case. Thomson's case for a "pegmatitic" origin for the other

* Half-life is the time taken for half the amount of the parent element to decay completely to the daughter element.

two types rests on the presence in the surrounding rocks of pegmatitic bodies that might have been the source of the molybdenum, plus the presence in the mineralized rock of "characteristic pegmatitic minerals". However it seems to the writer that many of the 'characteristic pegmatitic minerals' are in fact more characteristically hydrothermal, e.g. fluorite, tourmaline, and iron sulphides. The writer would suggest instead a common origin in the late-magmatic solutions derived from the crystallization of the Laurentian granites and syenites of the Grenville province.

Prospecting and Exploration

Basically, prospecting and exploration for deposits of molybdenum is no different than for deposits of other metals. Experienced prospectors need little additional information, if they consider the basic facts concerning the occurrence of the metal. Prospectors with no previous experience may be helped by a study of the literature on prospecting issued by the Geological Survey of Canada and provincial organizations. The following additional pointers may be useful.

Recognition

Molybdenite may readily be recognized by its lead-grey colour, flaky or platy form, and extreme softness. The only mineral with which it is commonly confused is graphite, and then mainly when the minerals are finely divided. Molybdenite, when rubbed on glazed porcelain (a cup, plate, etc.) gives a greyish green streak, and when rubbed on paper it gives a bluish grey streak; graphite, in both cases gives a black to dark steel-grey, shiny streak. Other field tests include the following:

1. When heated in an open tube, molybdenite gives off sulphurous fumes, and a pale yellow crystalline sublimate of molybdenum trioxide is formed on the sides of the tube.
2. Molybdenite is infusible before the blowpipe and imparts a yellow-green colour to the flame.
3. The powdered mineral, when heated on charcoal in the oxidizing flame, emits a strong sulphurous odour, and remote from the mineral, it deposits a coating of molybdic oxide. (This is yellow when hot and white when cold.) Closer to the heated mineral the coating is copper-red. If the white coating is touched intermittently with the reducing flame it becomes deep blue.

Favourable Prospecting Areas

The recognition of the metallogenic provinces in which molybdenum occurs is of great help in selecting favourable areas for prospecting and exploration. These are foreshadowed according to the main types of deposits on Map 1045A-M3 (in pocket). Generally, the chances of finding further deposits within a known favourable area are greater than those outside such an area. However, it must always be kept in mind that the data used in compiling this map are necessarily incomplete and areas now shown blank may later prove to be favourable when explored in detail. Certain patterns of distribution nonetheless do emerge, as has already been indicated.

Within any one of these favourable areas the known habits and geological associations of molybdenum deposits may be used to narrow down the 'target'. The more important deposits economically are almost exclusively associated with bodies of acidic igneous rocks (granites, granodiorites, quartz diorites) and in particular, with the margins of such bodies. It is also probable, though not established, that the margins of bodies of intrusive character are more favourable than those of granites of metasomatic or metamorphic origin. That is, the search should probably centre around definite bodies of equigranular intrusive granite, rather than areas of granitic gneisses and feldspathic schists which form large sections of the Canadian Shield for example.

There is also an indication that granites rich in biotite mica and/or potash feldspar (orthoclase) may be more favourable source rocks of molybdenum than other granites.

As yet there is no evidence that particular configurations of the contacts of the igneous bodies are more favourable for the location of molybdenum deposits than others. Promising deposits have been found in 'valleys' in the contact and along 'spurs' or protuberances. Faulting is apparently of little influence in determining the location of the deposits along the contact.

The above remarks apply mainly to the pegmatitic, pegmatitic-quartz-vein, quartz-vein, and 'skarn' metasomatic types of molybdenum deposits. They also concern disseminated deposits, either syngenetic or epigenetic, except that in these the whole of the igneous body is a likely target. Even for these however, there is some indication that the most favourable place is not far from the contact—e.g. the Molly mine in British Columbia.

Favourable Types of Deposits

All types of molybdenum deposits are not equally profitable. Indeed certain deposits will not under normal conditions, develop into mines. This applies necessarily to those deposits in which molybdenum is the sole or chief potential product. Where molybdenite is a subsidiary component, the determining factor is naturally the tenor of the principal component. Although much molybdenum may be won from such a deposit, it is not a true molybdenum deposit from the prospecting and mining point of view.

Of the Canadian deposits that must be mined mainly for their molybdenum content, the most promising types are: disseminations and impregnations, pegmatitic quartz veins, and breccias and stock-works. These types are the ones most likely to fulfill the necessary conditions of tonnage and grade; but by no means must it be inferred that every representative of these classes will be economically valuable.

Most pegmatite deposits are too small and too erratic in grade to constitute mineable orebodies under normal economic conditions. In places, pegmatite deposits may occur closely associated with other more plentiful types of deposit and all may be mined as a single operation. On the whole, however, it is not worth while to prospect for molybdenite-bearing pegmatites.

Skarn-type metasomatic deposits are also small and erratic in grade and have never yielded any molybdenite, even as a by-product and even under conditions of emergency.

Pyroxenitic deposits in the Grenville province of the Canadian Shield have yielded considerable molybdenite during wartime, and in some, very rich pockets of molybdenite occur. But under normal conditions of supply and demand they also are probably too small and too erratic in grade to be mined profitably.

Prospecting Methods

All the usual methods of prospecting may be applied to the search for molybdenite deposits (*see* Lang, 1956; Dreimanis, 1958). Unlike most other minerals, however, discrete flakes of molybdenite may be found in soil overlying a molybdenite deposit, after the weathering away of less-resistant sulphides. For example, on the Kirkham property of Quebec Metallurgical Industries, Limited, the molybdenite-bearing zones are indicated by a deep red-brown soil (due to weathering of pyrrhotite) in which fresh flakes of molybdenite can often be seen. According to the company geologist, vegetation is also more luxuriant over these mineralized zones.

Geochemical Methods—The now widely used techniques of geochemical prospecting may be applied to the search for molybdenum. The general procedure is similar to that used in the search for copper, lead and zinc, but techniques have recently developed for the detection of small amounts of molybdenum in samples of soil, stream sediments, etc.

A simple, rapid quantitative method for determining small amounts of molybdenum in soils and rocks was developed by the United States Geological Survey in connection with the field work of its Geochemical Prospecting Group (Ward, 1951). The useful range of the method is from 1 to 32 ppm molybdenum, but the upper limit can be extended. It is claimed that an analyst with "a minimum amount of skill" can make thirty Mo determinations in an 8-hour day.

North (1956) has more recently developed a method for determining trace amounts of tungsten and molybdenum in soils by means of dithiol (toluene-3 : 4-dithiol). This method allows the determination of molybdenum over the range 1 to 100 ppm in soils. The results obtained suggest that the method is sufficiently accurate for geochemical prospecting and that thirty or more determinations can be made per man per day. Only simple apparatus is required so that the method is suitable for use in the field.

Recent investigations by the Geological Survey of Finland (Kauranne, 1958) involved the determination of molybdenum in glacial till by colorometric methods —that is, the measurement of the intensity of the reddish brown colour induced in an acid molybdate solution by potassium thiocyanate and stannous chloride. This colorometric method is said to be relatively rapid and very sensitive, its accuracy being about ±5 per cent. Disturbing ions are Cu, Co, V, W, Ta, and Nb. The thickness of glacial drift or till covering the bedrock varies between 5 and 6 metres and values of between 0 and 50 ppm Mo were determined, the background value being taken as 3 ppm. The molybdenum was observed to be enriched in the finest size-fractions of the drift (having a grain size less than 0.015 mm).

Biogeochemical Methods—These comprise the sampling and analysis of vegetation growing in areas where the solid rock is covered by overburden. By this means it is possible to detect anomalous concentrations of metals derived from hidden ore deposits.

According to Warren, Delavault and Routley (1953), preliminary investigations have shown that some species of trees can take up relatively large amounts of molybdenum even from comparatively unimportant showings of the metal. Variations from normal are apt to be much greater for molybdenum than for such metals as copper or zinc. Even the relatively minor amount of molybdenum accompanying disseminated copper minerals produces greater anomalies in the overlying vegetation than does the much more abundant copper. The above authors give results of analyses of various parts of the alpine fir which they used for sampling purposes. The preliminary results suggest that where potentially economic amounts of molybdenum exist in the bedrock, the needles, tips, or second-year stems of the trees may contain from 40 to 60 ppm.

At Rautio, Finland, Marino (1953) investigated the molybdenum content of twigs and leaves of the plant *Ledum palustre* growing in an area of bog, around and under which sparse disseminations of molybdenite occur in granite and granodiorite. The molybdenum content was determined spectrographically in the ashes of the plant samples; the leaves and the twigs were analyzed separately. The results seemed to indicate that for molybdenum it made no difference whether the leaves or the twigs were used. On the other hand, analyses for copper indicated that this metal was concentrated much more effectively in the twigs than in the leaves.

This biogeochemical survey at Rautio showed very close agreement between the molybdenum content in the vegetation and that in the underlying granite and granodiorite. As the latter "exceptionally rises" to a maximum of 0.02 per cent Mo, it would seem that the method is sensitive and that molybdenum mineralization of potential economic worth should give clear anomalies in the overlying vegetation. The geology, topography, and climate in central Finland are almost identical to those in large areas of the Canadian Shield, so that the results of the Rautio survey suggest a use of this method in Canada.

In California, where conditions are nearly like those in parts of the Cordilleran region of Canada, Cleveland (1957) reported that plant parts collected over molybdenum-bearing deposits show an abnormally high molybdenum content and that the assimilation of the metal by the plants is not affected by soil pH. He also makes the point, mentioned previously, that molybdenum may be useful as a "pathfinder" element in the search for other metals such as copper.

It would thus seem that biogeochemical prospecting is a potentially useful tool in the search for deposits of molybdenum in drift-covered parts of Canada.

Geophysical Methods—Deposits of molybdenite are on the whole not very suited to prospecting by geophysical methods. Molybdenite itself is non-magnetic and a poor conductor of electricity. Normally the mineral occurs so sparsely disseminated that the geophysical properties of the mineralized rock differ little from those of the surrounding unmineralized rock. Where molybdenite occurs with minerals or rocks that possess marked geophysical characteristics, the distribution of these may be delimited by geophysical methods as a guide to the distribution of the molybdenite as well. For example, the Grenville-type molybdenite deposits with their large content of pyrrhotite and pyrite may be detected by electromagnetic or possibly magnetic methods. Once the distribution of the accessory minerals is ascertained it is a much simpler matter to prospect these restricted areas by any method suitable for molybdenite.

Kelly (1940) has described a typical geophysical survey carried out at the old Spain mine near Griffith, Ontario.

Economic Considerations

The assessment of the economic potentialities of a molybdenite occurrence differs only in detail from the assessment of deposits of any of the more common base-metals. The main point, common to deposits of any metal, is the establishment of enough ore of high enough grade to be mined profitably. All known Canadian molybdenum ores would have to be concentrated at the mine to a marketable product, and it is unlikely that any sufficiently high grade ore will be found in Canada to bear the cost of shipping to a custom concentrating plant. At present there is only one molybdenite-concentrating plant in the country and that concentrates ore mined on the property. One or perhaps two more plants may be established, but it seems extremely doubtful whether these will handle outside ores.

The usual marketable product from a molybdenum mining operation is a concentrate of molybdenite (MoS_2). This is sold directly to the consumers—almost entirely steel and other metallurgical works. Sometimes the concentrate is roasted, thereby changing the sulphide MoS_2 to the oxide MoO_3 and thus producing a more marketable product. This is the only practice now followed in Canada. A high-priority (99.9-per-cent) molybdenite product may be produced for use as a lubricating medium in motor oils and greases.

At present there is apparently no free market for molybdenum concentrates; most are purchased on a contract basis. Thus requirements concerning grade and permissible impurities are specified by the customer according to the destined use of the concentrate. Generally speaking, the marketable product is a concentrate ranging from 80 to 90 per cent molybdenite, that is—48 to 54 per cent molybdenum metal. Copper is the most undesirable impurity and most purchasers will not accept concentrates containing more than 0.2 per cent copper. Iron content should not exceed 10 per cent; and bismuth and tin not more than 0.5 per cent each.

According to McInnis (1957, p. 72) the prices for molybdenum concentrates have varied considerably. During World War I the price initially was about $1.10 per pound of concentrate containing 90 per cent MoS_2, but towards the end of 1917 it rose to as high as $2.25 per pound. By 1919 the price had dropped to 65-85 cents per pound. In a very limited market of 1929-30, prices were only 35 and 45 cents a pound, and they remained at this low level until 1949. At that time an upward movement started; in 1950 quotations were running at 54 to 60 cents and in 1955 from $1.05 to $1.10 per pound of contained MoS_2. The price for molybdic oxide was $1.24 to $1.31 per pound of contained Mo. Since then prices appear to have remained fairly steady. In June 1958 the *Engineering and Mining Journal* quotation for 90-per-cent concentrate was $1.18 to $1.23 per pound of contained Mo (metal). At this price the value of a normal mine concentrate would be about 50 to 60 cents per pound f.o.b. the mine.

The main requirement specified by a purchaser of molybdenum concentrates is an adequate present supply of a uniformly-high-grade product. As the material is mainly used as an alloying metal in a steel bath, small deviations from the specified grade and small increases in undesirable impurities will considerably alter the physical characteristics of the resulting steel alloy.

Size and Grade of Deposit

From the above considerations the requirements in grade and size of workable molybdenum orebodies may be estimated. No definite figures can of course be given, for, as in estimating the potential of any orebody, local conditions play an important role in determining costs. Using the prices and grades given above, the approximate values per ton of molybdenite ore of varying grades are as follows:

MoS_2 in Ore (%)	Value of Ore per Ton ($)
1	14.00
0.5	7.00
0.3	4.20

Canada's only producing mine, at Lacorne, Quebec, is currently stoping quartz veins in a 650-ton-per-day operation. In 1957 this operation treated 465 tons per day containing 0.46 per cent MoS_2 and 0.041 per cent Bi at an average cost of $5.70 per ton. This mine processes its concentrates to molybdic oxide, and in 1957 it received $1.38 per pound of contained Mo—a higher price than would have been obtained had the company sold its molybdenite concentrate directly. At such a price and grade the molybdenite in the ore would have a value of $8.65 per ton of ore. In addition there is the value of the bismuth produced (130,000 pounds in 1957).

Thus it would appear that on the basis of molybdenum content alone the minimum requirements of a vein-type operation would be an ore grade of at least 0.5 per cent MoS_2 and ore reserves adequate to sustain a 500-ton-per-day operation over a long enough period to amortize the plant and equipment and to give a reasonable profit. These figures suggest reserves of the order of 1 million tons proved and probable before the commencement of such an operation. The cut-off grade for such an operation is of the order of 0.3 - 0.4 per cent MoS_2.

It is not as easy to give corresponding figures for a large-scale bulk mining operation for molybdenum, mainly because there is no Canadian example. In the United States the Climax mine in 1955 treated up to 33,000 tons of 0.6-per-cent-MoS_2 ore per day in what must be regarded as a highly profitable operation. Costs per ton of ore for this operation are not known.

By-products

The above discussion has considered only deposits from which molybdenum alone would be produced. Several producers recover other metallic products in greater or lesser amounts. The presence of by-product metals will, of course, make any operation more profitable providing their recovery does not involve a too-fundamental departure from the flow-sheet for molybdenite. The Lacorne mine of Molybdenite Corporation of Canada, for example, recovers bismuth metal as a by-product. The percentage of Bi in the ore is of the order of one tenth that of MoS_2. The Climax mine recovers wolframite and cassiterite as by-products. Copper, generally in the form of chalcopyrite, is also a likely by-product from molybdenite-mining operations. However, copper is a very undesirable impurity in molybdenite concentrates and the separation of copper and molybdenum sulphides sometimes proves expensive and difficult. So far as is known no mine actually produces copper as a by-product from a molybdenite plant, although the reverse is very common (see below).

Small amounts of molybdenite in ores of other metals are commonly recovered as a by-product; according to McInnis (1957, p. 16), 65 per cent of the supply of molybdenum in 1955 came from mines operated chiefly for molybdenum and the remaining 35 per cent was recovered as a by-product from copper or tungsten ores. In the United States in 1956, two mines were operated chiefly for molybdenum, six recovered molybdenum as a by-product from copper ores, and one recovered the metal as a by-product from tungsten ore.

The economics of such operations are naturally governed by the main metallic product; the presence or absence of molybdenite will normally have little effect in determining if the deposit could be mined at a profit. In general it may be said that molybdenite can be recovered as a by-product if it is present in one tenth the amount that would be required in order to mine it alone. Thus in the United States, the molybdenite content of copper ores from which molybdenum is recovered as a by-product ranges from about 0.01 to 0.08 per cent. No molybdenite is yet recovered as a by-product in Canada, but it will probably be recovered from copper ores in the fairly near future.

Chapter VI

DESCRIPTION OF PROPERTIES

Molybdenum deposits have so far been reported from only three of the principal geological regions of Canada—the Canadian Shield, the Cordilleran region, and the Appalachian region.

THE CANADIAN SHIELD

For many decades the Canadian Shield has been the sole source of Canada's molybdenum production and indeed nearly all of the molybdenite won from Canadian deposits has come from this region. The Lacorne mine in the Preissac-Lacorne area of northwestern Quebec is now the only producing mine. The same area contains at least one other molybdenite deposit of significance, so that it bids well to remain Canada's most important molybdenum-producing area.

The Grenville province differs geologically from much of the rest of the Canadian Shield and also contains molybdenite deposits with characteristic mineral assemblages. As these deposits are in many ways unique in Canada they are discussed separately.

Northwest Territories

Some fifteen occurrences of molybdenite have been reported from the Northwest Territories, of which half are concentrated in the area immediately northeast of Yellowknife between North Arm and McLeod Bay of Great Slave Lake. Most of the occurrences are of mineralogical interest only.

At the *Eldorado mine* at Port Radium, Great Bear Lake, molybdenite occurs as a minor constituent of the complex nickel-cobalt-uranium-silver ores (Kidd, 1936, pp. 22, 24, 36).

From the east shore of *MacKay Lake,* Folinsbee and Moore (1950, p. 11) and Moore (1956, p. 45) reported 1-inch veinlets of quartz with 3 to 5 per cent molybdenite, cutting volcanic rocks near this contact with granite.

At the *Rag group* on the south shore of Stark Lake, 14 miles east of Snowdrift, pitchblende, chalcopyrite, molybdenite, niccolite, and galena occur in a shear zone. Cobalt bloom is present as a weathering product (Lang, 1952, p. 65).

Weeks (1932, p. 44c) mentioned a quartz vein with small amounts of molybdenite at *Term Point*, opposite Term Island in the Rankin Inlet area, District of Keewatin.

On *Edgell Island*—one of the Resolution group off the southeast coast of Baffin Island—pegmatites and stock-works occur carrying monazite, molybdenite, and ilmenite (Lang, 1952, p. 67).

On the *Arseno group* in Prosperous Lake area, a quartz-feldspar body carries tiny quartz veinlets in which pyrite, pyrrhotite, molybdenite, and fluorite occur. A chip sample yielded 0.24 per cent MoS_2 (Jolliffe, 1938, p. 38; Lord, 1951, p. 76).

In the *Quyta Lake area,* 3 miles south of Alexie Lake are pegmatites that carry beryl, tantalite, lepidolite, arsenopyrite, molybdenite, and chalcopyrite (Jolliffe, 1940, p. 9).

The *Aye group* is on the west side of Yellowknife Bay. Aplite dykes, sheared in parts, carry arsenopyrite, pyrite, chalcopyrite, molybdenite and gold (Jolliffe, 1938, pp. 18-19).

In the *Bighill Lake area,* some 15 miles east of the mouth of Yellowknife River, Jolliffe (1938, p. 11) reported seeing pegmatite dykes with arsenopyrite, molybdenite, and spodumene.

In the *Blaisdell Lake area,* 34 miles northeast of Yellowknife are pegmatites that carry beryl, columbite-tantalite, and cassiterite, with minor lithiophilite, molybdenite, arsenopyrite, and pyrite (Jolliffe 1944, pp. 22-23; Lord, 1951, pp. 85-86).

On the *X.L. group,* 58 miles northeast of Yellowknife, Lord (1951, pp. 298-300) reported seeing chalcopyrite, sphalerite, pyrrhotite, galena, pyrite, arsenopyrite, and molybdenite as disseminations in bodies of gneiss.

In the area of *Ross and Victory Lakes,* southeast of the Thompson-Lundmark gold mine, molybdenite occurs in pegmatite dykes together with tantalite-columbite, cassiterite, beryl, and lithium minerals.

On the *Baltic group,* at the northwest end of Hearne Lake, a network of blue quartz veins in quartz-feldspar porphyry carries arsenopyrite and minor galena, sphalerite, and molybdenite (Henderson, 1939, p. 14; Lord, 1951, p. 78).

On the property of *International Tungsten Mines, Ltd. (Philmore Yellowknife Gold Mines, Ltd.)* on Outpost Island in Great Slave Lake, sheared and silicified zones in quartz-mica schist and gneiss carry a complex mineral assemblage comprising ferberite, chalcopyrite, pyrite, magnetite, hematite, ilmenite, marcasite, bornite, chalcosite, covellite, molybdenite, and scheelite. Gold and tin are also reported (Lord, 1951, pp. 236-240).

Alberta

During 1957 and 1958, new deposits of molybdenite together with radioactive minerals were found near *Andrew, Waugh, and Johnston Lakes* by field parties of the Research Council of Alberta (Godfrey, 1958). These constitute the only occurrences of molybdenite so far reported from Alberta. The discoveries are in the extreme northeastern corner of the province, some 100 miles northeast of Fort Chipewyan. The area is accessible by air on a scheduled passenger service operated by Canadian Pacific Air Lines from Edmonton to Beaverlodge, Saskatchewan or Fort Smith, Northwest Territories; but aircraft fitted with pontoons or skis are required to reach the interior.

According to Godfrey, the rocks in the area fall into three broad divisions: (a) granites and granite-gneisses; (b) quartzites, biotite-sericite schists, conglomerate and slate; and (c) porphyroblastic schists grading into porphyritic grey granite. Granite rocks in the area include hornblende, biotite, and muscovite granites and granite-gneisses. Feldspar augen-gneisses, amphibolite, and veinlets of epidote are commonly associated with these rocks. Some of the granites and gneisses grade into pegmatites. Division (b) contains pods, lenses, and stringers of quartz and pegmatite. Basic volcanic rocks and amphibolites occur in some of the metasedimentary bands. Quartzite and biotite schist may grade through porphyroblastic feldspar schist to augen or porphyritic grey granite-gneiss. Garnets are common in the quartzites and rare in granite-gneisses.

The bands of granitic and metamorphic rocks of this area have two distinct trends: one north and the other northwesterly.

Godfrey describes the principal mineralized areas. In a table (page 6) he lists one locality as having "important molybdenite" and six others as showing "minor molybdenite". In addition to radioactive minerals and pyrite, the minerals arsenopyrite, smaltite, pyrrhotite, galena, and chalcopyrite have been found in deposits in the area, although apparently not together with the molybdenite. The main locality for molybdenite is an outcrop of sheared metasedimentary rocks 2,000 feet southwest of the southwest arm of Andrew Lake. The outcrop also shows "a very high level of radioactivity". Godfrey states:

The outcrop measures 200 by 75 feet and consists of quartzite, biotite schist, feldspathic quartzite, porphyroblastic feldspar schist and pegmatite. Both molybdenite and the radioactive mineralization seem to be concentrated in a biotite schist band although small zones of significant radioactivity and flakes of molybdenite were noted elsewhere on the outcrop. The band of biotite schist, six inches wide, which strikes north 17 degrees east, contains molybdenite and yellow stains which resemble carnotite. This band can be followed for 110 feet before it is covered by glacial drift. The radioactive zone and surrounding rocks follow the same trend and dip either vertically or 85 to 90 degrees west. The mineralized biotite schist is iron stained and contains thin lenses and pods of quartzite and veins of quartz. Pyrite is found in all rocks and particularly in the metasedimentary rocks. Three grab samples taken from the highly radioactive zone have been assayed by G. S. Eldridge and Co., Ltd., Vancouver, and gave the following results:

Sample Number	*U_3O_8(%)*	*Mo(%)*
JG-58-44-1A	1.03	0.69
JG-58-44-1B	3.93	1.03
JG-58-44-1C	3.29	1.40

Semi-quantitative spectrographic analysis on two of the samples gave the following results (reported in per cent as oxides of the elements involved):

Sample JG-58-44-1A		Sample JG-58-44-1C	
Na	6.0	Na	0.25
Mg	7.5	Mg	10.0
Al	20.0	Al	15.0
K	8.0	K	10.0
Ca	2.5	Ca	0.25
Ti	4.0	Ti	5.0
V	0.15	V	0.1
Cr	0.25	Cr	0.1

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Sample JG-58-44-1A		Sample JG-58-44-1C	
Mn	0.2	Mn	0.3
Fe	20.0	Fe	20.0
Co	0.01	Co	0.01
Ni	0.01	Ni	0.01
Cu	0.04	Cu	0.03
Sr	0.01	Zr	0.15
Zr	0.1	**Mo**	**2.0**
Mo	**1.0**	Y	0.15
Ag	0.0008	Yb	0.03
Y	0.05	Ba	0.2
Yb	0.02	U	2.5
Ba	0.35	Pb	0.75
U	1.0		
Pb	0.5		

Si + non-detectables: Balance in both samples.

A second zone containing highly radioactive bands with molybdenite has been followed for over half a mile along the strike of the metasedimentary rocks at Spider Lake. Geiger-counter readings taken at intervals along the direction of the strike indicate that this radioactive zone may extend at least two miles. Similar radioactive occurrences with molybdenite associated with pegmatites have been described from several localities in northern Saskatchewan (Mawdsley, 1957).

A high level of radioactivity and yellow stains similar to carnotite were found in pink feldspar pegmatites within quartzites and biotite schist. In some cases similar-looking yellow stains are nonradioactive; these stains are thought to be derived from the weathering of disseminated flakes of molybdenite. The radioactive zone was noted along the peninsula at the northern end of Spider Lake and continues through the string of islands to the southwest. It reappears three-quarters of a mile south at the southwest corner of Spider Lake and has been noted at several points for another three-quarters of a mile farther south.

At other localities, mostly to the south of the southwest arm of Andrew Lake, flakes of molybdenite were found within a quartz vein, quartz-rich pegmatite, quartzite, and gneiss.

The molybdenite-bearing localities so far discovered are thus grouped in a rather restricted area, almost all lying immediately south of the long, narrow, southwest arm of Andrew Lake. As can be seen from the above descriptions, the deposits vary in type, ranging through pegmatites, quartz veins, and disseminations in gneiss, schist, and quartzite.

Saskatchewan

The Canadian Shield in Saskatchewan contains a few scattered molybdenite-bearing mineral deposits—in the Lake Athabasca, Cree Lake, Rottenstone Lake, and Churchill mining districts. In all the occurrences so far recorded, molybdenite is present as one of several minerals and is mainly of minor importance. As in Alberta, radioactive minerals are present in a high proportion of the occurrences in the Lake Athabasca district.

Beaverlodge Lake Area

At the *Ron 1-7 group,* Gatzke (Nesbitt) Lake, are pegmatitic deposits that carry hematite, pyrite, molybdenite, uraninite, monazite, thorite, zircon, chalcopyrite, pyrrhotite, and galena (Lang, 1952, p. 104; Christie, 1953, p. 81).

SS Concession (Goldfields Uranium Mine, Ltd.)—From 20 miles north of Goldfields, Christie reports pyrite, chalcopyrite, and molybdenite in a radioactive biotite- and chlorite-rich shear zone (Christie, 1953, p. 108).

TT Concession—At the southeast end of Gatzke Lake is a shear zone that carries hematite, uraninite, pyrite, and molybdenite (Christie, 1953, p. 108).

NN Concession—Thirteen miles northwest of Goldfields is a radioactive shear zone in mafic rocks, with pitchblende, pyrite, chalcopyrite, and molybdenite (Christie, 1953, pp. 107-108).

Athona Mines Ltd.—A little molybdenite occurs at Goldfields in granite and along slip planes in an older basic rock in the neighbourhood of gold-quartz veins carrying chalcopyrite, galena, sphalerite, and free gold (Alcock, 1936a, p. 28).

Black Lake Area

Pegmatites on the *Corrigan-Stinson Group* at Charlebois Lake, 30 miles northeast of Black Lake, carry molybdenite and uraninite (Lang, 1952, pp. 108-109).

On the *Row-Mike group,* in the Charlebois Lake area, uraninite, thorite, and molybdenite occur in pegmatite (Lang, 1952, p. 112).

McArthur-Anderson groups—At the extreme east end of Pluto Bay on Black Lake, lens-shaped, radioactive, molybdenite-bearing pegmatites have been reported (Hriskevich, 1949, p. 25).

Cree Lake Area

Seven miles south of the south end of *Holgar Lake,* molybdenite occurs as irregular grains in narrow quartz-feldspar stringers cutting hornblende schist (Sproule, 1938, p. 13).

At a locality northeast of the extreme southeast bay of *Upper Foster Lake,* south of the rapids from Upper to Middle Foster Lakes, Mawdsley (1957, pp. 40-44) reported the presence of radioactive pegmatites with "a fair amount of pyrite" and "a very little molybdenite".

Lac la Ronge Area

At the *Moore Point deposit,* chalcopyrite, pyrite, pyrrhotite, bornite, molybdenite, and magnetite, in quartz stringers up to 2 inches thick, have been introduced along shear planes in what was probably an impure quartzite, so as to form an irregular replacement deposit (McLarty, 1935).

On an island north of the narrows in *Pelican Lake,* DeLury (1924, p. 49B) reported "traces of molybdenite in contact metamorphic rocks."

Amisk Lake Area

At the *Prince Albert prospect,* Bruce reported quartz veins in a schistose, altered zone carrying gold, arsenopyrite, pyrite, molybdenite, galena, and stibnite.

The *Moody Prospect* at Birch Lake was staked by R. H. Moody of Beaver Lake, via Flin Flon. It carries pyrite, chalcopyrite, galena, sphalerite, molybdenite, and scheelite in a shear zone in a small granite boss cut by stringers of vein quartz. Assay returns of 0.16 per cent W and 0.63 per cent Mo were obtained from a sample.

Manitoba

More than 20 occurrences of molybdenite have been reported from that part of the Canadian Shield lying within Manitoba. Many of these are of minor, or only mineralogical interest. The main areas of concentration of molybdenite-bearing deposits are in the southeastern part of the province and in the Wekusko Lake area in the north-central part. The other deposits are mostly widely scattered.

Deposits in the southeastern corner of the province are concentrated into three general areas. In the extreme south they occur around Falcon Lake, very near the Ontario border; the second minor area of concentration is just north of Pointe du Bois, between the Winnipeg and Oiseau Rivers; and the third area is formed by a belt running southeastward from Lake Winnipeg, at the mouth of the Wannipigon River, to the Beresford-Garner Lakes area on the Ontario border.

Falcon Lake Area

The molybdenite deposits of this area have been described by Bruce (1918, pp. 22-25D), DeLury (1917, pp. 460-462; 1927, pp. 49-51), Eardley-Wilmot (1925, pp. 54-55) and Cole (1938, p. 168). The following is quoted from the account by Bruce.

> Recently claims have been staked for molybdenite in Manitoba near the Ontario boundary. The claims lie in tp. 9, rge. 16, W 1st mer. Falcon lake, a body of water of considerable size, draining into Shoal lake and thence into Lake of the Woods, lies just south of the locations. In summer Falcon lake can be reached from Ingolf, a station on the Canadian Pacific railway just east of the Manitoba-Ontario boundary, by a canoe route that leads through Longpine and West Hawk lakes, and there is another good water route, by way of the Falcon river, from Shoal lake, where the Greater Winnipeg Water District railway terminates. In winter there is good connexion with the railway by road. Summer roads could be built without great expense.
>
> The country has the typical, broken, lake-dotted character of the Precambrian, and has somewhat greater relief than most areas of similar rocks in Canada.
>
> Three days were spent by the writer in the district, and although accompanied by Mr. W. J. Gordon, who is thoroughly acquainted with it, the time was altogether too short to make a satisfactory study of the geology. Moreover, work was very seriously hindered by snow, which left only cliff faces and hummocks exposed. The writer has, however, had access to a private report by Geo. Hanson, to the published reports of Parsons on the Lake of the Woods district, for the Ontario Bureau of Mines, and of R. Wallace, for the Public Utilities Commission of Manitoba. The latter report does not include Falcon lake, but deals with the Star Lake district just north of it.
>
> GENERAL GEOLOGY
>
> The following is a very brief summary of the geological relations. The oldest rocks consist of a volcanic complex of schists and ellipsoidal-weathering greenstones. Involved in these are certain areas of sedimentary rocks, which have not yet been separately mapped.

The volcanics, and probably the sediments as well, are intruded by a fresh, reddish to grey granite-gneiss, which forms the country rock both to the northwest and southeast of the narrow belt of basic rocks between West Hawk and Falcon lakes. Parsons says of the part of this belt crossed by the Manitoba-Ontario boundary: 'The Keewatin formation is here about 4 miles wide and consists of fine-grained, highly altered rocks, which show little trace in the field of their origin. The most abundant rock is biotite schist, but hornblende schist is common. Near the contact of this formation with the Laurentian on the north, the rock becomes coarser grained and is almost granitoid in texture, though much darker, than the Laurentian gneiss with which it is in contact.'

West of Finnel lake, which lies just north of Falcon lake, there are many areas of ellipsoidal-weathering greenstone. In fact, this greenstone seems to have a greater areal extent than any other Keewatin type; but, since this massive rock stands up in ridges and hence was bare at the time the district was visited, whereas the lower country, which is probably underlain by schists, was snow-covered, the predominance of the ellipsoidal lavas may have been only apparent.

On the northwest side of the basic belt, near the Keewatin-Laurentian contact, a large number of pegmatite dykes of all sizes cut the older formation. Most of these are entirely within the schist and greenstone, but the largest one seen may be the pegmatitic edge of the main body of gneiss. A wide muskeg-filled valley, however, separates it from the nearest outcrop of normal granite-gneiss. The pegmatites occur in a belt lying parallel to the approximate line of contact between the two formations, and though not continuous, they form a zone about 2 miles in length north of Falcon lake. It is along this zone that claims have been staked for molybdenite.

The pegmatites consist mostly of a pink-weathering feldspar and quartz. Some of them are almost wholly feldspar, others seem to grade into typical quartz veins. In one place a pegmatite consisting of nearly equal amounts of quartz and feldspar gradually changes along its strike to a quartz vein with a feldspar border on each side, and farther along to an ordinary quartz vein. Muscovite is a fairly abundant constituent of the pegmatites and beryl is found, but is somewhat rare. Some molybdenite occurs in almost all the pegmatitic dykes of this zone. In one sample from the district, native bismuth occurs associated with the molybdenite.

Although in all cases related to pegmatites, the molybdenite is found with the following physical characters:

(1) As a constituent of typical pegmatite dykes.

(2) In equigranular granitic dykes.

(3) In quartz veins.

In the typical pegmatite dykes the molybdenite occurs as crystals varying from a fraction of an inch up to 2 inches in diameter. The size of the larger individuals seems to vary according to the distance of the dyke from the parent granite mass, the larger crystals being found in the dykes close to the edge of the main granite area. In these dykes, however, the total amount of molybdenite present is not greater, and possibly is even less than in those farther from the intrusive.

In the equigranular dykes the molybdenite crystals are much smaller, occurring as small hexagonal plates rather than as the large almost equally dimensioned crystals found in the typical pegmatites.

In quartz veins molybdenite flakes are found in veinlets traversing the quartz. These veins lie near the typical pegmatites, and in some of them the veinlets are made up largely of molybdenite, with only very narrow borders of feldspar. The molybdenite does not seem to be secondary in any sense except that the veinlets are a little later in age than the quartz veins, which they cut. In type they are similar to the occurrences in the larger dykes.

The molybdenite-bearing quartz veins are not large and they contain too little of the mineral to make them workable, even if they were of sufficient size. The equigranular dykes carry more molybdenite than the other types, but all those seen were too small to be important. In the pegmatites it is very difficult to obtain an idea of the proportion of molybdenite. The crystals are scattered irregularly through the quartz and feldspar, so that a face showing no crystals may show several when a thin layer has been broken off. Ordinary sampling under such conditions is worse than useless. The only method of arriving at an accurate estimate of the content of a vein is to take out and mill a fairly large quantity.

Judging from dyke material broken from the face of a small open-cut the molybdenite content is less than one-quarter of 1 per cent of molybdenite. This is in the only opening of any size made in the dykes. At this place the dyke is from 2½ to 3 feet wide and has been open-cut for 20 feet to a depth of 3 feet. The pegmatitic material breaks easily and a small quantity of almost pure molybdenite could no doubt be produced by cobbing such material, but it is doubtful if this could be done economically with so low grade a product as this seems to be. However, the accessibility of the district, the large number of well exposed dykes varying from 2 feet to 12 feet in width, and the ease with which a considerable quantity of the material could be taken out, without expensive mining machinery, make it possible that this prospect might be commercially worked at the present time.

The molybdenite content may be expected to continue fairly constant, but the depth to which the dykes extend cannot be foretold. Since they undoubtedly join the parent mass of granite below, the depth from the surface to which they reach depends upon the attitude of the granite. This can be ascertained only by drilling or by underground work.

Pointe du Bois Area

Shear zones, locally impregnated with sulphides, occur in andesitic lavas
52|51 on the property of the Manitoba Tin Company, Limited at Shatford Lake, 6 miles north-northeast of Pointe du Bois. A prospect shaft was sunk for 30 feet on one of these shear zones. J. F. Wright (1932, p. 105) reported that

> The schistose lava on the dump contains pyrrhotite and some pyrite, arsenopyrite, chalcopyrite, molybdenite, galena and sphalerite. The molybdenite is in quartz veins cutting the schistose lava.

In an earlier report Wright (1926, p. 99) mentions that molybdenite has been "noted as an accessory mineral in pegmatite at a number of localities west
52|50 of Pointe du Bois." He continues—

> A shallow prospect pit has been sunk on one of these occurrences about 1 mile west of lac du Bois and ¼ mile north of the City of Winnipeg railway near the southern side of section 23, range 13, township 15. At this point there is a small inclusion of andesite lava in the granite and there has been a concentration of molybdenite in a quartz-rich pegmatite which occurs along the andesite-granite contact. The general strike of the andesite inclusion is north 20 degrees east. The molybdenite occurs in small pockets and vests irregularly distributed along the contact for about 200 feet and across a width of from 2 inches to 1½ feet. Molybdenite in single flakes was noted at several nearby spots. However, only a very small quantity of molybdenite was seen at this locality.

Garner Lake Area (Wannipigon River)

Three occurrences of molybdenite, of only minor interest, have been reported from near the mouth of the Wannipigon River, on the east side of Lake Winnipeg. At the Gold Shore property of Gold Shore Mines, Limited, situated on the shore of Lake Winnipeg between the mouths of the Wannipigon River and Steep Rock Creek, molybdenite occurs in a vein carrying gold and copper values.

Eardley-Wilmot (1925, p. 56) mentions the occurrence of molybdenite with chalcopyrite in a quartz vein in tp. 25, rge. 9E, Wannipigon River. The occurrence is reported as of "mineralogical interest" only. One mile south of the east end of English Lake, north of Wannipigon River, molybdenite, chalcopyrite, and pyrite occur in quartz-bearing shear zones (Russell, 1949, p. 19).

On the Presto Group, 7 miles east of the San Antonio Gold Mine, molybdenite was noticed as a minor mineral in quartz veins carrying free gold, pyrite, chalcopyrite, arsenopyrite, tetrahedrite, galena, and sphalerite (Bull. Can. Inst. Min. Met., No. 366, Oct. 1942, p. 46b).

At Gold Lake, in tp. 23, rge. 14E, molybdenite of mineralogical interest only, occurs in gold-quartz veins together with galena (Eardley-Wilmot, 1925, p. 56).

Russell (1949, p. 11) reported minor molybdenite in quartz-carbonate fault zones at Garner and Wallace Lakes. Accompanying minerals are gold, pyrite, chalcopyrite, galena, arsenopyrite, sphalerite, and scheelite.

Wekusko Lake Area

The following account is quoted from J. F. Wright (1931, pp. 112-113).

Molybdenum. A number of molybdenite-bearing quartz and pegmatite bodies have been known for some years in Wekusko Lake area. In 1918, Alcock[1] examined a few of these and describes a deposit south of the Bengal deposit, to be discussed in a succeeding paragraph. Alcock states that here "The molybdenite occurs in a pegmatite dyke that runs at right angles to the river and cuts a fine-grained, dark-coloured, biotite gneiss. The dyke is 20 feet long and has a maximum width of 3½ feet. The pegmatite is composed of coarse orthoclase crystals and quartz, the quartz being so abundant in parts that it resembles a true quartz vein. The dyke contains molybdenite, pyrite and chalcopyrite. The molybdenite is concentrated in seams along the borders of feldspar crystals, along the contact of the dyke and country rock, and occurs also in the wall-rock for about half an inch from the dyke."

Alcock also states that "On the north arm of Herblet Lake molybdenite has been found in quartz veins, but only in small quantities."

R. C. Wallace mentions an occurrence of molybdenite on the Ginger Mineral claim, on the west side and near the south end of the narrows leading from Wekusko Lake to Crowduck Bay.

The Bengal group of mineral claims . . . . . were staked along the northwest side of Grass River, north of Crowduck Bay, in 1929 by Messrs R. Rosen, A. Hansen, and associates. The bedrock along the river bank is quartz-mica-garnet gneiss, which 35 to 200 feet inland is cut by a large body of granite and granodiorite. The contact of granite and sediments follows the foot of a hill, and the main prospecting has been done at two localities near the foot of this hill and at one point to the northeast on the face of a low cliff just above water-level.

The prospect pits expose bodies of pegmatitic quartz striking north 50 degrees west, or approximately at right angles to the strike of the foliation of the gneiss and of the contact between granite and gneiss. The quartz bodies extend from the sedimentary gneiss into massive granite, but, within 200 feet in the granite, the quartz masses narrow and end. The southeast continuation of the deposits across the gneiss is under drift and water.

The south molybdenite-bearing quartz deposit, explored in 1929, is 28 inches wide in a trench at the foot of the hill and extending 15 feet up the side of the hill. The quartz body narrows and ends in the granite 50 feet northwest of the trench. The white quartz is crossed by joint planes; flakes of molybdenite up to 1½ inches across are distributed along a few joint planes. Some small flakes of molybdenite lie apparently in unfractured quartz. Crystals and grains of pyrite and grains of chalcopyrite are associated with the larger flakes of molybdenite. The deposit dips 80 degrees northeast and the molybdenite and sulphides are localized along the hanging-wall of the mass.

Another parallel quartz body about 100 feet to the north is 18 feet wide where it lies in the sedimentary gneiss, where as in the granite it splits into two crooked branches, ending to the west within 200 feet. The quartz of the large body in the gneiss is white, coarsely granular; small areas of it contain large feldspar and mica crystals and a few grains of pyrite and chalcopyrite occur close to the walls.

[1] Alcock, J. F., 1920, p. 38.

Several other similar but smaller quartz bodies outcrop to the north along the contact between the granite and the sedimentary gneiss. One of these, about 3,500 feet northwest of the deposit described in the foregoing paragraph, is 19 feet wide, and is of coarse-grained quartz with many crystals of greyish microcline, light mica, and, in a few areas, grains of pyrite and chalcopyrite are abundant. No molybdenite was seen in the quartz exposed in the large cut along the side of the cliff at this locality.

Most of the pegmatitic quartz and pegmatite of the area carry only disseminated flakes of molybdenite, or the areas wherein molybdenite is abundant are small. Gold is absent or assays show only a trace. A few specks of free gold were found in a narrow quartz vein adjacent to the quartz body, 19 feet wide, described above. Small grains of galena and sphalerite occur in some of the molybdenite-bearing quartz.

J. F. Wright (1931, p. 92) also describes deposits on the Dion claims situated on top of the hill west of the south end of the narrows from Wekusko Lake to Crowduck Bay. These claims must be very near the Ginger claim mentioned by Wallace in the foregoing. The claims have been trenched to explore three deposits of gold-bearing quartz lying in grey granodiorite containing areas of pinkish granite. At one place a shaft had been sunk on a quartz vein 33 inches wide. Some of the quartz carried free gold and flakes of molybdenite. According to Wright, the free gold appeared to be distributed in the quartz near the molybdenite.

Miscellaneous Areas

Barrington Lake Copper Mines, Ltd.—On the east shore of Barrington Lake in the Granville Lake mining division, molybdenite occurs together with chalcopyrite, pyrrhotite, and pyrite in aplite dykes cutting volcanic rocks and, with chalcopyrite, in quartz stringers (Crombie, 1948, pp. 15-16).

Footprint Lake, Uhlman Lake Area—Scattered molybdenite has been found in several places near Footprint Lake (Wright, G. M., 1953, p. 15).

Wintering Lake Area, Cross Lake Mining Division—On the east shore of a small bay on the north shore of the large northwestern bay of Wintering Lake, molybdenite, pyrite, and chalcopyrite are reported to occur in quartz stringers cutting granite gneiss. On an island near the extreme northeast end of Wintering Lake, scattered molybdenite occurs in a showing of sulphides. On Chatham Creek, east of Wintering Lake, molybdenite flakes were seen in quartz-garnet gneiss (Dawson, 1952, pp. 25-26).

The Phantom Lake Claims, 5 miles south of Flin Flon in the Athapapuskow mining division, show quartz veins in shear zones carrying pyrite, chalcopyrite, and molybdenite (Wallace, 1920a, p. 26; Cole, 1938, p. 168).

Dominion Claims, Copper and Brunne Lakes, Athapapuskow Mining Division—Wallace (1920b, pp. 30-31) reports gold-bearing vein quartz carrying pyrite, galena and molybdenite.

Little Playgreen Lake, Oxford Lake Mining Division—At the north end of the lake, molybdenite occurs in pegmatites cutting granite (Tyrrell, 1901, pp. 6, 16G).

On *Echimamish River,* north of Little Playgreen Lake, Eardley-Wilmot (1925, p. 56) reported the occurrence of molybdenite along a contact zone between gneiss and intruding igneous rock.

At *Gorman Lake*, in the Island Lake mining division on the Ontario-Manitoba border, Derry and Mackenzie (1931, p. 14) found molybdenite, together with tantalite, pyrite, and chalcopyrite, in pegmatites in gneiss.

Ontario

Kenora District (Patricia Portion)

On the *Oliver claims* at Setting Net Lake, in Favourable Lake area, pyrite, pyrrhotite, molybdenite, magnetite, and chalcopyrite occur in contact-metamorphosed calcareous patches in greenstones. Molybdenite occurs in the outcrop (Hurst, 1929, pp. 78-81).

On the north shore of *Lang Lake*, in the Shonia Lake area, molybdenite occurs in a quartz vein (Laird, 1930, p. 18).

Harding (1935, p. 69) mentions the occurrence of flakes of molybdenite in pegmatite dykes cutting granite on the south shore of the narrows in *Carpentier Lake*.

The *Connel-Williams-Stirret group* is 2 miles northwest of Slate Falls on the south shore of Wesleyan Lake, in the Cat River area. There, quartz veins in granite carry pyrite, chalcopyrite, pyrrhotite, molybdenite, galena, and sphalerite, with gold values (Laird, 1930, p. 22; Harding, 1935, pp. 68, 73).

On the east side of *Reserve Lake* in the Fort Hope area, northeast of Eabamet Lake, molybdenite and "common sulphides" occur in numerous quartz veins and stringers traversing granite and neighbouring rocks (Prest, 1942, pp. 27-28).

Red Lake Area

Molybdenite occurs as an accessory mineral in some of the gold-quartz veins at such properties as the *Corless Patricia Gold Mines, Limited* in Corless township (Harding, 1936, p. 25), and the *Red Crest Gold Mines, Limited* in Todd township (Hurst, 1935, pp. 37-39).

In *Balmer township*, just south of O'Keefe Lake, Horwood (1940, p. 65) reported a blue quartz vein near a granite contact carrying molybdenite.

On the *Stupack-Bruce claims*, just east of Mackintosh Lake in Ball township, 0.68 per cent Mo has been reported from a shear zone (Horwood, 1940, p. 65).

Kenora District

On the *P. Dusang claim*, northwest of the Lower Kettle falls on English River, replacement type veins occur carrying pyrrhotite, pyrite, and molybdenite (Derry, 1930, p. 39).

On the *Cameron property*, 8 miles east-northeast of Minaki on the Canadian National railway 15 miles north of Kenora, molybdenite and radioactive minerals occur in a pegmatite (Lang, 1952, p. 118).

At the *Sultana gold mine*, Quarry Island, Lake of the Woods, molybdenite occurs as an accessory mineral in gold-quartz veins (Parsons, A. L., 1917, p. 299; Cooke and Johnston, 1932, p. 10).

At the *High Lake occurrence*, on the Ontario-Manitoba border, irregular quartz veins and stringers in shattered silicified prophyry carry chalcopyrite, pyrite and molybdenite (DeLury, 1927, p. 51; Greer, 1930, p. 55).

At the *Mikado mine,* Bag Bay, Shoal Lake, molybdenite occurs in a gold-quartz vein (Parsons, A. L., 1917, p. 299; Cooke and Johnston, 1932, p. 10).

At the *Gold Panner mine*, north of Kakagi Lake, molybdenite occurs as a minor accessory in quartz-carbonate veins in sheared quartz porphyry carrying gold and pyrite (Burwash, 1933, pp. 80-81).

In the *Quibell deposits,* just north of Quibell in Redvers township, molybdenite occurs disseminated in granite and granite-gneiss (Eardley-Wilmot, unpub. rept. 1942, *Geol. Surv., Canada,* Econ. Geol. files).

At *Contact Bay,* Wabigoon Lake, molybdenite, pyrite, and chalcopyrite occur in a 6-inch quartz vein and in fine quartz-stringers in Keewatin diorite (Parsons, A. L., 1917, p. 313).

The Van Houten gold syndicate holds a group of claims south of Alston Lake and west of Moose Bay on Dinorwic Lake, about 10 miles southwest of Dinorwic. On these claims quartz veins and stringers in a sheared zone in granite carry native gold with associated iron-bearing carbonate, pyrite, chalcopyrite, and molybdenite (Satterly, 1943a, pp. 46-47).

From the *E. D. Pidgeon property* on a small lake west of Upper Manitou Lake, 6 to 7 miles from Gold Rock, Eardley-Wilmot (1925, p. 77) reported minor molybdenite together with bismuthinite in a quartzose pegmatite dyke. In 1920, assessment work on this property yielded about 200 pounds of high-grade samples.

The Oro Plata Company, Limited held a property 1½ miles west of Benson Bay in the north-central part of Upper Manitou Lake on which patchy molybdenite occurred in quartz veins (*Mineral Resources Div., Dept. Mines, Tech. Surv.*).

At *Smooth Rock* (*Vickers*) *Lake,* southeast of Lower Manitou Lake, molybdenite has been reported from two localities at the south end of the lake. At one locality it occurs with gold, pyrite, and pyrrhotite in a quartz vein in 'trap rock', and at the other locality it occurs in the trap rock itself near a granite contact (Walker, T. L., 1911, p. 49; Parsons, A. L., 1917, p. 310).

From *Grave Lake,* west of Lower Manitou Lake, Thomson (1934, p. 18) reported the occurrence of white quartz veins carrying pyrite, chalcopyrite, and molybdenite.

At the *Coates showing,* Gullwing Lake, Webb township, 15 miles northeast of Dryden, pegmatite dykes rich in quartz and feldspar intrude a hornblende schist and follow along the general strike. In one of the dykes molybdenite is associated with pyrite, pyrrhotite, and mica (Eardley-Wilmot, 1925, p. 77; Harding, 1950, p. 26).

De Coursey-Brewis Minerals hold a 26-claim group to the southwest of the Pidgeon Molybdenum Mines property (*see* p. 73), along the same granite contact. According to a report in *Financial Post* (Feb. 22nd, 1958) a diamond-drill hole on this group intersected a pegmatite stock-work zone similar to the one investigated on the Pidgeon property. Some 27 feet of core in this hole carried molybdenite, though it was not of ore grade.

Just south of *Young Lake*, 4 miles due north of Valora station on the Canadian National railway, molybdenite and chalcopyrite have been reported in a sulphide replacement body in Keewatin greenstone (*Geol. Surv., Canada,* Map 557A, marginal notes).

Ignace Area

Some molybdenite occurrences in this area have been described by Tanton (1938a, pp. 6-7, 9) and Satterly (1943a, pp. 60-62). The following is from Satterly's report. The occurrences are situated on, or south of, McNamara Lake, the south end of which is 7 miles due south of Ignace. A belt of volcanic rocks with minor amounts of sediments about a mile wide parallels the west shore of McNamara Lake and strikes northwest. To the south of McNamara Lake the belt swings to a direction slightly north of east. The molybdenite occurrences are within this belt of volcanic rocks but are intimately associated with the numerous masses of granite or pegmatite found within the belt. On the Olson claims, 1½ miles south of McNamara Lake, the molybdenite showing is in a rusty-weathering biotite granite whose exposed width is 10 feet. Exposures of the country rock (amphibolite) both north and south of the granite suggest that the latter is in the form of a dyke. The molybdenite occurs as coarse scales or crystals, up to ¾ inch across, in quartz stringers filling fractures in the granite. There is no molybdenite in the granite itself. On the Wilson claims, about a mile southeast of the southeast bay of McNamara Lake, the country rock is banded metamorphosed impure quartzite lying north of metamorphosed basic volcanic rocks. In one pit, well-bedded impure quartzites contain a silicified zone with disseminated pyrrhotite and, in a 2- to 4-inch-wide zone, disseminated molybdenite with quartz, sericite, and very finely divided sulphide. At two other places minor molybdenite has been found in zones of heavy pyrrhotite mineralization. None of these showings seems to be of commercial importance.

Pidgeon Molybdenum Mines Limited, Echo Township

Molybdenite was found in 1946 by J. K. Webb and H. E. Neal in biotite-quartz monzonite between Lateral Lake and Moly Lake and east of Lateral Lake (Armstrong, H. S., 1951, p. 37). Subsequently 11 claims were staked on the showings east of Lateral Lake by G. L. Pidgeon of Wabigoon. After some stripping and trenching, the property was acquired by Detta Minerals Limited in 1954. This company diamond-drilled two holes into the main showing. One of the holes was followed by an adit from which a bulk sample was obtained and used for test work in Ottawa.

In 1957, Pidgeon Molybdenum Mines Limited was formed to acquire the claims. They were purchased in September of the same year as a result of an agreement among Candore Exploration, Limited—the successors to Detta Minerals—Mid North Engineering and Services, Limited, and Rio Canadian Exploration, Limited. Sogemines Development Limited participated with Rio Canadian in forming the new company.

Detailed mapping and a diamond-drill program were then carried out on the showings. In all, 17 diamond-drill holes were completed with a total of 5,393 feet of drilling.

The writer visited the main surface showings and the adit in September 1958. The following description is based on personal observations and on information courteously supplied by Rio Canadian Exploration, Limited.

The property is approximately 25 miles southwest of Sioux Lookout. It can be reached by driving 24 miles along the Sioux Lookout-Dryden highway and then turning northwest along logging roads and tracks for some 6 miles.

The geology of Echo township is shown on H. S. Armstrong's (1951) map (No. 1950-1). The molybdenite deposits on the Pidgeon property are located along the eastern end of the southern contact of a lenticular intrusive mass, elongated in an east-west direction, in the northwestern corner of the township. Armstrong (p. 25) refers to this mass as the "Lateral Stock". In Echo township the mass is more than 2 miles long and about a mile wide. It continues to the west for an unknown distance into Webb township. The rocks of the Lateral stock are generally fairly coarse grained, with a high ferromagnesian content. Large patches of biotite are very abundant. The rocks are gneissic, except for the more massive aplitic parts. The mineral composition indicates that the rocks range from biotite-quartz monzonites to biotite granites, with most specimens belonging to the former group (Armstrong, 1951, p. 26).

The intrusive rocks of the 'Lateral' stock are bordered and overlain by hornblende-rich sedimentary schists of the Abram Series of pre-Algoman age. Those sedimentary rocks bordering the stock form a band which varies in width due to variations in dip, but has a true thickness of the order of 1,900 to 2,000 feet (Armstrong, 1951, p. 16). It appears that the 'Lateral' stock has either caused or been injected into an eastward-plunging anticlinal structure in the sedimentary rocks. Armstrong believed that this anticline is superimposed on the northern limb of a larger synclinal structure. On the southern flank of the stock, where the molybdenite deposits are, the sediments strike between N45°E and N60°E and dip southward between 40 and 65 degrees. On the north of the stock the strike is N70°E and dips are from 35 to 50°N.

Along the southern contact of the stock the 'granite' contains irregular dykes of aplite that are cut by quartz and pegmatite stringers. The heaviest molybdenite mineralization is associated with the quartz and pegmatite, although much of the aplite carries disseminated molybdenite. The aplite dykes strike N55°E and dip at 70 degrees to the southeast, and, therefore, into the cover.

Diamond-drilling has revealed that the aplite occurs in a series of parallel dykes—some which do not come to the surface but stop at the contact with the sediments. The dykes are confined to a zone extending roughly 200 feet out from the contact and for this reason do not reach to any great depth.

Beyond this zone, the trace of a dyke is in places marked by quartz veins and breccia.

The principal showings on the property are in two outcrop areas lying along the southeast contact of the 'granite'. The easterly outcrop is almost along the contact. It is 80 to 120 feet wide and some 2,200 feet long; the southernmost 300 feet of its length shows the best mineralization. Some 800 feet to the southwest, the second area of outcrop is 70 to 100 feet wide and about 700 feet long. The outer edge of this outcrop lies some 400 feet within the 'granite' stock. Apart from these two areas of outcrop, the intrusive stock within the Pidgeon property is entirely swamp-covered.

The adit driven by Detta Minerals in 1954 lies towards the southern end of the large easterly area of outcrop (*see* Fig. 2 in pocket). The outcrops consist of banded pink and grey granitic gneiss, heavily intersected by pegmatitic quartz veins and pegmatite, which form highly irregular bodies.

The gneisses have an almost constant strike, consistently at N30-40°E, and they dip 30 to 40°SE. They show a marked banding consisting of a medium- to coarse-grained grey biotite gneiss and parallel bands of varying widths of a fine-grained, pink aplitic granite. The proportions between the two rock types vary greatly. In some places the aplite is present as very rare narrow bands in the grey granite-gneiss; in others it occurs as large irregular bodies that appear to be replacing the host rock.

The aplite is everywhere crosscut by quartz-pegmatite bodies. These vary from masses or veins of almost-pure quartz with only one or two pink feldspar crystals, to coarse pegmatite with abundant feldspar. The latter type normally holds a large amount of greenish yellow sericitic muscovite, with which a good deal of molybdenite is commonly associated.

As shown in Figure 2, the larger quartz-pegmatite veins show a preferred strike-direction of around N60°E; they have steep rolling dips. Many other, smaller and less-regular veins and masses form complicated stock-works. The veins and stock-works cover the entire width of the outcrop but appear to be concentrated in three 12- to 30-foot-wide zones, trending northeasterly and separated by like widths of granite-gneiss almost free from quartz and pegmatite.

The adit has been driven under this area of outcrop about 300 feet from its southern tip. Figure 3, shows the geology of the back and northwest wall of this adit, which has been driven through a series of quartz veins and pegmatites in grey granitic gneiss and pink aplite to intersect the overlying sediments. At the face these sediments consist of fissile dark hornblendic schists, striking N45°E and dipping 50°SE. The contact is sharp and apparently concordant to the strike and dip of the sedimentary schists. It is noticeable that a quartz-pegmatite vein in the gneiss terminates abruptly at the gneiss-schist contact.

The most conspicuous feature in the adit is the large pegmatitic quartz vein striking at an angle across it (*see* Fig. 3). This vein varies between 2 and 7 feet thick and is composed mainly of white vein-quartz, with comparatively rare crystals of pink feldspar. It holds patchy, scarce molybdenite, commonly associated with greenish muscovite. From the northern wall of this large vein, offshoots, up to a foot thick, branch out into the granite and aplite, and these also carry various amounts of coarse molybdenite flakes. On the west wall of the southerly sideswipe (short drive south at the adit's middle point), the quartz vein shows an increased proportion of feldspar, as euhedral crystals up to several inches across. The proportion of molybdenite also seems to increase though it is by no means abundant. The sulphide occurs as isolated flakes up to 1 cm across.

Molybdenite apparently does not occur in the gneiss away from the pegmatitic quartz veins and there is no general dissemination in the gneiss in the adit.

Farther northeastward along the escarpment beyond the adit, outcrops are fairly plentiful and have been extensively trenched and blasted where there were showings of molybdenite in aplite or pegmatite. On the whole, the mineral is less abundant than in the outcrops southwest of the adit.

About 1,000 feet northeast of the adit, a stripped and blasted outcrop shows the grey granitic gneiss striking N40°E and dipping at 50°SE. The gneiss shows the usual thin aplitic bands. It is 'overlain' higher up the escarpment by what appears to be a great thickness of pink aplitic granite cut by wide pegmatitic quartz veins. Molybdenite is irregularly scattered through the aplite in well-formed flakes up to 5 mm across. It is accompanied by pyrite.

There are at least three major quartz-pegmatite veins in this outcrop, varying in thickness between 2 and 5 feet. They can be traced for several tens of feet in a general N35°E direction, but their courses are somewhat sinuous in detail. The pegmatites are zoned, with feldspar occurring predominantly along both walls, whereas the cores of the veins are pure quartz. The feldspars are pink, well-formed crystals, up to an inch or two in length, arranged in irregular groups in the quartz. Mica, where present, occurs along the wall zones with the feldspar. Molybdenite also is concentrated preferentially along the pegmatite walls and for an inch or so into the surrounding aplite. Strings of well-formed flakes of molybdenite are also evident in the aplite along cracks or fractures leading from the walls of the pegmatite. Other molybdenite occurs at random in the aplite without any apparent localizing structures. This last type of occurrence is very characteristic, consisting of euhedral crystals from 3 to 5 mm in diameter set individually or in small groups randomly oriented within the aplite.

The above observations show that the molybdenite in the pegmatitic quartz veins is associated with the feldspar-rich parts along the walls of the veins and hardly at all with the quartz-rich cores. Moreover, molybdenite occurs nearly exclusively in those patches in which muscovite accompanies the feldspar.

The second main area of outcrop shows the same fundamental rock types as the first—a medium- to coarse-grained grey biotite gneiss with bands of a light pink aplitic granite varying between ½ inch and perhaps a foot in thickness. The banding strikes at N45°E and dips at 45°SE. In some parts of the outcrop the strike of the actual foliation in the grey gneiss appears to be a few degrees (5-10) to the west of that of the banding caused by the alteration of the two rock types, but mostly the two strikes seem to coincide.

The pegmatitic quartz veins, which vary in feldspar content, cut this banded rock at all angles; two prominent strike-directions appear to be just north of east and just west of north. Dips are mostly nearly vertical. The dykes vary in width from less than an inch up to a maximum of about 4 feet. All gradations occur—from massive glassy quartz to a dominantly feldspar-rich pegmatite with only 5-10 per cent interstitial quartz. Most of the feldspar-rich types show much yellowish muscovite and generally hold more molybdenite. Commonly the sulphide and the mica occur intimately intergrown. Molybdenite also occurs in the quartz-rich types as large isolated euhedral flakes.

Except for the more regular vein-like forms, the pegmatites occur as irregular stock-works in the gneiss; this is especially true of the feldspar-rich types.

The occurrence of molybdenite in the pegmatitic veins and bodies shows the same features as those already described from the more northerly group of exposures. Coarse flakes occur irregularly scattered throughout the pegmatitic material, in places in aggregates a few inches across. There is a definite tendency for the mineral to be associated with the feldspar-rich parts, and also a definite concentration of medium-grained molybdenite flakes on the pegmatite walls—a thin zone extending an inch or two into the surrounding aplite. Irregular concentrations of molybdenite flakes, roughly 1 to 3 mm across, also occur at places within the aplite itself.

Molybdenite is the chief sulphide present in the showings on the Pidgeon property and the only one of economic importance. The only other sulphide observed by the writer was pyrite, which is mostly irregularly distributed as well-formed cubic crystals with the molybdenite. In a report to Pidgeon Molybdenum Mines Limited, A. C. Thompson supplied some additional information. He stated that the wall-rock adjacent to the veins is normally impregnated with "a variety of amorphous pale sulphides, not yet certainly identified." Magnetite is said to occur as fine granules among which molybdenite is in places finely intermingled. "Antimony sulphides are also present, sometimes in heavy aggregates with the molybdenite." Tin is present, probably as cassiterite, and as much as 0.02-0.03 per cent Sn has been found in samples assayed for the element. Small amounts of chalcopyrite, bismuthinite, fluorite, and possibly barite were also tentatively identified.

A concentrate prepared at the Mines Branch, Ottawa, from a sample of the ore, assayed 82 per cent MoS_2, 0.30 per cent Cu, and 3.11 per cent Bi. The copper content would be acceptable, but the bismuth content is well above the maximum limit of 0.2 per cent. In addition to the copper and bismuth, the final concentrate also contained 2.03 per cent Fe, and 1.4 per cent Pb. The iron is contained mainly in pyrite and would undoubtedly be removed by repeated cleaning of the concentrate in a full-scale milling operation. The lead is probably present in the unidentified sulphides mentioned by Thompson, and perhaps also in the antimony sulphides. The mineralogy and chemistry of this deposit again illustrate that bismuth is a common associate of molybdenum in this type of deposit.

The grade of the ore and the amount available are indicated by the results obtained by Detta Minerals in 1954, tabulated below. The core assays from diamond-drill hole No. 1 are compared with those obtained from the adit that was later driven along the line of the hole.

Section	Width (feet)	Per cent MoS_2			
		Core	Muck	Channel	Average
1	23.4	0.72	0.24	0.37	0.44
2	25.8	0.92	0.57	0.52	0.69

These two sections were separated by 19.0 feet assaying 0.04 per cent MoS_2.

Later, the drilling carried out by Pidgeon Molybdenum Mines Limited indicated four separate zones of sufficient size to be mineable units. One zone lies at the southwest end of the area drilled and the southwest limits were not determined. The other three consist of parallel zones, one of which does not outcrop, lying farther to the northeast and passing through the main showing where the adit was driven. These lenses total 275,000 tons averaging 0.6 per cent MoS_2, including an allowance for 10-per-cent dilution. It is believed that additional ore could be blocked out by drilling the southwest lens, as fairly heavy mineralization occurs in outcrop for about 300 feet beyond the point drilled. However, in order to substantially increase the tonnage, the company geologists consider it necessary to prove the existence of parallel zones extending well underneath the sedimentary cover. In addition, further drilling could be carried out across the nose of the intrusive stock to test for additional ore lenses in that locality.

Since the completion of the drilling program in 1957, no further work has been carried out on the property (up to the time of writing).

Rainy River District

A. L. Parsons (1918, p. 181) reported the presence of molybdenite together with pyrite and sericite in conglomerate at *Bad Vermilion Lake* near Mine Centre, a Canadian National Railways station some 50 miles east of Fort Frances.

In the *Crow Rock—Turtle Lakes* area, northwest of Atikokan, molybdenite occurs at various places in pegmatite dykes (Tanton, 1927, p. 10C).

From *Steep Rock Lake,* A. L. Parsons (1917, p. 312) reports molybdenite in a quartz vein in chlorite schist at or near its contact with granite.

Thunder Bay District

Molybdenite is reported near *Harvey Station* on the Canadian National railway by Eardley-Wilmot (1925, p. 109) and by Gledhill (1924, p. 25). In 1919 about 1,000 pounds of 0.4-per-cent-MoS_2 ore was sent to the Mines Branch, Ottawa, for testing. The ore showed fairly small flakes of molybdenite disseminated through a gangue of quartz and green hornblende, and associated with small amounts of pyrite, mica, and white feldspar.

From a portage between *Seseganaga and Kawaweogama Lakes,* Gledhill (1924, pp. 25, 28) reported molybdenite in hornblende schist bands.

Hopkins (1918, p. 194) reported the presence of molybdenite on the portage at the north end of *Tamarack Lake,* about 7 miles north of Collins on the Canadian National railway. The mineral occurred as flakes up to ¼ inch in diameter in a dyke of pink pegmatitic granite intruding biotite granite-gneiss. Hopkins also reported several deposits between Armstrong and Collins. Two miles south of the railway on an island in Tunnel Lake, 10 miles west of Armstrong, the mineral occurs as patches in granite. Float containing molybdenite was also said to have been found at Trout Lake and at Collins, 8 miles farther west.

Although molybdenite appears to be widespread in this area, nothing of possible commercial interest has so far come to light.

On a peninsula at the east end of *Lac des Mille Lacs,* molybdenite is reported in "quartz veins cutting granite, hornblende gabbro and related rocks" (Walker, T.L., 1911, p. 56; Tanton, 1938b).

On the north and south shores of *Middle Shebandowan Lake,* in Hagey and Haines townships, molybdenite occurs in quartz veins cutting hornblende gabbro. On the north shore of the lake it occurs alone, whereas on the south shore it is accompanied by galena and chalcopyrite, and gold and silver values are present (Tanton, 1938b; also *Geol. Surv., Canada,* Map 338A, marginal notes).

The Conmee deposits (Young-Walsh property) are situated 2 miles north of Kakabeka Falls station on the Canadian National railway, in con. II, lot 3, Conmee township. Molybdenite occurs in a pegmatitic quartz vein within a large dyke of "pyritiferous chlorite syenite" that intrudes the Keewatin schists of the area. The mineral occurs as very fine flakes or in a semi-amorphous form, as a rule evenly disseminated throughout the quartz gangue. In some places it occurs in vertical streaks of larger flakes. Pyrite is fairly common, and lesser amounts of chalcopyrite are present (Eardley-Wilmot 1925, p. 107; Tanton, 1926, pp. 26-27.

In *Jacques township,* lot 10, con. I, about 15 miles north-northwest of Port Arthur, MacDonald (1939, pp. 10,16) reported the presence of an irregular quartz vein carrying molybdenite.

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In *McTavish township,* NE¼ lot 5, con. VII—3 miles northeast of Loon Lake Canadian Pacific station and 30 miles northeast of Port Arthur—an occurrence is described by Eardley-Wilmot (1925, p. 108) who says:

> A series of pegmatite dikes cut alternating belts of granite and greywacke. These dikes are very conspicuous, as the intruded rocks have weathered out, leaving exposed ridges running in a southeast direction. Molybdenite occurs as fracture fillings within the pegmatites and along the contacts. The occurrence is quite free from foreign sulphides, mica, etc. There is considerable yellow molybdic ochre on the weathered surfaces. The gangue is pink orthoclase feldspar and quartz.
>
> Work was done in 1918, on two of these dikes which vary in width from 25 to 50 feet; the more westerly has been stripped for a distance of about 1,000 feet, over which length scattered showings of molybdenite occur. The easterly dike has been opened up by surface workings to a depth of 2 feet over a length of 230 feet; the mineral in it is mostly confined to the westerly contact wall.

(*See also* Hawley, 1929, pp. 82-83; MacDonald, 1939, p. 10).

In 1958 Lindsay Explorations carried out surface exploration on a 10-claim property in this township. The property is probably the same as, or near to the occurrence described by Eardley-Wilmot. Bulldozing uncovered a pegmatite zone 300 feet long and 110 feet wide. "Grab samples were encouraging" (*Northern Miner,* Aug. 7th, 1958).

On *Onaman River* at the eastern boundary of the Nipigon Provincial Forest, flakes of molybdenite have been observed in sheared, highly altered granite (Moorhouse, 1938, p. 18). Near Conglomerate Lake in the same area, Moorhouse reported "heavy molybdenite float". Gledhill (1925, pp. 82-83) described quartz veins carrying gold, pyrite, and molybdenite at the Kenty claim in the same locality.

At the east end of North Wind Lake, also in the Onaman River area, some specimens bearing molybdenite have been found (Gledhill, 1925, p. 67; Moorhouse, 1938, p. 18). More recently, North Wind Explorations are reported to have investigated a molybdenite-gold occurrence in this area. In 1958 the control of this company was taken over by Nortoba Nickel Explorations, who were reported to be planning further investigations (*Northern Miner,* May 29th, 1958, p. 23).

On the Rolandson property, near Crooked Green Lake also in the Onaman River area, Moorhouse (1938, p. 18) reported the presence of a molybdenite-bearing vein.

At the *Amorada Gold Mines, Limited,* Dorothea township, molybdenum occurs as an accessory in a gold-bearing quartz-carbonate vein (Laird, 1936, pp. 88-91).

From the *Sturgeon River occurrence,* also in Dorothea township southwest of the Amorada mines, Laird (1936, p. 79) reported the occurrence of molybdenite with pyrite and chalcopyrite in diorite.

Molybdenite occurs on the west shore of *Burrows Lake,* 15 miles northwest of Longlac. The mineral is disseminated through areas of gneissic granite considered to be remnants of earlier foliated rocks caught up in regional granitization processes. Associated minerals are pyrite and chalcopyrite. Molybdite occurs as a weathering product (MacDonald, 1941, pp. 13-14). Eardley-Wilmot (1925, p. 107) reported that samples from this deposit constituted "a 3 per cent ore".

Near *Longlac Station* on the Canadian National railway, molybdenite has been reported to occur in pink syenite dykelets cutting coarse-grained amphibolite (Fairbairn, 1937, p. 17).

It has been reported from several localities in the neighbourhood of *Schreiber* on the northern shore of Lake Superior. Most of the occurrences are of mineralogical interest only; the molybdenite is as an accessory mineral in copper and other base-metal ores.

At the *Big Duck Lake occurrences,* 14 miles due north of Schreiber, molybdenite is a very minor accessory in quartz veins carrying heavy chalcopyrite and pyrite. Other minerals include pyrrhotite, galena, sphalerite, and magnetite (Hopkins, 1921, p. 22).

Molybdenite is accompanied by chalcopyrite in quartz veins on the *McKenzie and Blanchford claims* southeast of Schreiber (Hopkins, 1921, p. 23).

On the *Jackson claims,* directly north of the Canadian Pacific railway at a point 3 miles east of Schreiber, gold-bearing quartz veins carry pyrite, galena, sphalerite, chalcopyrite, and minor molybdenite (Hopkins, 1921, pp. 14-15).

At the *Jackfish-Pritchard property* on the southwest side of Owl Lake, 11 miles north of Jackfish Bay, pyrite, molybdenite, and molybdite occur in a plug-like body of granite pegmatite intruding syenite gneiss and hornblende schists. Bartley (1938, p. 40) reported an assay result of 1.68 per cent Mo and 0.03 ounce gold per ton from a sample from this deposit.

The Terrace Cove deposit, Homer township, is of historical interest only as it is the first record of the occurrence of molybdenite in Canada (Logan, 1863, p. 705). Molybdenite occurs together with "yellow and vitreous copper ore" (chalcopyrite and chalcocite) in a set of north-south quartz veins in red feldspathic gneiss. The veins are 3 to 4 inches wide and are cut by later trap-dykes.

Algoma District

Michipicoten Area

At *Molybdenite Lake* near Michipicoten Harbour, molybdenite has been reported from a coarse-grained quartz-rich pegmatite (Bell, J.M., 1905, p. 305).

Molybdenite from the *Regnery Metals property* in tp. 28, rge. 24, about 13 miles west of Hawk Junction, was sampled and sent to the Bureau of Mines at Ottawa in 1938 for testing. Results were said to have been poor (Eardley-Wilmot, 1938, p. 17), but subsequent work was reported to have proved a large tonnage of higher-grade, cleaner molybdenite. The property was operated until January 1940; the underground workings then consisted of a 45-degree incline shaft, 243 feet deep, and two levels at incline depths of 92 and 230 feet respectively (Ont. Dept. Mines, Ann. Rept., vol. 49, pt. 1, p. 225). During

1939 about 426 tons of ore was treated; of this, 125 tons was hoisted during that year. A total of 2,250 tons of waste was also hoisted. In March 1940 the mill was moved to the Allen-Goudreau gold claims (Michael-Boyle) in tp. 27, rge. 25.

In 1957 a group of claims covering the Regnery Metals property was optioned by International Ranwick, Limited. The shaft and levels were unwatered and a program of sampling was started. An attractive feature of this property was that beryllium was said to have been noted in assays obtained from car samples during the previous work, but the beryllium-bearing mineral had not been identified. Check samples for beryllium were taken in 1958 and sent for processing. (At the time of writing, the chemical and mineralogical results had not been obtained—*Northern Miner,* July 10th, 1958.)

The molybdenum-beryllium minerals on the Regnery Metals property are disseminated in a shattered-granite contact zone.

Peters-Quilty Group—This property, 3 miles east of Limer on the Algoma Central Railway, was also recently acquired by International Ranwick, Limited, and a program of surface trenching and sampling has been started. Latest reports indicated that a molybdenite-bearing zone, 700 feet wide, had been delineated and its length was being steadily enlarged. Plans were being made for the driving of an adit (*Northern Miner,* July 17th, 1958).

Other Areas

Tanton (1917, p. 182) and Maynard (1930, p. 125) reported occurrences of molybdenite from the *Oba area.* Maynard's account follows:

> A few crystals of molybdenite occur in the schist complex at the edge of a pegmatite dike one mile north of mileage 96½ on the Canadian National Railway, west from Foleyet. A similar deposit occurs 2½ miles south of mileage 102, west from Foleyet.
>
> Molybdenite occurs at two points near Langdon on the Algoma Central Railway: on a hill between the Oba River and mileage 236½, and on the west bank of the Oba River opposite mileage 236.
>
> The only molybdenite seen in the vicinity of Kabinakagami Lake occurs in a 3-inch pegmatite dikelet cutting the schist complex on the southeast point of the main northern peninsula.

From the *Goulais River Iron Range,* Moore and Armstrong (1946a, p. 23) report insignificant amounts of molybdenite in a quartz vein in tp. 27, rge. XII, northwest corner.

In *Gaudette township,* a molybdenite property about 5 miles northeast of Searchmont was operated by D. J. M. Crichton and E. J. Rivers from June to December, 1943. Twelve diamond-drill holes—totalling 2,000 feet—were drilled. About 1,500 feet of open-cut 8 feet deep was excavated. One hundred tons of molybdenite ore was produced and 42 tons was shipped (Ont. Dept. Mines, Ann. Rept., vol. 53, p. 182).

From the *Whiskey Lake occurrence,* Moore and Armstrong (1946b, p. 17) reported the presence of pyrite, chalcopyrite, and molybdenite in a small quartz vein in granite in the southern part of township 130. The locality is given as

6 chains north of the Whiskey Lake road at a point 1½ miles along the road west of the highway. The occurrence is of no economic importance.

Sudbury District

From *Foleyet township* Maynard (1930, p. 125) reported the occurrence of a few crystals of molybdenite in schist at the edge of a pegmatite dyke along the Canadian National railway west of Foleyet.

In *Swayze township* molybdenite occurs as an accessory mineral in quartz veins, carrying pyrite, chalcopyrite, galena, and sphalerite. These veins occupy fractures in greenstone on the Kenty Gold Mines, Limited property.

From *Genoa township* Bannerman (1930, p. 27; 1934, p. 71) mentioned the occurrence of molybdenite, with pyrite, in pegmatite at Alike Lake.

In *DesRosiers township* at Twin Lake, molybdenite occurs in gash veins of quartz and in the quartz-rich core of a pegmatite dyke cutting gneissic granite (Bannerman, 1930, p. 27).

A report in the *Northern Miner* (Jan. 1st, 1959) mentions the discovery of molybdenite on a group of claims in DesRosiers township. The claims are held by Jonsmith Mines. The ore minerals are reported to occur in a granitic dyke in "basic schist", in two separate showings. The first showing is reported to be 5 feet wide and to assay 0.63 per cent molybdenum over 60 feet. The second, which is said to be about 430 feet long and to vary in width from 6 inches to 3 feet, "averages about 2.0 per cent (Mo)."

At the Jerome mine in *Osway township,* on the south shore of Lake Opeepeesway, molybdenite has been recognized together with native gold, pyrite, chalcopyrite, tetrahedrite, galena, and sphalerite. The orebody is a vein in a shear zone along the contact of a lenticular porphyry body. The vein matter is bluish, cherty replacement silica with a later, white carbonate replacement zone along one wall.

From the property of the Three Ducks syndicate on the east shore of Three Ducks Lake in *Chester township,* Laird (1932, pp. 28-30) described a quartz vein carrying gold, tetradymite, and molybdenite, with molybdite as a weathering product.

On the Eccles-Holmes property, a quartz vein in granodiorite carries pyrite, chalcopyrite, molybdenite, and gold (Laird, 1934, pp. 75-76).

At the Saville property, on a peninsula in Claw Lake, *Cabot township,* quartz veins in granite and sheared porphyry show two mineral assemblages: (a) native gold, pyrite, galena, molybdenite, and chalcopyrite; and (b) abundant molybdenite and pyrite, with a trace of gold (Laird, 1934, p. 68). The same molybdenite-bearing quartz veins have also been described by Gledhill (1926, pp. 78, 82) and Kindle (1936, p. 25).

Molybdenite is an accessory mineral in the gold-silver ores of the *West Shiningtree gold area.* Other minerals are chalcopyrite, pyrrhotite, galena, and barite (Kindle, 1936, p. 152; Cooke, 1946, p. 64).

The Matan's prospect lies about ¼ mile west of the Canadian National railway, 2 miles south of Raphoe Station, Roberts township. Three small quartz veins, from an inch to 6 inches wide, cut through granite country rock. The principal vein is 25 feet long and pinches out at both ends as well as in depth. It contains only scattered grains of molybdenite. A number of joints in the granite are also filled with molybdenite but the total quantity is small, and there is little prospect of more being found (Eardley-Wilmot, 1925, p. 106).

From *Hess township* Osborne (1929, p. 67) mentioned the presence of molybdenite in quartz in small granite bodies intruding pre-Huronian rocks.

At the Worthington Mine, *Drury township,* seams of molybdenite here and there cut through pyrrhotite ore or greenstone country rock (Parsons, A. L., 1917, p. 313).

On the Vermilion River occurrence, where the river touches the western boundary of *Denison township,* molybdenite is reported in gold-quartz veins in diorite (Bell, R., 1891, p. 25F).

Barlow (1906, pp. 24-25H) mentions that Selwyn reported flakes of molybdenite in a specimen of pyrrhotite ore from the original outcrop of the Murray mine, *McKim township.*

Cochrane District

From *Chipman township* Hopkins (1918, p. 197) mentioned the occurrence of molybdenite together with pyrite and pyrrhotite at the Pine Lake deposit, 8 miles southeast of Grant station on the Canadian National railway.

On the property of Dukes Molybdenite Mining Syndicate, north of Lake Abitibi, *Steele township,* near Mace on the Canadian National railway, a wide shear zone with quartz veins and pegmatitic bodies occurs in greenstone schists. Molybdenite is present as erratic disseminations bordering the quartz veins. Several pits were sunk on one of the quartz veins in 1934, and more pits and trenches were excavated in 1937. The mineralized zone of quartz and pegmatite exposed by this surface activity was more than 2,000 feet long; assays showed a high molybdenum content with some gold. (The Canadian Mineral Industry in 1937; *Canada Dept. Mines, Resources,* Bur. Mines Rept. 791, p. 19).

On the Raty property, lot 7, con. IV, *Rickard township,* molybdenite is present in gold-silver-quartz veins, together with bismuth and lead tellurides, pyrite, chalcopyrite, and galena. Molybdic ochre and native copper occur in the outcrop (Knight *et al.,* 1919, pp. 61-62; Kindle, 1936, pp. 3-4).

On the Abate claim, lot 4, con. I, *Beatty township,* molybdenite occurs in a gold-quartz vein in greywacke schist (Parsons, A. L., 1917, p. 289; Knight *et al.,* 1919, p. 54).

On the Mobb claim, lot 9, con. IV, *Playfair township,* quartz-calcite veins carry molybdenite, pyrite, and chalcopyrite (Wright, D. G. H., 1922, p. 20).

In *Tisdale township* molybdenite occurs as a delicate coating on much of the ore of the West Dome Lake mine (Burrows, 1924, p. 53).

Timiskaming District

On claim 17010 near the southeast corner of *Timmins township,* "considerable molybdenite" has been reported from the ankeritic foot-wall zone of a quartz vein. Low gold values occur in the molybdenite zone.

On the property of Bourkes Gold Mines, Limited, lot 9, con. II, *Benoit township,* pyrite, chalcopyrite, galena, molybdenite, and gold occur in quartz-calcite veins in a shear zone (Wright, D.G.H., 1921, pp. 53-55).

The Brett-Trethewey copper prospect on the eastern boundary of *Clifford township,* extending into Ben Nevis township, shows minor molybdenite in a chalcopyrite deposit in a brecciated and sheared zone (Gledhill, 1928, pp. 23-24, 34).

On the Biedermann claim on the south boundary of *Terry township,* extending southwards into Dunmore township, is a patchy occurrence of pyrite, chalcopyrite, and molybdenite in a pegmatite vein with a quartz-rich core, cutting pink granite (Wright, D.G.H., 1922, pp. 19, 21; Kindle, 1936, p. 147).

Molybdenite occurs with other sulphides and gold on the Archambault claim near Goodfish Lake, *Morrissette township.* The ore minerals occur in a carbonate zone at the contact between greenstone and quartz porphyry (Burrows and Hopkins, 1916, p. 22; Wright, D.G.H., 1921, p. 62).

In the same locality, Wright reports that the Martin claim shows a quartz vein carrying native gold and molybdenite.

On the property of Greenlee Mines, Limited, in *Bompas township,* pegmatitic quartz veins carry molybdenite and pyrite. Assay values of 0.70 per cent MoS_2 are reported (*Mineral Resources Div., Dept. Mines, Tech. Surv.*).

Molybdenite is widespread as an accessory mineral in gold ores of the Kirkland Lake and Swastika areas, *Teck township.* Accompanying minerals include native gold, gold tellurides, pyrite, chalcopyrite, galena, sphalerite, and graphite. Localities that have been described include: the Swastika occurrences (Burrows and Hopkins, 1923, p. 52), the Tough-Oakes and Teck-Hughes mines (Burrows and Hopkins, 1920, p. 23; Todd, 1928, pp. 68,85), and the Wright-Hargreaves mine (Thompson, 1923, pp. 63-65).

Hopkins (1914, p. 21) writes:

> Molybdenite has been deposited abundantly in fractures, usually as a thin film. Gold-bearing solutions have circulated along these planes and the veins have been enriched by the deposition of gold in these later fractures. Later movements have often slickensided these planes, while the gold, altaite and other minerals may be polished. In some cases the gold must have been deposited after the slickensides were formed since the veinlets of the metal were observed on the 200 foot level of the Tough-Oakes mine cutting across the smooth planes of the molybdenites.

There has, apparently, been no attempt to recover molybdenite as a by-product from any of the mines of the area.

Hopkins (1923, pp. 69, 73-74) mentions the occurrence of minor molybdenite in gold-bearing veins at two properties in *Lebel township*; at the Bidgood

Kirkland Mines 5 miles east of Kirkland Lake, and on the Queen Lebel property on the southeast shore of Gull Lake.

The gold-quartz veins of the Argonaut mine in *Gauthier township* carry minor molybdenite together with tellurides, chalcopyrite, pyrite, and specularite (Gledhill, 1928, pp. 21,34).

On the Thompson claims, on the eastern boundary of *Argyle township,* minor molybdenite occurs in a gold-quartz vein in a sheared zone in granite (Kindle, 1936, p. 74).

Powell Township—(*See also* New Ryan Lake Mine, p. 87). At the Young-Davidson mine near Matachewan, the orebodies consist of mineralized syenite carrying disseminated pyrite and gold. In addition, fine fractures carry gold, chalcopyrite, and galena, with minor molybdenite, scheelite, and specularite (North and Allen, 1948, p. 635).

From *Eby township* Dyer (1935, pp. 52-53) described gold-quartz veins carrying pyrite, chalcopyrite, and molybdenite at the Lucky Kirkland Gold Mines in N½ lot 2, con. VI, 2½ miles west of Swastika.

Several prospects in *Boston township* carry minor molybdenite in gold-bearing quartz veins. Other minerals include pyrite, chalcopyrite, and galena, and in one or two places, specularite, bismuthinite, tetradymite, and magnetite (Burrows and Hopkins, 1921, pp. 11-14; Abraham, 1951, pp. 57, 61-63).

In *McElroy township* the O'Hare group is reported by Abraham (1951, p. 52) to carry molybdenite in an intrusive breccia.

A quartz vein on the Charest group of claims is reported to carry a little molybdenite together with pyrite. The vein is 6 inches wide and occurs in a 4-foot dyke of granite cutting andesite. The mineralization is largely confined to the granite (Abraham, 1951, p. 44).

On the Judge property, on the south boundary of the township, a quartz-calcite vein carries pyrite, chalcopyrite and molybdenite with some gold values (Bell, L.V., 1930, pp. 108-109).

Molybdenite as an accessory mineral has been reported in *Skead township* from gold-bearing quartz veins on the following properties: Crawford-Skead claims, N½ lots 9 and 10, con. V (Burrows and Hopkins, 1921, pp. 24-25); La Fond Gold Mines, Limited (previously Grace Lake property, previously Wisconsin-Skead claims) in lot 10, cons. V and VI (Bell, L.V., 1930, pp. 111-113; Hewitt, 1950, pp. 31-33); Sampson claim, lot 10, con. VI (Burrows and Hopkins, 1921, p. 26); and Skead Gold Mines, west of St. Anthony Lake (Burrows and Hopkins, 1921, pp. 21-22).

J. E. Thomson (1947, p. 29) reported that pyrite, molybdenite, and galena, with low gold values, occur in a quartz stock-work in intrusive porphyry at the Cook claims (Tyon Gold Mines, Ltd.) on the boundary between *Hearst and Skead townships.*

On the Hurst property at Pigeon Lake, *Knight township,* a gold-bearing quartz vein carries pyrite, chalcopyrite, and "considerable molybdenite" (Graham, 1932, pp. 59-60).

New Ryan Lake Mine

The Ryan Lake property of Min-Ore Mines Ltd., at present under lease to International Ranwick Limited, lies in Powell township, 3½ miles due north-west of Matachewan. The property is connected to Matachewan by 2 miles of paved and 2 miles of gravel road. At the time of writing it was the only active mine in the Matachewan area, but a mile or so to the south are the former gold producers of Matachewan Consolidated Mines and Young-Davidson.

The writer visited the property in June 1958 and received courteous assistance from the management and staff of International Ranwick Limited. Special thanks are due to Mr. J. D. Mateer, Manager, and Mr. W. Rainboth, geologist.

The Ryan Lake mine was originally a copper producer. The initial drilling and exploratory work was done on the property by Ryan Lake Mines Ltd. in the spring of 1947. Several X-ray angle-holes drilled along the main shear zone gave an average grade of 2.77 per cent Cu and low values in Ag, Au, and Mo over a true thickness of 7.3 feet. The drilling was done partly on this main zone and partly on two parallel zones about 200 feet to the north. The parallel zones showed widespread low values. The company consultant estimated, as a result of this work, that over an 800-foot length of the main zone, to a depth of 370 feet, there was about 200,000 tons of ore with an average grade of 2.9 per cent Cu. The gold content was about 0.02 ounce a ton.

Teck Exploration Company, Limited took an option on the property in May 1948 and drilled an undisclosed number of holes before dropping the option in October of that year. It is believed that angle holes were drilled to intersect the ore zone at a depth of 600 feet. Teck Exploration also made a composite sample (75 pounds) from the drill-core taken by Ryan Lake Mines Ltd. from the main ore zone. The assay results from this were: 0.03 oz/ton Au, 0.60 oz/ton Ag, 3.59 per cent Cu, and 0.30 per cent MoS_2. In 1950 Ryan Lake Mines made an unsuccessful attempt to obtain mill feed by open-cut methods and then started to sink a shaft in ore on the main shear zone. The first level was established at 90 feet. Drifts were driven east and west of the shaft along the ore zone and stoping was commenced. A stope east of the shaft was reported to have an average grade of 3 per cent Cu over widths up to 15 feet. By May 1951 a mill was in operation, but working below capacity. Concentrate averaged 24.32 per cent Cu, 4.19 oz/ton Ag, 0.135 oz/ton Au, and 2 to 3 per cent MoS_2. In October of that year the company was reorganized as New Ryan Lake Mines Ltd.

A report for June 1952 mentions that the westerly drift on the 90-foot level was then 600 feet from the shaft, at which point a cross-fault, striking N60°E, was encountered. The shaft had been deepened and drifting was in progress east and west of the shaft on the 200-foot level. A parallel ore zone, 140 feet south of the 'main' zone, had been indicated by drilling from the second level. The low-grade north zone had been intersected by horizontal drill-holes from both levels.

Late in 1952 a crosscut was driven from the 200-foot-level drive east to cut the south zone. Some drifting revealed widths of 4 to 6 feet of well-mineralized rock. During 1953 the shaft was deepened to 459 feet and the third and fourth levels were opened up. A crosscut was driven north from the 200-foot main drive west to the low-grade north zone indicated by diamond-drilling the previous year. About 250 feet of drifts were driven to the east and west on this zone, producing 1,700 tons of ore containing 1.1 per cent Cu. The country rocks of the north zone are andesitic and dacitic lavas cut by feldspar-porphyry dykes—fractured and weakly mineralized with chalcopyrite. Work on this zone stopped in March 1953.

On the main zone, stopes on the second and third levels and the drift to the west on the fourth level were supplying the mill feed. An ore shoot on the 'south' zone gave some high-grade ore but lacked continuity.

Two new surface showings were discovered to the north which were called the 'copper showing' and the 'molybdenite showing'; these are described below as the 'intermediate' and 'north' showings respectively.

The operations of New Ryan Lake Mines during 1954 resulted in a loss. In September 1955 the company was reorganized as Min-Ore Mines Ltd., with new directors. But the new company was also unsuccessful; its 1956 operations showed a loss of $157,650.

In early 1957 the mine was closed down and leased to G. S. Welsh of Matachewan who kept the water pumped out and supplied the mill from the clean-up operations. International Ranwick began an exploration program on the property in February 1958 and drilled 65 holes underground from the four levels plus several surface holes. At the time of writing the investigation had moved underground with drifting and stoping to provide feed for the modified mill in order to ascertain the best treatment methods. The reserve of mineable ore at the commencement of underground operations was an estimated 2-year supply for a 125-ton-per-day milling operation. Estimated average grade of this ore was 0.5 per cent Mo, 1.25 per cent Cu, and $1-value gold per ton.

At present, International Ranwick is providing funds to bring the property back into production on a 'money-back-plus-60-per-cent-of-subsequent-profits' arrangement. In August 1958, mining was brought to a halt because of difficulties encountered in concentrating the ores, mainly in producing a molybdenum concentrate sufficiently low in copper from an ore that contains talc.

Mine Workings

The mine was opened up by a vertical shaft, 459 feet deep, of two compartments—one hoisting and one manway, each 4 feet by 4 feet 8 inches inside timbers. Levels were established at 90, 192, 317, and 442 feet, respectively known as Nos. 1, 2, 3, and 4 (*see* Fig. 4). The shaft was sunk in the main ore

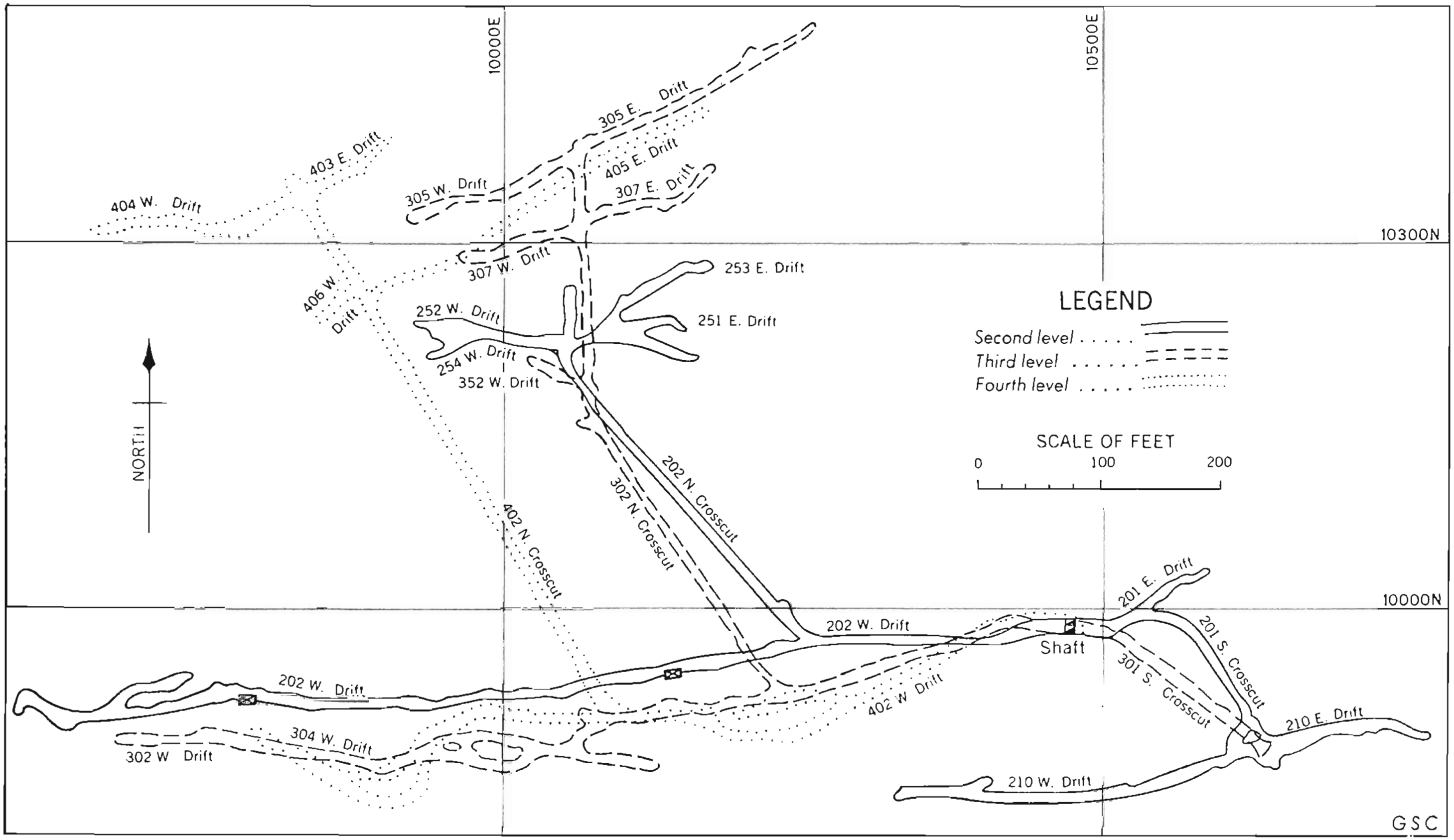

Figure 4. *Composite plan of Nos. 2, 3, and 4 levels, New Ryan Lake mine, Powell township, Ontario.*

zone and most of the previous development work had been done to the west of it, along the main zone and on a parallel one some 200 feet to the north. Most of the copper ore had been stoped from an almost vertically plunging ore shoot west of the shaft. The workings had a maximum strike-length of about 550 feet on the No. 2 level and narrowed down to about 200 feet on the bottom level. Between the shaft and the old worked area a 100-foot diabase dyke cuts through the ore zone and interrupts it. A certain amount of stoping had also been done on the northerly ore zone, from No. 4 level upwards.

Underground work during 1958 was concentrated on development and preparation for stoping on the northerly zone on No. 3 and No. 4 levels, and some development of the main zone east of the shaft pillar.

General Geology

The geology of the Matachewan area has been described by Cooke (1919) and Dyer (1935). The latter gives accounts of the geology and the operation of gold mines of the area, notably the Matachewan Consolidated and the Young-Davidson mines. No reports exist which deal with the Ryan Lake deposit as such.

The group of claims comprising the Min-Ore holdings around the Ryan Lake mine lie mainly within an east-west belt of Keewatin rocks that runs almost across the middle part of Powell township (*see* Fig. 5, in pocket); the belt is bounded on the north and south by areas of Timiskaming sediments. These Keewatin rocks comprise acidic and basic volcanic flows and fragmental volcanic rocks. The belt also includes bodies of pre-Algoman diabase, gabbro, and serpentinite. Numerous intrusions of syenitic feldspar porphyry and porphyritic syenite occur within the belt and play an important role in the ore zones at the Ryan Lake property.

Dyer (1935) discussed the syenites and syenite porphyries of the area, particularly the intrusions on the Young-Davidson and Matachewan Consolidated properties. According to him, intrusion of syenite porphyry into the Keewatin and Timiskaming rocks is very general throughout the Matachewan area. The most common rock type is a hornblende syenite that is commonly porphyritic and varies in colour from red to grey and brown. The feldspar is orthoclase with, in some cases, a little albite; the basicity varies with varying amounts of hornblende or biotite. The percentage of quartz is generally low. Apart from the Young-Davidson porphyry two other bosses were noted by Dyer in Powell township. In both of these the rock is mainly a red hornblende syenite.

A small boss of porphyritic syenite outcrops on the Ryan Lake property some 1,700 feet north of the mine workings. This outcrop is of some economic interest as it contains copper and molybdenum (see below). The rock is a massive and blocky porphyritic syenite with phenocrysts of brick-red to pink feldspar up to ½ inch long, set in a medium-grained, equigranular groundmass of hornblende and/or biotite. The groundmass is apparently free from quartz although considerable amounts have been introduced into the rock in the form of veinlets and stringers, apparently in connection with the copper-molybdenum metallization.

The form of this body is not clear due to lack of outcrops, but it is probably a round or oval-shaped boss several hundred feet in dimensions. As well as these boss-like intrusions, dykes of porphyry of various types are numerous throughout the Matachewan area. In Powell township many of them are red hornblende syenite porphyry. Syenites of basic composition are also numerous, differing very little mineralogically from the syenite porphyries. The feldspars are mostly orthoclase and there is a greater proportion of basic minerals in them, although these minerals are the same as those in the syenite porphyry, i.e. biotite, hornblende, and magnetite. "In most cases the rock was proved to be merely a basic marginal phase of the ordinary red syenite porphyry owing to the latter having assimilated a greater proportion of the greenstone" (Dyer, 1935, p. 23).

Two main types of dyke porphyry are recognizable on the New Ryan Lake property (based on field observations). The first is a red porphyry with a reddish brown groundmass and abundant, commonly crowded, red to pink feldspar phenocrysts only a few millimetres in dimensions. The phenocrysts commonly crowd out the groundmass in this type. The second type is a grey or brownish porphyry with a fine-grained, microcrystalline groundmass in which are set fairly rare feldspar phenocrysts—pink or white, and of varying dimensions between 1 and 10 mm. Both types appear to be petrologically similar and are probably of the same origin. Observations during the present investigation were not sufficient to determine any difference in the two types—in mode of emplacement for instance—but Dyer's observations regarding porphyries in the area just south of the Ryan Lake property are of interest in this respect. At the Young-Davidson property, Dyer recognized three main types of porphyry: a cherry-red, coarsely crystalline type, in which the porphyritic texture is not generally seen; a grey, more compact type, with more distinct phenocrysts; and a fine-grained, dense, dark brown type with a tendency towards smaller phenocrysts. Under the microscope all these types look much alike. The main constituent is orthoclase; a minor amount of albite may be present; and hornblende is relatively small in amount, being somewhat more plentiful in the darker phases. A little quartz may be present, but it is thought to be secondary. Calcite, however, is present in large amounts. Accessory minerals are magnetite, pyrite, apatite, titanite, and zircon. As no sharp boundaries were seen between the various types, they are considered to be differrentiates of the same magma. The dark brown type is probably a marginal phase, such as that found at the boundaries of the boss; it grades into the grey porphyry. The cherry-red type is probably a slightly later differentiate, as it is found in the central part of the stock and in a few places it appears to make a rather abrupt contact against the grey. It was noted that the grey porphyry shows alteration to red along quartz veins and there is, therefore, some possibility that the cherry-red rock has formed by alteration from the grey porphyry by the action of ore-bearing solutions.

Ore at the Young-Davidson property is present only in the cherry-red porphyry, probably because that porphyry is more brittle and has fractured more readily, allowing freer access to the gold-bearing solutions. The coarse, cherry-red type described by Dyer does not seem to be present on the Ryan Lake property, but the red-porphyry type with the crowded phenocrysts may be an approximate equivalent. This type was observed, for example, along the main ore zone at the surface in the wall of the west trench (see below), and it is possible that Dyer's suggestion—re the relation between the reddening and ore deposition—applies there also. In the mine, veinlets and irregular patches of red feldspar could commonly be observed in the grey or brown porphyry near the ore-bearing zones, and most of the highly mineralized porphyry was the red type. The syenite-porphyry dykes vary greatly in size; the biggest cited by Dyer—estimated at 6,000 feet long and 100-150 feet wide—occurs in the northern part of the township. "The dykes strike in various directions, but there is a tendency toward parallelism with the strike of the intruded rocks." This relationship is certainly true for the porphyries observed on the Ryan Lake property. Although exposures were by no means adequate for the purpose, it could be seen that the porphyry dykes had a general easterly strike parallel with that of the volcanic and other layered rocks on the property; the dips of both were vertical or very steep. The thickness of the dykes appeared to range between 10-20 and 200 feet. Several north-striking dykes of Matachewan diabase cut the easterly trending formations; indeed this is the type area for their development (*see* Fig. 5). At least six of these dykes have been mapped on the property, the largest being several hundred feet wide. The only dyke within the area of the present workings cuts the main ore zone about 150 feet west of the shaft. The dyke is 100 to 150 feet wide; it strikes almost due north and has a vertical dip. It is present on all levels of the mine with approximately unaltered width. The rock is moderately fine grained and even textured, with a well-developed diabasic texture. In outcrop it is solid and fresh looking, and well but tightly jointed.

The Keewatin rocks on the property have a general easterly strike and they dip steeply south. They may be differentiated into two easterly trending belts, but exact description is limited by sparsity of outcrop and lack of exact petrographic determination of the rock types.

In the south, there is an easterly trending belt, at least 400 feet wide, of what has been termed 'peridotite'. This 'peridotite' is a black to dark green, fine-grained, soft rock that appears to be highly serpentinized; it may originally have been an ultrabasic rock or a basic lava flow. This belt of serpentinized rock is succeeded, about 200 feet north of the shaft, by an easterly trending belt of andesitic to basaltic volcanic rocks with intrusions of diorite in places. The junction between the 'peridotite' and the volcanic rocks is not visible as the contact is occupied by a porphyry intrusion. The east-west belt of Keewatin rocks appears to have an anticlinal structure, whereas the belts of Timiskaming rocks to the north and south are in the form of synclines down-folded into the older rocks. The synclinally disposed belts of Timiskaming rocks appear to be further folded into a large eastward-plunging anticline, the nose of which is intersected by the north-trending fault along the Montreal River. Keewatin rocks appear from under the Timiskaming synclines both on the south and north, but on the south they are blanketed by the overlying Cobalt (Animikie) sediments. To the west, the main anticline is again cut off by a major north-trending fault, along Lake Mistinikon. Timiskaming rocks again appear west of this fault, suggesting perhaps that the major anticline is closing on this end too—that is, plunging to the west. Thus the belt of Keewatin rocks in which the Ryan Lake deposits lie may be in the form of an elongated dome, whose culmination occurs somewhere about midway between Lake Mistinikon and Montreal River.

The folding in the anticline is very tight so that all dips are nearly vertical. Strikes are practically due east, indicating strong compression in a north-south direction. The shearing in the rocks generally follows along the regional schistosity or layering and commonly favours the contacts between the formations. For instance both the Young-Davidson mine and Matachewan Consolidated deposits lie along the southern contact of the southernmost of the Timiskaming synclinal belts. There, porphyry intruded along the contact with the Keewatin rocks appears to have been fractured by the shearing and to have provided a suitable host for the gold-bearing solutions. The two major northerly trending faults of the area, along the Montreal River and Lake Mistinikon are later than the folding and the syenite intrusions, but earlier than the intrusion of the numerous Matachewan diabase dykes.

The easterly shearing within the block of ground between these two major faults was probably the result of the same forces that caused the faults themselves. The Montreal River fault appears to be overthrust to a certain extent and may be due to east-west compression subsequent to the north-south compression that caused the folding. The parallelism of the Matachewan diabase dykes with the two major faults and the great number of dykes occurring between them, seems to indicate that they filled tension fractures that open as a relief to the east-west compression that probably caused the major faulting. The cooling of the area after the Algoman orogeny would also add to the tensional stress in the rocks, and the resulting fissures may have extended deep enough to tap the source of the diabase (basaltic) magma.

Ore Deposits

The ore-bearing zones on the New Ryan Lake property are related to easterly trending, steeply dipping shear zones in the belt of Keewatin rocks that occupies most of the claim group. The original discovery and development took place on such a shear some 800 feet north of Ryan Lake. This is some distance from the Keewatin-Timiskaming contact, but evidence seems to show that to the west the shear does run along the contact (*see* Fig. 5). This shear zone occurs in a belt of what is probably serpentinized peridotite and will be referred to as such in the following account. In many places it appears to be running along the contact between the peridotite and a porphyry dyke to the south. A subsidiary mineralized shear zone lies some 150 feet to the south of, and parallel with, the main zone. This is also in peridotite. The 'north mineral zone', which has been opened up by crosscuts from the drifts on the main zone, lies in andesitic volcanic rocks some 200 feet north of the main zone. In reality there are several such mineralized shears in this position lying parallel with each other; some of them may be due to splitting or branching along the dip of the zone.

The Main Ore Zone

The 'main ore zone' was examined on the surface and at various places underground. Along the surface are two trenches; the westerly one was by far the larger, but it is now partly filled with water. The surface workings begin at the western side of a large diabase dyke about 150 feet east of the shaft and extend for about 600 feet to the west. Outcrops around the old surface workings are scarce, except for the walls of the trenches themselves. In the more westerly of the two trenches the shear zone can be seen to occur along the contact between the serpentinized peridotite and a porphyry to the south. The sheared zone is about 4 to 5 feet wide, with an almost vertical dip. The shear mostly occurs in the peridotite, which shows a multitude of parallel, commonly curving, polished slip-planes, all striking mainly parallel with the strike of the zone as a whole. The serpentinite in the zone is crushed and soft, with probably a considerable amount of talc. The shearing has also affected the porphyry body, which in places is crushed and sheared for as much as a foot from the contact. The latter, though sharp, is very irregular; the softer peridotite has been squeezed into the porphyry in irregular bulges. A good deal of fibrous asbestiform material has been developed in the shear zone, probably by hydrothermal solutions circulating along it. This fibrous mineral has also developed in joints and slip-planes in the porphyry for some distance from the shear zone. In some places it may have been mechanically squeezed into irregular cracks, but in others it appears to have developed as crossfibre, deposited from solution in joints in the porphyry.

The porphyry in the westerly trench is to some extent mineralized with chalcopyrite and a little pyrrhotite in the form of small veinlets and fracture coatings. Calcite is present in a few places. There is little or no introduced quartz and very little visible molybdenite. To the east, the porphyry contact swings southward away from the shear zone, but the bedrock cannot be studied because of heavy overburden. In the eastern part of the surface workings the shear zone lies wholly between walls of peridotite. One or two outcrops of porphyry occur north of the eastern part of the open-cut, but these are not extensive enough to determine the shape and size of the body there.

Very little molybdenite is to be seen in the main zone at the surface, but the underground exposures, especially those on No. 2 level, revealed more of the mineral. On No. 2 level just east of the shaft (201-east vein) the main zone consists of a 10- to 15-foot band of highly sheared peridotite and porphyry. This carries parallel or subparallel quartz veins and lenses which vary in width between an inch and a foot. The dip of these quartz veins, like that of the shearing in the zone, is vertical. The porphyry-peridotite contact could be seen in the middle of the back of the drive. Both rock types are involved in the shearing and both carry the quartz veins, although the effects are much more pronounced in the peridotite than in the porphyry. The quartz veins and lenses carry high concentrations of molybdenite and chalcopyrite, but these minerals are also disseminated in the sheared rocks on either side. The vein quartz is a greyish, greasy-looking, opaque type. Molybdenite and chalcopyrite, with very minor amounts of pyrite, are scattered through the quartz, heavily in places, as fine-grained patches, strings of grains, and as individual flakes. The ore minerals are much finer grained than, say, the molybdenite in the quartz veins of the Lacorne-Preissac area of Quebec. The vein quartz exhibits many small vugs or geodes of the order of a few millimetres across. The walls of these show perfect, crystal-clear prisms of quartz, perfect, minute tetrahedra of chalcopyrite, and flattened, tabular crystals of pink feldspar. The latter mineral also occurs as small indefinite patches in the vein quartz outside the geodes. Other minerals observed in the geodes include a white fibrous or hair-like zeolite and clear rhombohedra of calcite.

Another notable constituent of the quartz veins is light to medium green, fine-grained, prismatic to fibrous talc(?). This mineral occurs in patches in the vein quartz near its walls and in the sheared country rock. Chalcopyrite and molybdenite are also present, commonly in abundance, in the sheared country rocks on the vein walls. Typically the molybdenite occurs in these as fibrous or very thin layers showing slickensiding and polishing. It has obviously been 'smeared-out' by post-depositional movements along the shear zone. These layers or films look very spectacular but they are extremely thin and actually make up little of the vein matter. Molybdenite is also present in the sheared wall-rocks, especially the peridotite, as a series of clusters of flakes about $\frac{1}{2}$ mm across and in places as almost solid patches. These must represent the pre-shearing form of the mineralization in the vein walls, which has in parts been later smeared-out to form the spectacular films.

The porphyry ore in this main zone is a tough, pink to red, jasper-like material. The original porphyritic texture has been broken down and streaked-out, due to the crushing and shearing. Chalcopyrite is more abundant than molybdenite.

The main shear zone on No. 2 level, as at the surface, runs along the porphyry-peridotite junction. The porphyry, to the south of the shear, is not very wide, perhaps 10 to 20 feet. The 201-south crosscut is, in a short distance, once more in peridotite.

According to information received from the mine manager, drift 201 averaged 0.85 per cent Mo and 0.85 per cent Cu over a distance of 55 feet and an average width of 9.8 feet, tapering off to the east. Much of the main zone west of the large diabase dyke was stoped out in the previous operations and few exposures were available for study. In the old stopes below 202-west drift, the payable widths were said to average between 4 and 7 feet. The back is available for inspection from planking over the old stopes. It showed a quartz vein averaging about 2 feet wide carrying plentiful molybdenite. The vein walls were loci for shear planes showing horizontal slickensiding on No. 3 level. From the main zone east of the shaft, 301-south crosscut was driven at an angle of about 30 degrees with the main shear zone. At a distance of about 100 feet from the shaft it ran into a highly sheared and altered area in the peridotite. This area has given some spectacular values in both molybdenum and copper. A series of shears, faults, and slips cut the peridotite at all angles, but they mainly strike about north and dip between 50 and 70°W. These are filled with gouge of clay-like material and 'pseudo-asbestos' carrying large amounts of fine-grained molybdenite and some solid chalcopyrite. The zone as a whole seems to strike about N40-50°E, and is therefore at an angle to the main shear. A crosscut 60 feet long gave an average, for both walls, of 1.77 per cent Cu and 0.27 per cent Mo. At the time of the writer's visit the face was still in this zone. The extension of this zone is somewhat problematical. The shears have been picked up on No. 2 level in 201-south crosscut where four separate shears were mapped. These carry abundant chalcopyrite (partly oxidized to covellite), but no molybdenite. There had been no development in this area on No. 4 level.

North Mineral Zone

The mineralized zone to the north of the main one (mentioned above) was being tested and developed along several parallel drifts, mainly on No. 3 and No. 4 levels. The face of drift 307-west, in June 1958, showed a silicified zone with thin, irregular quartz veins. Here and there occurred indefinite streaks and patches of silicified rock containing extremely finely divided molybdenite 'dust' which gave a bluish black appearance to the quartz. On the north wall of the drift was a patch of breccia consisting of wall-rock and this bluish quartz cemented by a later generation of vuggy quartz. The wall-rock was a green andesitic type.

Drift 307-east was being prepared for stoping at the time of the writer's visit. At the face was a 10-inch vein of quartz with silicified walls carrying abundant chalcopyrite and molybdenite. The foot-wall to the north was a feldspar porphyry—a type with a grey-brown, fine-grained groundmass in which white to pink phenocrysts were scattered. On the hanging-wall was a green andesitic volcanic rock. The vein dipped 70°S. The vein developed by 305 drifts was stated to be the main, immediate source of ore in the mine, and it was being prepared for stoping at the time of the writer's visit. The workable part has a strike length of about 340 feet and has been followed down to No. 4 level (where it had previously been partly stoped) and up to No. 2 level. At the 302-north crosscut it is a quartz vein about 3 feet wide carrying sulphides; but it widens out considerably to the west where it was said to reach a maximum width of 23 feet. However at the west face in June 1958, the vein had dwindled to an insignificant width. There is a certain amount of silicification in the volcanic rocks on either side of the quartz vein.

Samples from this vein, taken previously, gave 2.63 per cent Cu and 0.81 per cent Mo, over a width of 3.2 feet for a strike length of 348 feet. In the old stopes below 305-west drift, the westernmost face shows a pronounced shear on the hanging-wall and another, parallel one in the centre of the face. These shears are occupied by a thin, greenish gouge clay. The vein matter in the face is highly silicified rock, shot through with numerous irregular quartz lenses and veinlets. Patches and vein-like forms of heavy chalcopyrite occur near the hanging-wall side, but on the whole, sulphides are not abundant. Molybdenite was not observed, except for some patches where it was present in a dust-like form in quartz. Late calcite veins and patches intersect the ore.

The 403 vein on No. 4 level is the most northerly vein yet developed on the New Ryan Lake property. It has been stoped for about 70 feet above the level by the previous workers. At the face of the east drift there is a 9-inch vein on the north, or foot-wall side, heavily mineralized with chalcopyrite. About 2 feet from this, towards the hanging-wall side, is a parallel vein 1 inch to 2 inches wide also carrying chalcopyrite. Between these veins are short gash veins of quartz in the diorite country rock carrying the copper mineral which is also plentifully disseminated through the rock. Molybdenite is not at all obvious, except as a polished film on the foot-wall slip-planes of the wider quartz vein. Veins of late white calcite strike across the drift.

Parallel with, and about 120 feet south of the main vein, another mineralized zone has been explored on both the No. 1 and No. 2 levels. In the 201-east drift, samples from this zone assayed between 1 and 7 per cent Cu, and 0.06 and 0.60 per cent Mo.

On the surface to the north of the present mine workings two mineralized zones have been discovered and superficially investigated by shallow surface trenches.

In the north showing a trench and a shallow face have been excavated along the lower edge of prominent outcrops of massive, blocky porphyritic syenite, about 1,700 feet north-northwest of the mine shaft (*see* Fig. 5). The rock shows phenocrysts of brick-red feldspar up to ½ inch long set in a medium-grained groundmass of feldspar and biotite or hornblende. No free quartz was visible in the groundmass.

The exposures are cut at intervals by irregular, thin stringers and veins of white quartz, averaging about ½ inch wide. They strike at about N20°W and their dips are generally vertical, but many branch and split. Associated with these veins in places are 'spots', patches, and individual grains of chalcopyrite and molybdenite. These minerals also occur disseminated irregularly in the groundmass of the rock. Quartz is also present as irregular replacement patches in the syenite. Calcite is present sparingly as late, very thin veinlets.

The most obvious occurrence of molybdenite is in a thin film or coating on the surfaces of the many late slip- and joint-planes in the syenite. These films are due to the crushing and smearing-out of molybdenite already present in the rock, to produce a very thin, mirror-like film of amorphous mineral. They give evidence of late, post-mineralization movements. The introduction of the chalcopyrite and molybdenite seems to be definitely connected with that of the quartz veins and stringers. In the southwestern corner of the trench or pit, there is a definite concentration of quartz veins and ore minerals. This is intersected by a marked slip-plane striking N70°E and dipping at 85°S. Its walls have a thin, slickensided mirror of molybdenite. The slickensides plunge eastward along the plane at 18 degrees. A 12-foot sample across this concentration assayed 0.40 per cent Cu and 0.42 per cent Mo. The contact between the greenstones and the syenite was said to lie 200 yards west of the trenches, but had not been picked up to the east, so that the form of the syenite body was somewhat uncertain.

The intermediate showing lies some 600 feet southward from the north showing. It consists of a patch of outcrop, about 50 feet square, on the south-facing slope of a small hill. Shallow trenches and pits have been blasted in the rocks. The rocks outcropping at this showing are nearly all of a very dense, fine-grained, dark green to black basaltic type, very blocky and close jointed. The attitude of the rock is difficult to determine because of the absence of any distinctive banding or bedding. Parts of the outcrop are medium grained, resembling mica lamprophyre and hornblende lamprophyre. Towards the west side of the outcrop are two, parallel, rusty slip-planes, about 4 feet apart, striking generally N20°W and dipping about 30 to 40°E. The more easterly of the two is the more pronounced; on its hanging-wall at the south end is a 2- to 3-inch zone of vein quartz and, in parts, almost solid, fine-grained molybdenite with a little chalcopyrite. Yellow molybdic ochre occurs as a weathering product. The length of the slip-plane thus mineralized is very short, and for most of its length the slip-plane is entirely unmineralized. Chalcopyrite occurs sparingly along fractures on either side of the slip, in association with stringers and irregular patches of quartz. Fair amounts of pyrite also occur toward the north end of the outcrop.

About 30 feet to the east are two other parallel slip-planes or faults, about 3 feet apart, striking north and dipping almost vertically. Chalcopyrite and molybdenite occur sporadically along these slips. The easterly slip has a 1-inch band of sheared material with fine amorphous molybdenite. The westerly slip shows a lenticular vein of quartz up to 3 or 4 inches wide, well mineralized with fine-grained molybdenite and chalcopyrite. The quartz is crushed in places, and the movement may have accounted in part for the finely divided nature of the molybdenite. Thus the chalcopyrite, molybdenite, and quartz at the intermediate showing seem to be localized along generally north-striking faults or slip-planes in basaltic rocks.

Nipissing District

A. L. Parsons (1917, p. 295) reported that H. Shephard had staked claims for molybdenite in lot 10, con. III, *Garrow township*. These were not seen by Parsons.

On the A. Lavallee property in lots 1 and 2, con. III, *Kirkpatrick township,* 36 miles west of North Bay, quartz veins are reported carrying molybdenite (*Mineral Resources Div., Dept. Mines, Tech. Surv.*).

Specimens from *Great Manitou Island* in Lake Nipissing were examined by Hoffman (1890, p. 44R). They carried molybdenite and pyrite in a quartz-feldspar gangue.

Molybdenite was reported by Barlow in 1897 in Olrig township near Talon Chute, but T. L. Walker (1911, p. 48) who later examined the occurrence, found only graphite, in small scales in crystalline limestone.

Eardley-Wilmot (1925, p. 87) reported a little molybdenite in a quartz-pyroxene zone mineralized with pyrrhotite, and pyrite, on the Gauthier claim, lot 27, con. IX, *Calvin township.*

Net Lake (Barton) Property

The old Barton or Net Lake property lies in *Strathy township,* about 4 miles north of the town of Temagami. It is approached by a rough bush trail leading east from highway 11 at a point about ½ mile north of the road bridge over Net Lake narrows at Goward. A short distance along this trail is the old headframe and dump at the main prospect shaft. The property lies about halfway between the Ontario Northland railway track and the west shore of Net Lake, on a north-trending ridge of high ground. The area is well wooded with a secondary growth of white birch, poplar and alder.

The Barton property was first worked many years ago. The early operations are described by T. L. Walker (1911), A. L. Parsons (1917) and Eardley-Wilmot (1925). According to Eardley-Wilmot, the prospect was first opened up about 1909. A 50-foot shaft was sunk on the main mineralized outcrop and about 200 tons of rock and ore were removed, but none was shipped and this material remained on the dump around the shaft.

During World War I, the property was leased to J. W. Barton of Toronto, who erected a good camp, hoist, headframe, boiler house, and pump. Subsequent forest fires have destroyed the camp and boiler house, but the headframe and shaft timbering still remain at the main shaft. At the time of the writer's visit the area was being investigated by a private consultant to assess its economic potentiality.

An assay by the Mines Branch, Ottawa, of a sample from an unspecified locality, is reported by Walker as follows:

Mo	4.67 per cent
Cu	0.10 per cent
Au	0.002 oz/ton

Eardley-Wilmot mentions that in 1918 Mr. Barton shipped 1,216 pounds of hand-cobbed ore to the Mines Branch, Ottawa. This assayed 8.42 per cent MoS_2, and from it, 94 pounds of pure molybdenite was recovered. A. L. Parsons, who visited the property during the first war, estimated that about one fifth of the material on the dump consisted of quartz that would run 1 per cent MoS_2.

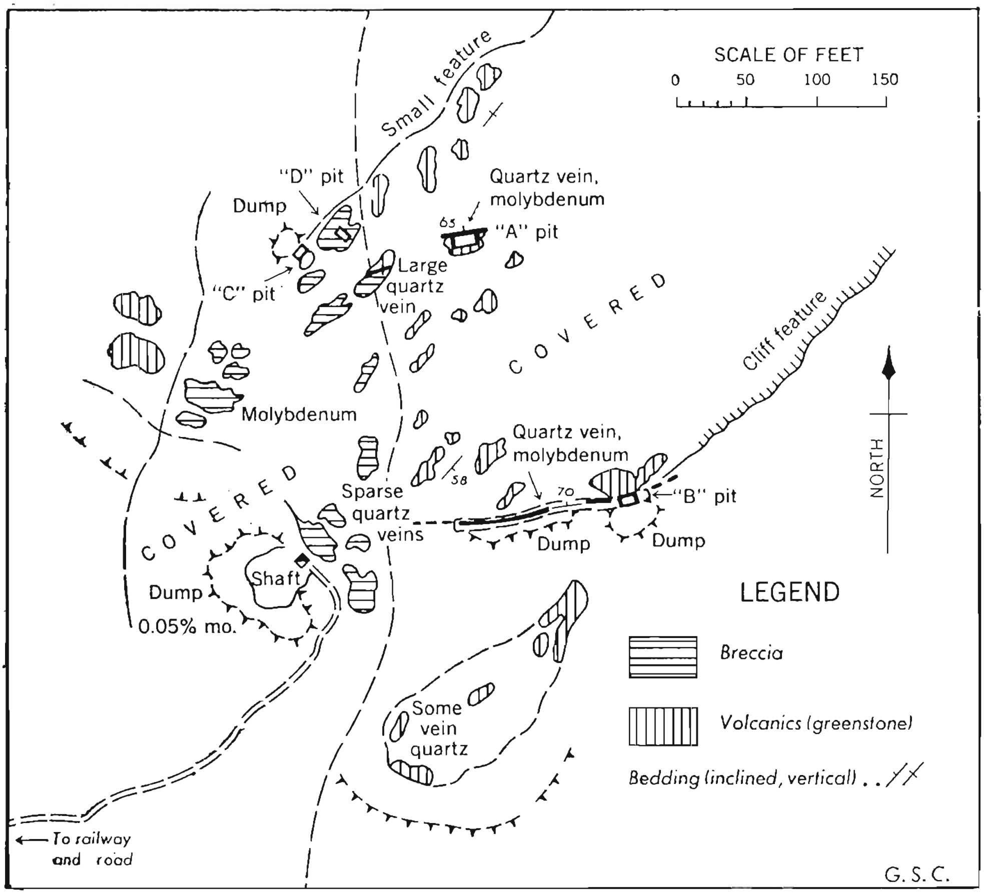

Figure 6. *Sketch map of main breccia area, Barton property, Ontario.*

The composite of grab samples of the dump material taken by the writer at regular intervals assayed 0.05 per cent Mo. Individual quartz veins away from the main breccia bodies showed the richest molybdenite, but these were nowhere more than a foot wide and if mined over a stoping width they would not be economical.

The deposits lie in an area of Keewatin greenstone that is bounded to the west by granites. The property is underlain principally by fine- to medium-grained dark green igneous rocks of basaltic or perhaps dioritic composition. These may be parts of a sill or dyke, or perhaps a thick lava flow. Intercalated in places are minor bands of fine-grained, lighter green andesitic flow-rocks. The relation between the two types is not easy to define due to lack of outcrops. The molybdenite-bearing deposits consist of rather irregular areas of angular breccia cemented by white vein quartz, and of quartz veins (*see* Fig. 6). Most of this quartz is barren, but in places it carries notable molybdenite.

The breccia seems to consist mainly of the darker green, medium-grained rock, typically in very angular, rectangular, or wedge-shaped fragments distributed in irregular areas or in breccia veins. Matching walls are common in the veins and the displacement of the breccia fragments has been very small. On the whole, little or no replacement of the country rock by quartz has taken place. The cementing medium is almost exclusively white vein quartz but some carbonate was observed in places. The ratio of country rock to vein quartz probably averages something like 5 or 10 to 1. At the edges of the breccia areas the quartz appears in veins of diminishing size until the country rock is free from quartz.

In the country rock, some distance from the main breccia area, rather narrow veins of quartz can be seen; many of these carry conspicuous amounts of molybdenite. The strike of all the veins observed by the writer is within 5 degrees of due east and the dip is 60 to 70°N. The veins are only 3 to 9 inches wide.

A good exposure of one of the veins could be seen in the long, narrow trench west of the old shaft. The vein there, which had been followed for some 100 feet by the trench, was between sharp walls of medium-grained greenstone and was nowhere more than 6 inches wide. The molybdenite occurred along each wall in thin zones, $\frac{1}{8}$ to $\frac{1}{4}$ inch wide, in rosette-like flakes up to $\frac{1}{2}$ inch in diameter, lying with the longer dimension parallel with the vein walls. In some places a small inclusion of country rock was visible in the vein, and these inclusions had a thin border-zone rich in molybdenite. Small amounts of pyrite and chalcopyrite accompanied the molybdenite.

Similar small veins cutting greenstone could be seen at a point about halfway along the trail from the railway to the old shaft. The attitude of these was identical to the attitudes of the veins mentioned above, as was the wall zone of molybdenite rosettes.

At a shallow pit some 200 feet northwest of the old shaft, was a quartz vein 6 inches to a foot thick, striking east and dipping 65°N. This was almost free of sulphides; only an odd flake of molybdenite and a few grains of chalcopyrite could be seen and there was no concentration on the walls as in the other veins.

The rosette-like form of the individual molybdenite flakes is reminiscent of the Lacorne ore rather than, say, the New Ryan Lake ore. Apart from a little fine-grained chalcopyrite, molybdenite seems to be the only metallic mineral in the quartz veins. The distribution of the sulphides in the veins, and especially in the breccia, is extremely erratic and the deposit, though geologically interesting, seems to be too low in grade to be of economic interest.

Other exposures of quartz breccia occur outside the area shown in Figure 6. According to Mr. A. Briden (personal communication), these show characteristics similar to those described above.

Northern Quebec

Abitibi County

At the Barry occurrence, on the east shore of Lac aux Loutres, *Barry township,* molybdenite occurs in narrow quartz veinlets cutting porphyritic rock (Faessler, 1935, p. 38; Dresser and Denis, 1949, p. 45).

Bourlamaque township—(*See* Savard-Poulin claims p. 104).

The gold-bearing zones at the West Malartic mine (Pan Canadian Gold Mines, Limited) *Cadillac township,* carry accessory molybdenite with pyrite, pyrrhotite, chalcopyrite, and arsenopyrite (Gunning and Ambrose, 1940, pp. 103-7).

At the McDiarmid showing, rge. VII, lot 44, *Cléricy township,* Ambrose (1941, pp. 51-52) reported molybdenite on slips in carbonate lenses in a zone of soft chlorite schist. Other minerals are pyrite and fuchsite. The ore carries gold.

In rge. III, lot 37, *Dufresnoy township,* at the Newbeck property (Norbec, Lake Dufault Mines, Limited), molybdenite occurs along the margins of diorite inclusions in the Newbec breccia. Other minerals in the ore are chalcopyrite, pyrrhotite, and pyrite (Wilson, 1941, p. 124; Ambrose, 1941, p. 41).

At the Beattie mine on the northeast shore of Duparquet Lake, *Duparquet township,* about 20 miles north-northwest of Noranda, minor molybdenite occurs as films on small faults in the ore (Dresser and Denis, 1949, p. 96).

The Rainville property of Nordis Gold Mines Limited, rge. I, S½ lots 13-15, 17, 18, and lot 16, *Duprat township,* extends into Beauchastel township, but molybdenite is found only in Duprat township (*see* Ingham, Robinson, and Ross, 1949; Robinson, 1943, p. 17). The claims are mainly underlain by rhyolites, with minor amounts of basic volcanic rocks and diorites. A westerly extension of the Quesabe fault trends south of west across the northern part of the property and appears to join a large, southwest-trending quartz vein in the southern part of lot 16, rge. I. The quartz vein contains many brecciated fragments of wall-rock and is quite different from the mud seam and narrow shear zone characterizing the Quesabe fault. It is not known whether the quartz vein represents the continuation of the Quesabe fault or whether it occupies a subsidiary fracture that branches off the fault to the southeast.

During 1950, six diamond-drill holes were directed to explore the Quesabe fault on the property. All the holes intersected fault material and some quartz, but assays from most of the core were low in gold. The most westerly hole was drilled southwards towards the surface exposure of the main quartz vein. The lower part of the hole passed through large quartz veins and bottomed in granite. The quartz veins contained pyrite and molybdenite and a section of core 67 feet long assayed, on the average, slightly more than 0.2 per cent MoS_2.

At the Canadian Malartic mine, *Fournière township,* molybdenite occurs sparingly in the gold ore. Associated minerals are pyrite, chalcopyrite, fluorite, scheelite, and specularite (Gunning and Ambrose, 1940, pp. 69-71; Cooke, 1946, p. 73).

From the Baptiste River claims, *Landry township,* Faessler (1936, pp. 32-33) reported molybdenite flakes in quartzite near pegmatite dykes.

In 1937, La Reine Gold Mines, Limited, under a prospecting campaign on its gold property, discovered showings of molybdenite; these were said to be plentiful in quartz veins 3 miles south of Dupuy station, *La Reine township* (La Reine Molybdenum Corporation, Ltd.). After several thousand feet of diamond-drilling, a 3-compartment shaft was sunk to 120 feet, and some drifting was carried out at the 100-foot level. Apparently no ore was mined (Bur. Mines, Canada, Rept. 791, pp. 19-21). *See also* L. V. Bell (1937, p. 4); Ross *et al.* (1938, pp. 3-4).

On the Bergeron claims, *Launay township,* molybdenite, pyrite, and gold occur in a quartz vein cutting granite (Lang, 1933, pp. 34-35; Dresser and Denis, 1949, pp. 419-420).

At the Dome mine (Jowsey) claims, *Louvicourt township,* pyrite, molybdenite, gold, and tourmaline occur in quartz lenses in outcrops of granodiorite 4½ miles west of the main mass of the Bourlamaque batholith (Bell and Bell, 1932, p. 97).

On the Ron and Chalifour molybdenite prospect, 2½ miles north of Taschereau, *Privat township,* pink granite is cut by quartz veins carrying molybdenite, pyrite, chalcopyrite, and tourmaline (Ross *et al.*, 1938, p. 6).

The Gilligan molybdenite prospect, rge. IV, lot 61, *Senneterre township,* is accessible by a trail 0.4 mile long from a point on the Canadian National railway 1.1 miles east of Lapage River (*see* Que. Dept. Mines, Map 261, Senneterre). The discovery was made in the early 1940's along the north edge of a large outcrop area at about the centre of lot 61. Fine molybdenite with some pyrite can be found in two *en échelon* shear zones, cut by quartz veins. These veins strike east and dip about 60°S. The wall-rock is pink to grey biotite granite. A contact between the granite and volcanic rocks lies about 200 feet south of the shear zones.

The Grenier claims, rge. VII, lots 35 to 41, and rge. VIII, lot 39, in the same township, are underlain mostly by highly altered, amphibolitized, intermediate to basic lavas which strike north and dip 60°W. Granite—part of a large batholithic mass lying to the east—covers the easternmost quarter of the claims. Quartz veins and veinlets are numerous at or near the contacts of the volcanic and granitic rocks. Most of these veins contain molybdenite, some chalcopyrite, and minor amounts of gold. A fairly high bismuth content is also reported (M. Latulippe, Quebec Dept. Mines, personal communication).

At the Alfred Reeves claims on the east shore of Lake Tiblemont, *Tiblemont township,* molybdenite occurs as veinlets and flakes in silicified and albitized granite (Bell and Bell, 1933, pp. 54-55).

The *Tiblemont Consolidated Mines, Ltd.* property is located on the large island in the centre of Lake Tiblemont. The quartz veins there, in altered sodagranite, carry molybdenite, gold, pyrite, chalcopyrite, and tetradymite (Bell and Bell, 1933, pp. 49-50).

Savard-Poulin Claims, Bourlamaque Township

This property was brought to the writer's attention by M. Latulippe of the Quebec Department of Mines, Bourlamaque Office. It was visited briefly during June 1958 and the outcrops and trenches were examined. The following description is quoted from Latulippe's (1958) report.*

The Savard-Poulin group of 45 claims lies in the northeast corner of Bourlamaque township. These are numbered C-118720, C-118721, and C-110325 to C-110331. The property is accessible from a road running west from the main Perron road just south of the spot where the Cournor shaft road begins.

Severe forest fires bared the numerous outcrops. All of this ground is underlain with granodiorite of the Bourlamaque batholith with some small intrusions of quartz porphyry, andesite dykes and quartz veins.

Most of the early work, which consisted of trenching and diamond drilling, was concentrated on these quartz veins for gold. Gold tenors appear to be low and erratic. Chalcopyrite is found along with pyrite in blobs and streaks in these quartz veins.

During the spring of 1957 two Val d'Or prospectors, Poulin and O. Savard, discovered chalcopyrite and molybdenite mineralization in a quartz porphyry mass which intrudes the granodiorite. The nearest contact of the batholith with the volcanic rocks lies 6,000 feet to the east.

This quartz porphyry mass is found along the south edge of a large granodiorite outcrop. It lies about 1,700 feet south and 500 feet west of mile post IX on the Louvicourt-Bourlamaque township line. The mass appears to be roughly triangular in shape with the apex of the triangle to the west. The south edge, except for the extreme west end, is overburden covered. This quartz porphyry body is 250 feet long in an east-west direction and 80 feet wide at its widest place at the east end. A narrow tongue of the same material is found to continue another 100 feet at the northeast end of the mass.

The quartz porphyry presents a smooth fine-grained aplitic-like surface which weathers white to cream. It shows up well against the coarse granodiorite. The quartz appears as irregular grains, in small vermicular arrangements and in larger irregular veinlets. The rock has undergone silicification, sericitization and chloritization. The feldspars are fine-grained and have probably been highly altered.

Chalcopyrite, molybdenite and a small amount of pyrite are found in the quartz porphyry in discrete grains or in irregular veinlets. These are disseminated throughout the mass. On a weathered surface it requires close examination to see the sulphide mineralization. Green copper stain can be seen on fine fracture planes. In a rock trench at the east end of the quartz porphyry mass one veinlet of molybdenite was 6 inches long and ½ inch wide. The copper and molybdenum content of the mass would be low and well below economic grade.

This body has some characteristics similar to those of primary porphyry copper deposits.

In the fall of 1957 2 diamond drill holes were put down for a total of 610 feet. These were placed at a point 1,700 feet south and 500 feet west of mile post IX on the Bourlamaque-Louvicourt township line. Hole No. 1 was drilled to cut the rock under the rock trench in a N.10°E direction at an angle of —35°. It cut granodiorite and some of its facies with occasional pyrite and chalcopyrite mineralization. The best assay returned 3.35 per cent copper from 218.1 to 219.1 feet. Other assays were 0.04 per cent copper across 1.2 feet, 0.07 per cent copper across 1.5 feet and 0.18 per cent copper across 1 foot. Hole No. 2 was drilled at an angle of —45° in a S.20°E direction. It cut granodiorite with a 12 foot greenstone inclusion. No mineralization was reported in this hole. No molybdenite was reported in any of these holes.

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Preissac-Lacorne Area

This area is treated separately from the rest of Abitibi county because of its predominant position as regards molybdenite deposits. It contains the only producing molybdenite mine in Canada (at the time of writing), and one potential producer, as well as a great many small deposits, some of possible economic interest.

Molybdenite was first reported in this area at Indian Peninsula on Kewagama Lake (L. Preissac), in 1901. Since then, prospecting has disclosed molybdenite-bearing veins along a belt of granitic rocks about 30 miles long—stretching from Preissac township eastward to Fiedmont township. Molybdenite deposits are found in Lacorne, Lamotte, Lapause, Malartic, and Vassan townships, as well as the two already mentioned. Work has been concentrated mainly on two areas —the southwestern corner of Lacorne township, and Indian Peninsula.

Geology

The geology and mineral deposits of the Preissac-Lacorne area have been described in several reports; the most important are by Mailhiot (1920a, 1920b), Gerrie (1927), Hawley (1930), Cooke, James, and Mawdsley (1931), Norman (1944, 1945), Tremblay (1950), Rowe (1953), and K. R. Dawson (1954).

Rowe (p. 2) states—

> The consolidated rocks of the (area) are Precambrian in age and consist of meta-volcanic rocks, meta-sedimentary rocks, and large and small masses of plutonic rocks, ranging from acidic to ultrabasic in composition. Acidic to intermediate plutonic rocks which have intruded closely folded, meta-volcanic, meta-sedimentary, and altered ultrabasic, rocks are the most abundant rocks in the region, and include the Preissac-Lacorne batholith and associated pegmatites, aplite and quartz veins.

The Preissac-Lacorne batholith, with which the molybdenite deposits are connected, spatially and, perhaps genetically, consists chiefly of granitic and syenitic rocks. It occupies most of the area of Preissac, Lamotte, and Lacorne townships, and adjacent parts of Vassan, Fiedmont, Villemontel, and Figuery townships. It extends for more than 30 miles east-west and averages 12 to 14 miles wide. The batholith is oriented with its long axis nearly parallel to the fold axes in the area. Tremblay (1950, p. 30) recognized six main rock types within the batholith: hornblende monzonite, biotite-hornblende granodiorite, amphibolite, biotite granodiorite, muscovite granite, and pegmatite material.

Mineral Deposits

Numerous granitic pegmatites are associated with the Preissac-Lacorne batholith. The pegmatites are marginal to and outside the batholith, and three regional zones of pegmatites and quartz veins have been outlined: (1) pegmatites of the inner zone containing beryl but no lithium minerals, (2) a central zone containing all the spodumene-bearing pegmatites, and (3) an outer zone of quartz veins that carry molybdenite (*see* Fig. 7).

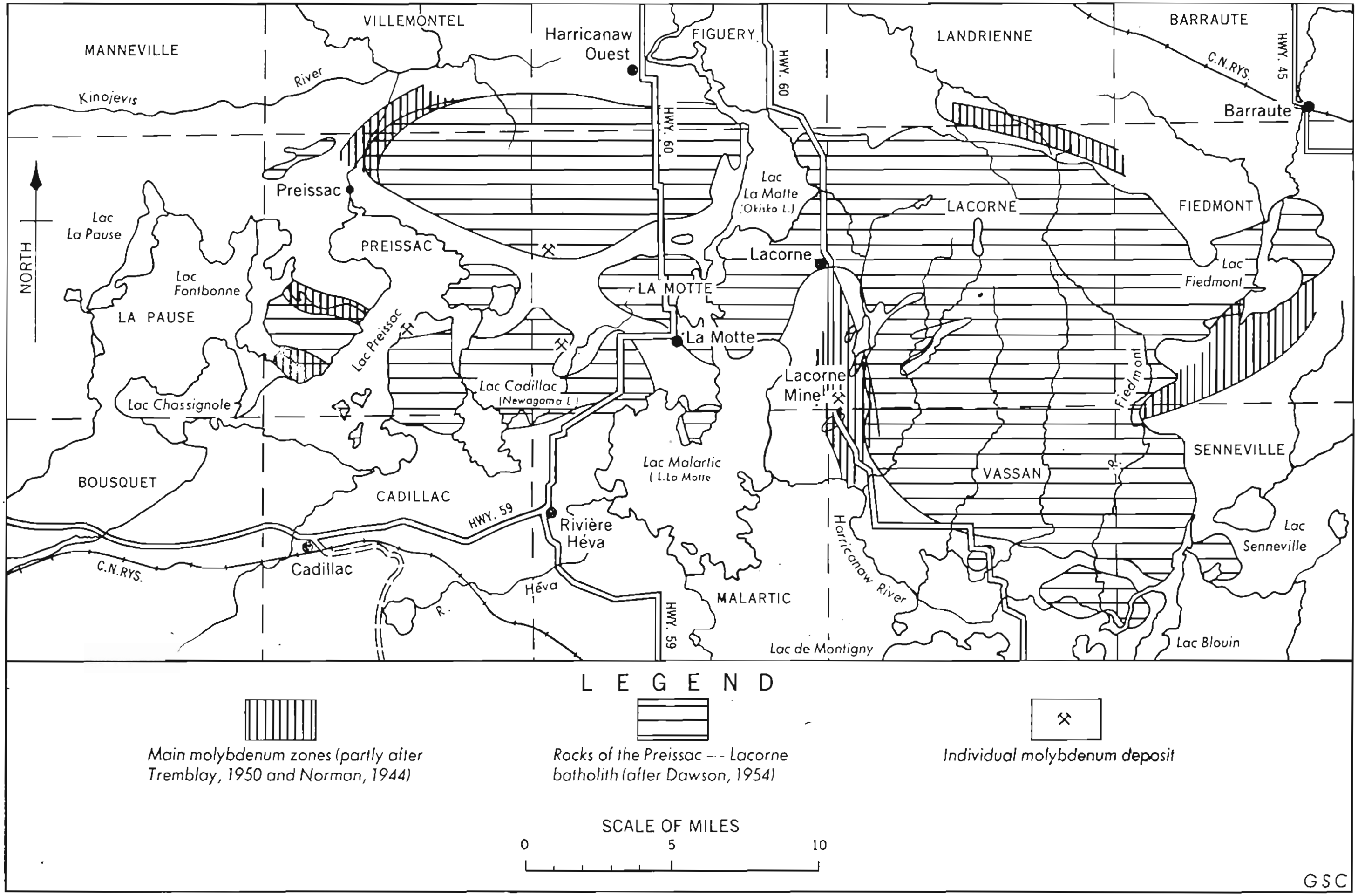

Figure 7. *Molybdenum-bearing zones surrounding the Preissac-Lacorne batholith, Quebec.*

Tremblay, (1950, p. 72) stated that the zoning presents a picture of mineral succession from the muscovite granite outwards, but that it does not explain why most of the higher-grade ore-bearing pegmatites are concentrated at certain places.

> The occurrences of more important deposits seem to be related to some structural control. They appear to have formed in areas of intense fracturing close to contacts of granitic masses with volcanic or sedimentary rocks, and more especially where embayments of granite occur in the older rocks.
>
> Molybdenite has generally a flaky habit, and occurs in normal quartz veins, in pegmatitic quartz veins, and in banded pegmatite dykes or masses. In the banded pegmatites, as in the normal quartz veins, molybdenite is commonly found in small amount and generally in the more siliceous parts. Only the pegmatitic quartz veins contain molybdenite in appreciable amounts....

Le Roy-Fiedmont Mining Company, Limited

This company was incorporated in 1928 to operate the claims on lots 40 to 46, rge. IV, Fiedmont township, following the finding of an occurrence of molybdenite-bearing pegmatitic quartz veins about a mile southeast of Lake Fiedmont. The following description is taken from the account by Tremblay (1950, p. 88).

> The claims were staked for the molybdenite-bearing veins, and exploration work, commenced in November 1928 and continued through the first half of 1929, was suspended in the summer of 1929. Much stripping and trenching were done along and across the veins, and a few test pits were sunk.
>
> Most of the veins occur along fractures and shear zones in a small quartz diorite mass that cuts a highly altered basic to intermediate lava. The veins appear to occur more abundantly in zones close to the contact of this diorite mass with the invaded rocks and can be found either on the eastern or western sides of this mass. On the east, within a distance of 1,000 feet in a south 25 degrees east direction, at least ten small quartz veins, varying in width from a few inches to 8 inches and traceable for short distances, have been noted and are associated with numerous quartz stringers. All the veins strike about 20 degrees east of south and dip steeply northeast to vertically; and most of them contain some molybdenite, apparently in very small amount. These eastern veins carry a few pegmatitic patches only, and some occupy definite shear zones. On the west, in the area close to the small mass of amphibolite, and within 1,000 feet in a north-south direction, ten veins varying in width from a few inches to 10 feet have been counted. All but two strike between north and north 30 degrees west, and dip about 50 degrees east. They are definitely pegmatitic and contain much molybdenite in places. Molybdenite is commonly concentrated in the pegmatitic areas. The veins are lens-like, and near where they pinch out they become strongly pegmatitic and highly mineralized with molybdenite. The other two veins strike about east, and also contain some molybdenite. They are small and dip south. Quartz, feldspar, and muscovite are the common minerals. Fluorite and beryl were also observed at one place.

In 1955 four diamond-drill holes, totalling 1,820 feet, were bored to test the veins. The two best sections in No. 1 hole assayed 1.71 per cent Mo over 0.8 foot and 0.66 per cent Mo over 1.1 feet.

Lacorne Mine (Molybdenite Corporation of Canada, Limited)

This property has the distinction (at the time of writing) of being the only producing molybdenite mine in Canada. It lies at the intersection of Lacorne, Lamotte, Malartic, and Vassan townships and occupies 1,647 acres. The property is easily reached by car from either Val d'Or or Amos; it is about halfway between these two towns on the Val d'Or-Amos highway.

The writer visited the mine and plant during June 1958 and was shown the mine maps and plans and certain features of the underground geology. Thanks are due to Mr. P. Ranger, president, and Mr. B. Joyal, manager, for the facilities made available to the writer during his visit, and to J. D. MacNeill and R. M. Poulin, geologists, for their ready cooperation and friendliness.

In the following description the writer has drawn heavily on previous publications, mainly those by Norman (1945, 1948b), Tremblay (1950), and O'Neill (1957) to supplement his own observations.

History

The earlier history of the Lacorne mine is given in some detail by Tremblay (1950, pp. 78-80):

An Indian was the first man to notice molybdenite on this property, and as a result of his discovery Hugh Gilligan of Cobalt, in 1915, staked the southern half of lots 1 and 2, rge. I, Lacorne tp. In the following year, L. N. Benjamin of Montreal, and associates, bought the property from Mr. Gilligan and held it until November 1921, when Molybdenite Reduction Company was incorporated to take over and operate the claims. In the following years, this company increased the number of its claims to include most of the property held today. In Abitibi, this showing was then known as the Eureka mine or Benjamin claims.

In 1917, L. N. Benjamin and associates did some 1,000 feet of stripping and trenching, blasted twelve to fifteen test pits, and sank a shaft, on the site of the present shaft, on one of the largest veins of the deposit to a depth of 30 feet at an angle of 60 degrees south. In 1923, about 200 tons of ore were sent to Ottawa for mill tests, and C. S. Parsons reported on this ore as one readily amenable to concentration by flotation. In 1927, Molybdenite Reduction Company deepened the shaft to 80 feet, and by April 1, 1928, had reached a depth of 150 feet. Some lateral work was also done on the 100- and 150-foot levels. During the winter of 1928, a 30- to 50-ton mill was erected, and in the spring of 1929 commenced operation. About 17 tons of concentrate were then produced, of which only 9.5 tons (approximately 16,000 pounds of MoS_2) were sold.

Early in January 1930, Hollinger Consolidated Gold Mines, Limited, took an option on the property and immediately began extensive exploration work. The shaft was deepened to 275 feet, and lateral work was concentrated on the 250-foot level. The results were not encouraging, and at the end of June the company ceased operations and abandoned its option. At the end of 1930, total stripping and trenching at the surface amounted to about 3,500 feet, of which 1,500 feet in the vicinity of the shaft uncovered ten veins.

No further work was done on the property until the summer of 1937, when Molybdenite Reduction Company, Limited, then incorporated as Molybdenite Corporation of Canada, did some diamond drilling and assessment work. The concentrator operated for a time in 1939 and about 2,240 pounds of molybdenite were shipped. The property was inactive from 1940 to the middle of 1942, but in July of that year, due to a great increase in the demand for molybdenum, Wartime Metals Corporation took over the property and got it into production. The property was designated as the Lacorne Molybdenum Project, and was under the management of Siscoe Gold Mines acting for Wartime Metals Corporation. As the old mill was unsatisfactory for efficient production, a new 200-ton mill was installed and commenced operations on May 17, 1943. In July 1945, the property was returned by Wartime Metals Corporation to its former owners, and since then has been under the management of Molybdenite Corporation of Canada. During the period from May 1943 to July 1945, about 2,663,000 pounds of molybdenite were produced.

In July 1945, the mill concentrate carried a fair percentage of molybdenite, but contained impurities that made it undesirable and almost unsaleable. These impurities were bismuth and copper. Accordingly, the mill was remodelled, and a new milling procedure established in May 1946. Bismuth was recovered separately and a molybdenite concentrate answering market requirements was obtained. The following figures give the percentages of the main constituents in the different concentrates:

—	MoS_2%	Bi%	Cu%
Old concentrate	88	2.5	0.5
New MoS_2 concentrate	94	0.4	0.1
Bismuth concentrate	12	30.0	....

The production for the period 1942-1947 is as follows:

—	Quantity (pounds)	MoS_2 (per cent)	Bi (per cent)
Molybdenite concentrate—			
1942 to July 15, 1945	3,066,800	86.85	
July 15, 1945 to May, 1946	1,424,600	85.41	
May 1946 to Dec. 31, 1946	837,500[1]	94.44	0.44
Jan. 1, 1947 to Nov. 20, 1947	798,426	93.84	
Bismuth concentrate—			
May 1946 to Dec. 31, 1946	76,000		27.36
Jan. 1, 1947 to Nov. 20, 1947	13,740.5		96.67

[1] Produced in part from ore and in part by retreating 640,000 pounds of concentrate (85 per cent MoS_2) produced prior to May 1946.

As the company was operating at a loss it (terminated) underground operations late in November, 1947. The mill ran, however, until the end of April, 1948. . . . In 1946 there was an operating loss of about $44,839 on sales amounting to $300,531. In May 1948, ore reserves were estimated at 130,983 tons 0.51 per cent MoS_2 and 0.09 per cent bismuth. . . .

In 1951 the property was leased to Molybdia Corporation, Limited, in which Molybdenite Corporation held a 50-per-cent interest, and operations were resumed. Molybdia Corporation operated the mine and plant until May 1953, at which time Molybdenite Corporation signed a contract with the American Defense Materials Procurement Agency, under which the company agreed to sell 6,000,000 pounds of molybdenite and 450,000 pounds of bismuth to the United States Government over a period of 6 years. Following this agreement, Molybdenite Corporation reacquired the properties and purchased all assets and other interests of Molybdia Corporation. A program of expansion was started in order to meet the terms of the contract. In October 1953 new financing was arranged, comprising credit to the extent of $540,000 from the U.S. Export-Import Bank and additional funds raised through sale of stock. The mill resumed operations in March 1954, and in July 1955 the daily capacity was increased from 400 to 550 tons. During 1957 the average daily tonnage was 544; in 1958 this was stepped up to 650.

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A new molybdic oxide plant was brought into operation late in 1956, and at the time of writing a plant was under construction for the production of high-grade molybdenite for lubricants.

Production

The following table gives the tonnage of ore mined and the amount of concentrates produced:

Period	Ore Mined (tons)	Grade	MoS_2 Produced (pounds)	Mo Produced in MoO_3 Concentrate (pounds)	Bi Produced (pounds)
1951 – May 1953 (Molybdia)......	175,000	—	1,165,861	—	88,718.0
1954....................	105,922	—	878,153	—	70,796.0
1955....................	157,013	—	1,288,777	—	98,988.5
1956....................	165,026	0.45% MoS_2 0.038% Bi	1,413,400	—	117,044.1
1957....................	169,601	0.46% MoSe 0.041% Bi	—	878,223	130,391.0
1958....................	191,645	—	—	816,371	141,206.0

Ore Reserves

	Proven (tons)	Grade (% MoS_2)	Probable (tons)
End of 1955..	176,166	0.438	
End of 1956..	184,861	0.5	300,000
March 1, 1958..	180,983	0.34	408,000

Workings

At the time of the writer's visit, the mine was accessible by means of a 3-compartment shaft inclined at 60 degrees, 14½ by 4½ feet inside the timbers. Levels had been established at 250, 375, 500, 625, and 750 feet vertically below the collar of the shaft. Broken ore and waste was hoisted in two, inbalance, 2-ton skips, which were also used for men and materials. All the ore was being won by shrinkage stoping of the individual quartz-pegmatite veins.

Milling

The plant at the Lacorne mine is the only one in Canada today (1959) which treats this type of ore. The following is a short outline of the beneficiation of the ore.

Ore from the 250-ton coarse-ore bin is passed over a picking belt where waste country rock and the more obvious pieces of beryl-rich material are removed. The ore passes through a 15-by-24-inch jaw-crusher and a 4-foot Symons cone-crusher, after which it is stored in a 1,000-ton fine-ore bin. Fine-grinding takes place in two ball-mills—one is 7 by 7 feet and one is 7 by 6 feet—each operating in closed circuit with a rake classifier, giving a minus 48-mesh overflow. From there the pulp is pumped to the flotation circuit where a molybdenite-bismuth concentrate is made.

Cyanide is used to depress chalcopyrite, but the excess of this depressant also depresses the bismuth. As a result the concentrate contains about 1 per cent Cu. Amyl xanthate is the collector for bismuth and donfroth-250 is used as a molybdenite collector and frother. Sodium sulphite is added to regulate the pH.

The concentrate is then batch-leached in two 750-gallon Pfaudler autoclaves with HCl and HNO_3. This removes Bi and Cu in solution. The mother liquor is diluted with water to a pH of 1 at which the precipitation of Bi as BiOCl is complete and the precipitate is collected as a sludge. The copper in solution goes to waste.

The bismuth oxychloride is then smelted with fluxes, producing a slag and bismuth metal; the latter is poured into 100-pound bricks for marketing.

After leaching the molybdenite concentrate is dried in infra-red driers and then roasted in a 10-foot-diameter, six-hearth, Herreshot roaster to produce MoO_3 which is the final product.

Geology

The pegmatitic quartz veins carrying the molybdenite occur in, and to the northwest of a large sill or stock of biotite granite that varies in grain size from medium-coarse to fine. The granite mass, so far as is known, is a northeast-trending body about 3,000 feet long. In the upper levels it is about 1,400 feet wide, narrowing to about 1,100 feet at the 750-foot level. The northerly contact strikes about N45°E and dips about 70°NW. The southeasterly contact is irregular, but in general it strikes about N20°E and dips about 40°W. The northeasterly 'nose' of the granite body appears to rake to the southwest at about 35 degrees.

Tremblay (1950, pp. 36-37, 81-82) described the rock forming the Lacorne stock as a biotite granodiorite and commented on its uniformity of composition. The main minerals are oligoclase, quartz, some microcline, biotite, and epidote.

The granodiorite stock or sill is bounded to the north and south by schists of apparently sedimentary origin. These rocks mainly comprise highly foliated biotite schists, and lesser amounts of hornblende schists. Tremblay (p. 81) states—

> The biotite schists are fine- to medium-grained, dark-grey to brown rocks consisting mainly of biotite, quartz and feldspars. Traces of bedding were seen in places, but in general are poor, and no top determination is possible. . . . Near the mine two cleavages can be seen in the biotite schist: an older one conforming closely with and generally obscuring the bedding structures and a later cleavage superimposed on the other and probably parallel with the axial directions of the main intrusive bodies or folds of the area.

In the area of the mine workings a variety of schists may be observed, including quartz-rich and hornblende-rich types and, more locally, schists carrying a high tourmaline content.

Schist-granite contacts appear to be sharp and, where examined, they were fairly conformable. Tremblay (p. 83) continues—

> From the surface down to a depth of about 300 feet, this northern contact is not a sharp feature, but is represented by an alternating succession of schist bands and granitic dykes. As many as fourteen dykes have been counted in such a succession on the 150-foot level within a distance of 200 feet. On the 500-foot level however, the contact zone appears to be narrower. From the surface down to the 250-foot level the granodiorite is intensely faulted, whereas on the 500-foot level faulting is not as prevalent. The veins, too, at this depth appear in general to be more uniform and regular in width than they are nearer the surface. If these observations are correct, they would suggest that the present surface is near the roof of the granitic body.

In the northwestern part of the workings, to the north of the granite contact and at various distances from it, is an area in which numerous granitic sills or dykes appear in the schist. These become so abundant that they almost coalesce, to form what was previously described as a minor 'plug' of granite. However, it appears now that this is not a solid body like the main stock or sill, but a very close concentration of these dykes. Elsewhere sills and dykes of granitic material are met here and there in the schist underground. The dyke concentration seems to appear first on the 375-foot level, and, like the main granite mass, it apparently rakes westerley so that the workings on the 750-foot level are presently only just approaching it from the east.

Veins

Tremblay (1950, pp. 83-86) and O'Neill (1957, pp. 45-46) give detailed descriptions of the different types of veins met with in the Lacorne mine, and new information resulting from development work since these two accounts were written, has not changed the overall picture to any appreciable extent. Both writers recognize three age-groups among the veins met underground. Only one of these groups is significant as an ore producer. Group 1 comprises the oldest veins; these are few in number and economically unimportant. They are mainly narrow, small, and are composed almost entirely of quartz, but they carry a little muscovite and molybdenite. Group 3 is made up of the youngest veins, which are also of little economic significance. Generally, they vary in width from a few inches to a foot, and carry very little molybdenite. They cut across the older veins, striking between due east and N30°E. They appear to be confined to the granodiorite mass. Fluorite and hematite are the main constituents. Muscovite, quartz, and feldspar are generally present in amounts that vary along the strike and dip of the veins. Pyrite, chalcopyrite, molybdenite, calcite, and powellite are also present in various amounts. The veins of group 2, of intermediate age, at present supply most, or all, of the ore. This group includes two sets of veins—similar in appearance except that one set is slightly more quartzose and contains more of the rare minerals commonly found in pegmatites, and less molybdenite. Some veins at least, of this quartzose set, definitely cut some of the veins of the other set. Figure 8 (in pocket) illustrates the vein system on the 750-foot level.

The so-called 'easterly veins' strike between N60 and N80°E, and dip between 45 and 65°SE. These veins are present in both the granodiorite and biotite schist and cut the contact at low angles, appearing to pass from the one rock type to the other without any marked change in direction. However, they vary considerably in width after passing the contact, in either direction. In the schist they are generally more or less concordant with the schistosity, though crosscutting relations are not uncommon. If followed in a westerly direction, many of these veins pinch out and new veins come in, mostly on the foot-wall, giving an *en échelon* pattern. This pinching out is commonly accompanied by a marked flattening of the dip of the vein; the normal dip is resumed by the new vein in the foot-wall.

In some of the northwestern parts of the workings there are 'complexes' of veins, generally of diminished widths and lying in various attitudes. Many of the veins are folded in a ptygmatic fashion. Parallel series of these veins, with only a few feet of schist between, are common. The vein walls in schist are mainly clean and sharply defined, but commonly irregular, presenting convex bulges towards the schist, suggestive of replacement. Where the schistosity is parallel with the vein there is often a slip-plane along the wall(s).

In granodiorite these 'easterly veins' have sharp walls and are less complex—there is no splitting and branching or folding. They are also narrower and straighter than the 'northerly veins', but are more fractured.

The 'northerly veins' trend between N20 and N40°W, generally with very steep to vertical dips. These veins are confined to the granodiorite, pinching out at the contact. Some of them appear to be arranged *en échelon,* stepped eastward to the northeast. They are generally wider than the 'easterly veins', varying from a few feet to 15 feet. They are irregular, but are commonly lens-shaped. Some 'northerly veins' are probably older than a few 'easterly veins', but most veins of both sets are believed to be contemporaneous. The 'northerly veins' widen where 'easterly veins' pass laterally into them. Many are high grade and constituted the orebodies originally worked on the property. It was previously thought that the 'northerly veins' were, as a rule, of much higher grade than the 'easterly veins', but recent work has tended to show that this is not necessarily so; some of the 'easterly veins' are just as rich.

In 1957, 68.9 per cent of the ore milled was supplied from the 'northerly veins', and 31.1 per cent from the 'easterly veins'. Ore reserves for the two types were as follows:

	Northerly Veins	*Easterly Veins*
End of 1957	55 per cent	45 per cent
End of 1956	89 per cent	11 per cent

O'Neill (1957, p. 46) described one further type of vein which has been recently opened up on the 625- and 750-foot levels:

It occurs along a strong shear which dips at 30° to the N-W. and strikes S30°W. The vein varies in composition from quartz and muscovite to a brecciated pegmatite composed chiefly of large crystals of calcite, quartz and red and white feldspar. It contains heavy concentrations of molybdenite smeared along the walls, disseminated throughout the vein material and seeping out into the walls. The vein is enclosed by a large carbonatized and albitized zone. The zone itself is locally brecciated and contains angular inclusions of dark highly altered rock of unknown origin. It has been noted that, when either N-S veins or E-W veins of age group *2* have entered this zone, their normal vein filling has been replaced with the later vein material characteristic of the zone, that is, calcite and feldspar plus molybdenite; thus giving better grade to the included vein. The dip and strike of the carbonatized-albitized zone conforms with that of the shear. As for the age of the vein, it would appear that the shear may be older than age group *2* veins, however later movement and vein filling is younger. The carbonate and feldspar of the zone itself would be of the same age as the latter vein filling. This material has probably followed the zone of weakness caused by the shear and impregnated the surrounding rock.

Movement on this shear appears to be south-side up and slightly to the west. It is at present impossible to estimate with any accuracy the extent of this movement. However the resultant horizontal offset of the south contact has been at least 200'.

Mineralogy

The veins show several mineralogical differences, which appear to be mainly dependent on the nature of the enclosing rocks.

The veins in schist (all 'easterly veins') are generally much higher in quartz and generally, but not invariably have a zone along either wall, 1½ to 2 inches wide, of white oligoclase. Where these zones are best developed no feldspar occurs within the quartz of the rest of the vein. In less-common instances the feldspar is not neatly zoned, but occurs in patches in the quartz throughout the vein. Many of the thinner veins seen were composed almost entirely of white oligoclase, with only a few patches of quartz at intervals along the centre. A greenish sericitic muscovite occurs irregularly in patches in the quartz; this varies in grain size from about 1 or 2 mm up to about 5 mm. Much of the molybdenite is concentrated in these mica patches as irregular scales or flakes. It also occurs as individual flakes or patches in the vein quartz or feldspar, and in places as a very fine impregnation along the vein walls. Tourmaline is present in places as aggregates of black prismatic crystals. This mineral is also abundant in places in the wall-rock. Green or blue-green beryl seems to be confined to the veins within the schist and tends to occur along the foot-wall side. Its distribution is irregular; some very fine crystals are present, but much of it appears as indefinite patches in the quartz. Pyrite is scarce as patches and individual euhedral crystals. Other minerals present are chalcopyrite, bismuthinite, native bismuth, fluorite, apatite, and scheelite.

Within the granodiorite the 'easterly veins' carry, in addition to white oligoclase, a pink to brick-red feldspar, which does not show any tendency to be concentrated along the walls. Muscovite, on the other hand, is mostly concentrated along the walls, and the adjacent granodiorite has, in places, been highly altered and is definitely reddish. Generally these 'easterly veins' in granodiorite contain less quartz than those in schist, but otherwise the mineralogy is the same, except for the absence of beryl as already noted. The mineralogy of the 'northerly veins' has been described by Tremblay (1950, pp. 84-85).

> The 'northerly veins' consist of quartz, red (microcline and albite) and white (albite-oligoclase, about An_{10}) feldspars, light green muscovite, and molybdenite. Quartz is the most abundant constituent, but in these veins it is not as abundant as in most of the

'easterly veins'. It occurs in individual lenses or irregular patches elongated parallel with the strike and dip of the vein, and also in irregular grains well mixed with feldspars and muscovite. Some parts of the quartz lenses or patches show fractures filled with feldspar. In some veins, only the red feldspar seems to occur; in others, both are present. The feldspars generally form irregular patches with muscovite or occur as minute streaks in or between quartz masses, and in some veins are abundant. The white feldspar commonly forms a narrow zone that may be continuous at the granite contact. Light yellowish green muscovite is found in patches and streaks mixed with feldspars in or in between the quartz masses, and it is in such muscovite occurrences that molybdenite is concentrated in abundance. In places a strong concentration and development of muscovite can be seen in the granodiorite at the contact with the veins. Most of these 'northerly veins' are, in fact, more pegmatitic than the easterly ones and could readily be regarded as pegmatitic quartz veins. The agglomerations of feldspar and mica have been intensely sheared due to a later movement probably parallel with the veins, and show slickensided surfaces that formed later than the molybdenite, which occurs in fine powder along these surfaces.

Faults

Tremblay (p. 86) continues—

Fractures and faults are common features in the underground workings at Lacorne mine, and most of them are now filled with vein matter. Most of the veins occupy fault fissures, as evidenced by the fact that the older veins are displaced by faults occupied by veins of the younger types. Some late faults may or may not be filled with vein matter. In general, however, the displacement along all the veins amounts to only a few inches or feet, though one of the later faults has an apparent horizontal displacement of as much as 30 feet.

No general direction of movement along the faults has been determined, though in plan it appears that most of the faults are of the left-hand type. Most of the faults strike about parallel with the two main sets of veins, either 15 or 25 degrees north of east or at right angles to this direction. The easterly-striking faults vary in dip from southeast to 75 degrees northwest, whereas those striking northerly are vertical or dip steeply to the northeast.

In some parts of the mine, especially on the 250-foot level, and to a minor degree on the 375-foot level, the faults are so numerous and so closely spaced that where they intersect a vein the vein is sliced into so many small fragments that it is of little mineable value. This is particularly true of some 'easterly veins' not far from the shaft on the 250-foot level. There, in one place, the vein has been sliced into a group of small lenticular veins arranged *en échelon* and separated from each other by barren granite.

Most of the faults are small features; only two of consequence have been encountered underground. The most conspicuous one lies about 120 feet southeast of the shaft, strikes 15 degrees north of east, and dips 45 degrees southeast. It is a very pronounced feature on the 150- and 250-foot levels. It was also noticed on the 375-foot level, but appears to end at greater depth, as it was not seen on the 500-foot level. This fault is marked by several small mud seams, and in places the fault zone is at least a foot wide. It is filled with vein matter of composition similar to the 'easterly veins' entirely in granite, and on the 250-foot level much blue powellite, powdery hematite, and fluorite were found in it. Molybdenite is also present in powder-like form in this fault zone. The fault has a probable horizontal displacement of 30 feet.

The other fault, known only on the 375-foot level, occurs at the end of the long drift in the southeast section of the mine. It appears to be a sharp-cut fracture, with a horizontal displacement of about 60 feet. The fault strikes southeast, and movement along it is apparently right-hand.

Faulting is an important feature in some parts of the mine, particularly in the northeast section on the 150- and 250-foot levels. It seems less significant on the 375-foot level, although faults are common there too, but on the 500-foot level the faults have decreased in number and appear only as relatively minor fractures. This decrease with depth suggests a plug-like granitic mass, whose present surface lies close to the original, more easily fractured roof. If this is so, the larger veins only may be expected to extend to great depth.

Origin

Most workers who have studied the Lacorne deposits agree in relating the origin to the igneous rocks (the Lacorne intrusion), a part of the larger Preissac-Lacorne batholith. The writer has no reason to offer any alternative theory.

Other Occurrences

The *Dumont showing* has been described by Tremblay (1950, pp. 87-88) as follows:

> The Dumont claims cover lots 55 to 62, rge. IX, Lacorne tp., and were staked for molybdenite. In 1942, they were optioned to Sullivan Consolidated Mines, Limited, and by the end of the year 1,205 feet of stripping and trenching had been done to explore the molybdenite occurrences at the surface and 1,634 feet of diamond drilling had tested the mineral deposit at depth. In 1943, 1,960 feet were drilled to get additional information at depth. As the results were not satisfactory the drilling program was discontinued on February 15, 1943.
>
> The molybdenite-bearing dykes and veins are found mainly on lot 58 at the south-western end of Lake Roy, and the main showing can be seen at the lake shore. There a molybdenite-bearing dyke occurs in a narrow band of volcanic rock, now transformed to a hornblende schist, separating two lens-like sills of peridotite that trend east. The band of schist appears to be cut on the east by a small mass of granitic rock. The pegmatite dyke cuts across the schistosity of the hornblende schist, and varies in width from 4 to 13 feet. It has been traced for about 200 feet on a strike of about 35 degrees east, and dips steeply. The dyke is narrow at its eastern end, but gradually widens towards the west to where it reaches the southern contact of the northern peridotite sill, where it seems to disappear or to divide into many small, unimportant stringers that follow the contact. This dyke consists of quartz, microcline, albite (An_{0-6}), mica, molybdenite, and pyrite. A banding is noted at places, and is defined by a centre core of quartz bordered by a mixture of fine-grained albite and quartz. Molybdenite occurs as well-formed hexagonal crystals, either concentrated in book-like patches or disseminated in individual flakes in the feldspathic areas. The amount of molybdenite is not constant along the strike, but the minerals appear to be concentrated mainly in the banded parts of the dyke.

The Goyette-Sup claims are located in rge. IV, lot 6, and rge. V, lots 1-6, Lacorne tp. The writer is grateful to M. Latulippe of the Quebec Department of Mines, Bourlamaque Office, for information regarding these claims. They lie just east of route 60, some 30 miles north of Val d'Or, only a mile or two north of the Lacorne mine. The area is underlain by Keewatin lavas and Timiskaming sedimentary rocks, both highly altered to biotite schists and intruded by pegmatites and quartz veins.

In May 1958, A. Goyette discovered a 3-foot-wide pegmatite 200 feet east of the highway. This was stripped for 35 feet along the strike (N15°W). The dyke dips irregularly, both east and west. The biotite-schist country rock strikes N50°E. The pegmatite consists of quartz, feldspar, muscovite, and molybdenite and probably holds 1 per cent MoS_2. Isolated grains of chalcopyrite and sphalerite occur. Bismuth is present, probably as bismuthinite. The pegmatite is strongly zoned parallel with its walls, with alternating bands of quartz feldspar, aplite, and muscovite-rich pegmatite. In the aplite the molybdenite occurs as long, fine-grained streaks up to $\frac{1}{8}$ inch thick, parallel with the zones. In the quartz feldspar and mica bands the molybdenite is very coarse, with some flakes up to an inch across.

The Montpas-Sylvestre occurrence has been described by Norman (1944, p. 6).

> A massive body of quartz with irregularly distributed molybdenite, known as the Montpas-Sylvestre showing, occurs at the east contact of the Indian Peninsula granite mass east of Kewagama Lake, in lot 5, rge. 2, La Motte tp. This deposit can be traced north 15 degrees west across a series of separate exposures for about 700 feet along the east slope of a prominent ridge. The exposed width is 100 feet at one place, but the true width cannot be estimated until the dip, which may be either gentle or steep, is ascertained. Elongate granite and pegmatite inclusions, which form 50 per cent of the deposit in places, and mica-coated shear planes, strike north 10 degrees east to northeast at an angle across the deposit and dip 30 to 70 degrees east. Molybdenite occurs as scattered, well-formed crystals in quartz on the south side of the deposit, but is confined chiefly to a zone of mixed quartz vein material and included sheared pegmatite with a surface width of 50 feet in a trench across the central and largest exposure of the deposit. The zone strikes nearly northeast; it tapers to a point about 50 feet north of the trench, but is difficult to follow southward. The molybdenite content of this zone is probably between 0.5 and 1 per cent. Directly north of the deposit the granite contact apparently makes a sharp bend westward, and this feature of the deposit would merit investigation if extensive testing of the deposit by drilling were ever contemplated.

The property of *Belpat Molybdenum Mines, Limited,* ranges III, IV and V, lots 9-25, La Pause tp., was previously held by the La Pause Gold Mining Company. It covers a continuous area of 2,750 acres in the southwest corner of the township, south of Lake Patris. The property lies 9 miles north of the Rouyn-Val d'Or highway at a distance of 16 miles from Cadillac. It has been described by Ambrose (1941, pp. 45-47). Molybdenite and pyrite occur in a medium-grained albitite intrusion.

Since taking over the property the Belpat Company has drilled two diamond-drill holes for a total of 637 feet. Very little molybdenite was encountered.

At the *Lake La Motte occurrence,* Malartic township, J. A. Bancroft (1912, p. 239) reported a few small flakes of molybdenite in quartz veins in granite on an island in the middle part of Lake La Motte (Lake Malartic).

Indian Peninsula Area

The part of the Preissac-Lacorne batholith that outcrops on the Indian Peninsula between Lake Preissac (Kewagama) and Lake Fontbonne in Preissac township shows considerable concentrations of molybdenite-bearing quartz veins and pegmatitic quartz veins. One potential orebody here, that is reported to contain more than 1 million tons, has already been outlined by diamond-drilling, and indications are that other workable deposits will be found in the area. The Indian Peninsula must rank with the Lacorne area as one containing a special concentration of molybdenite in the Preissac-Lacorne batholith.

The general geology of the area has been comprehensively dealt with by J. A. Bancroft (1912, 1913b) and James and Mawdsley (1927). Norman (1944, 1945) summarizes the geology in his detailed accounts of the mineral deposits of the area. The following is taken mostly from Norman, supplemented by the writer's field observations and data supplied by Preissac Molybdenite Mines Limited.

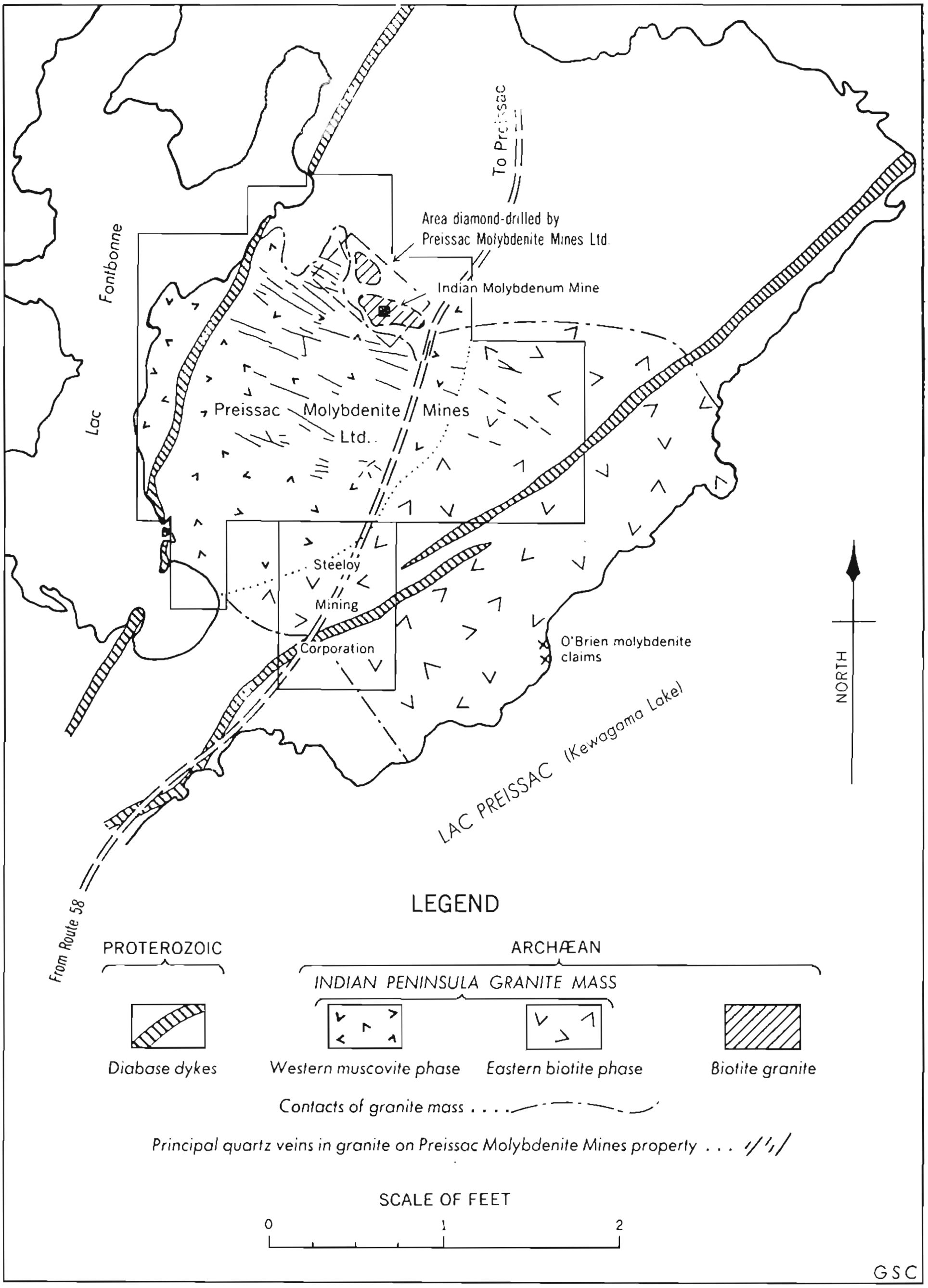

Figure 9. ***Sketch map of Indian Peninsula area, Preissac township, Quebec.***

The Indian Peninsula granite mass is divided into two major phases (*see* Fig. 9): a western, muscovite phase, which forms the high ground to the southwest and west of the old Indian Molybdenum mine, and an eastern or biotite phase. According to Norman (1944, p. 6) muscovite granite also occurs within the eastern part of the granite mass on the west shore of Lake Preissac at the old O'Brien molybdenum claims. The extent of the muscovite granite is not indicated. On the south the Indian Peninsula granite mass is bounded by peridotite; along its northern edge is a belt of amphibolite and hornblende schists, belonging to the Malartic group. Also partly in contact with the muscovite granite mass at the northern edge is a body (or bodies) of a probably older biotite granite (see below).

The main granite mass, especially the western, muscovitic phase, contains many quartz and pegmatitic quartz veins varying greatly in width from a few inches to many feet. These veins contain varying, but generally small, amounts of molybdenite (*see* Fig. 9). They mainly strike between N40 and 65°W; a few strike about N70°E.

These vein directions coincide with the main joint directions in the granite mass, as measured by the writer; the main joint direction is N10 to 65°W, with a subsidiary set at N70°E. The veins appear to have filled the main joint set in the granite, probably when these opened up, due to relative release of pressure or even to tension in a northeast-southwest direction. Most of the veins are lenticular in plan, reaching a maximum width in the centre and tapering off in each direction. Their lengths seem roughly proportional to their widths. Veins up to 12 feet wide with strike-lengths of several hundred feet were observed by the writer; on the other hand, the maximum width of veins about 20 feet long is of the order of 6 inches to a foot. The great majority of veins observed were sensibly parallel with each other, and in areas of greatest concentration they occurred one after the other separated by only a few feet of granite. In one section 200 feet long, around the escarpment south of the old Indian Molybdenum mine, there were six parallel quartz veins ranging in width from 1 foot to 12 feet and averaging 7 feet. Their strikes range between N65 and 50°W. Many of the shorter veins exhibited an *en échelon* arrangement, with a fresh vein appearing and 'making' in the granite to the right of the older one as it is traced northwards. All these features seem to suggest the filling of tension openings by the quartz along the main joint direction in the granite.

The vein filling is for the most part clean, white, vitreous to milky quartz. Within this the molybdenite occurs very sparsely, commonly as nearly perfect hexagonal flakes, 1 to 5 mm across and extremely thin. However, in places within any one vein there appear local concentrations of white feldspar and green sericitic muscovite, and at these places notable concentrations of molybdenite occur, together with pyrite. Some whole veins were seen to be composed of quartz and feldspar, with or without muscovite, and it was notable that such a pegmatitic quartz vein showed a relatively high molybdenite concentration. The pegmatitic quartz veins are few in comparison with the total mass of quartz veins, but nevertheless there seems to be a definite correlation between the pegmatitic character and the molybdenite content. This compares well with, for example, the pegmatitic quartz type of vein now being worked at the Lacorne mine. On the whole the quartz and pegmatitic quartz veins within the granite mass seem to be few in number and sporadic in molybdenite content. None has been worked in the past nor is any being investigated at the moment. They do however, in bulk, represent a great amount of molybdenum, and the whole of the Indian Peninsula granite mass, especially the western, muscovite phase, must be regarded as an area of great concentration of the element.

An especially interesting feature of parts of the granite mass in the area is the occurrence of molybdenite actually in the granite as scattered grains not associated with quartz veins. These grains apparently replace muscovite or fill cracks in the rock. No such zones have yet been found to be of economic interest, but their presence suggests the possibility that there might be large masses of ore in crush or shatter zones, if these are found.

Preissac Molybdenite Mines Limited

Of the area held by this company, the greatest interest has been shown in the part along the margins of the granite, particularly along the western part of the northern margin in the neighbourhood of the old Indian Molybdenum mine (*see* Fig. 9).

Eardley-Wilmot (1925, pp. 126-127) gave an account of the early work carried out on the molybdenite discoveries in this area. In 1901, J. F. E. Johnston of the Geological Survey of Canada first mentioned the presence of molybdenite and bismuthinite in quartz veins at Nose Point on the east shore of Indian Peninsula. Subsequent reports were made by several authorities, including T. L. Walker (1911) and J. A. Bancroft (1912); the latter gave a detailed description of all the molybdenite deposits in the region. In 1911 a quantity of ore was shipped to Queen's University, Kingston, Ontario, for testing purposes; this comprised 1,113 pounds assaying 7.4 per cent MoS_2, 300 pounds assaying 2.3 per cent, and 760 pounds assaying 1.8 per cent. During the same year Walker took samples of the veins; thirteen samples averaged 1.1 per cent MoS_2 and two averaged 7.0 per cent.

A. T. Mausure and A. E. Lehman surveyed the workings in 1912 and made a map showing the distribution of the quartz veins on the claims in the area. They mapped more than 16,000 feet of quartz veins—one vein was found to be more than 2,000 feet long, and several others, averaging 3 feet wide, were 500 feet long. Veins up to 16 feet wide were found. In 1916, St. Maurice Mines Co., Ltd. took an option on the properties from the owners, the St. Maurice Syndicate, Ltd. Controlling interest was transferred in 1918 to the Indian Peninsula Mining Co., Ltd.

In 1912, work had opened up a lenticular orebody at a break or fault in the granite contact, and to the south of this a pit had discovered a 14-foot quartz vein, from which an "average sample of selected milling ore" assayed 5.1 per cent

MoS_2. Up to the time of Eardley-Wilmot's (1925) report, no diamond-drilling had been done in the area, and the persistence in depth of the veins was not known. Although numerous quartz veins had been found over the whole area, a large number of those occurring in the granite were barren of molybdenite and in others the mineral occurred as irregularly disseminated flakes, especially where mica was present. Eardley-Wilmot (p. 127) remarked that "The veins higher up the mountain, remote from the contact . . . are not likely to be worthy of further exploitation." The most recent work in the area has proved the substantial correctness of his observations.

During World War II, Indian Molybdenum, Ltd. acquired control of the main showings. This company erected a mill and treated 91,489 tons of ore containing 781,910 pounds of MoS_2—an average grade of 0.42 per cent. The operation was managed by Dome Exploration Limited under special contract with the Wartime Metals Control Commission. A 20-per-cent incline shaft was sunk to exploit a deposit, discovered by diamond-drilling in 1942, in the southern part of lots 8 and 9, rge. V, Preissac tp. This orebody was mined and the ore was treated at a mill on the property until April 1944 when the contract with the Government was cancelled. Dome Exploration dismantled their mill and the claims were left idle until October 1955. Work on the claims was then started by the present owners, Preissac Molybdenite Mines (in which the controlling interest is held by Molybdenite Corporation of Canada). Diamond-drilling was started in January 1956 with two machines. To date 67 holes have been drilled, a total of 35,574 feet of drilling (*see* Fig. 9). The area held by Preissac Molybdenite Mines comprises the north halves of lots 2 and 3, rge. III; lots 1 and 2, rge. IV; and lots 1 to 9 and the south halves of lots 10, 11, and 12, rge. V. The turn-off to the property is on the Preissac road 9 miles north of the Rouyn-Val d'Or highway (route 58).

The published works on the geology of the ore deposits on the Preissac property are based on what was known from the drilling and underground operation of Indian Molybdenum, Ltd. The writer is grateful to Preissac Molybdenite Mines for information regarding their recent exploration in the area.

Regarding the old Indian Molybdenum mine, the best accounts are given by Norman (1944, 1945, and 1948a). The form of the granite contact in the area has been fairly well defined, because of good exposures and the mining that has taken place. Its form can be seen from Figure 9. The contact, which apparently trends easterly in the eastern part of the area, swings almost due north, west and northwest of the old workings along the eastern flank of a large northerly protuberance or spur of the muscovite granite. To the west of this spur there appears a complementary V-shaped indentation in the contact.

According to Norman (1944) the marginal zone of the Indian Peninsula granite mass there consists of muscovite granite, grading in a few places into biotite granite, with segregated masses or dykes of coarse quartz-perthite-muscovite pegmatite. This contact zone can be observed on the surface at present in a large exposure about 500 feet due west of the collar of the now water-filled incline to the old workings—an exposure which includes an old winze or shaft down to the mine. There the zone appears to be running almost due north. The biotite granite occupies the eastern edge of the outcrop; most of the rest is occupied by muscovite granite. The contact between the two types is very indistinct and gradational, and coarse pegmatite is widely developed, commonly reddened due to weathering of some of the iron. The old winze appears to have been sunk in the muscovite granite just west of the contact.

The collar of the old incline shaft shows the biotite granite—it extends in exposures several hundred feet north and a somewhat longer distance east of the collar. The granite is a fresh-looking, well-jointed, even-textured, medium-grained grey rock, with pink aplite veins up to a foot wide intersecting it in all directions. Norman considered this to be older than the muscovite granite with which it is in contact, and he termed it a porphyritic granite. This characteristic was not observed by the present writer in the outcrops studied. On either side of the biotite granite the muscovite granite is in contact with biotite-hornblende schists of the Malartic group. According to Norman the schist shows banding in places and contains zones with drawn-out fragments; it is probably an altered tuff. "Interlayered with the schist are a few, irregular, sill-like bodies of foliated diorite and . . . in the V-shaped indentation northwest of the mine, are peridotite and minor pillowed greenstones. The strike and dip of the schists conform roughly with that of the granite contact."

The schist-muscovite-granite contact was not seen by the writer, but immediately north of the old mine road, north of the old mill site, outcrops show the schists intimately invaded and partly replaced by the biotite granite. The rocks there are 'sandy-looking' biotite-hornblende schists commonly with quartz 'eyes' resembling old pebbles, or other clastic fragments, and they are highly contorted. The strike there is east, with dips of 50 to 60°N. The biotite granite appears to be invading the schists in the form of sills mainly conformable with the schistosity, but in parts crosscutting and replacing it. Norman's (1944) map shows another body of biotite granite in the schists northwest of the one near the shaft area. This was not seen by the writer. Due south of the old incline shaft a tongue of schists, occupying a depression, separates the biotite granite from the main muscovite-granite mass. The main ore zone is in the muscovite granite along this contact.

The ore is either a solid quartz vein with more or less feldspar, muscovite, and molybdenite, or it is a series of smaller veins in granite following the contact. In some places 'splashes' or patches of molybdenite occur actually in the biotite or muscovite granites. Norman was of the opinion that the main orebody at the old Indian mine was controlled by two parallel faults and a 'roll' in the granite contact that plunges to the northeast. He states (1944, pp. 7-8):

> The two faults that bound the ore-body are about 40 feet apart. They dip 40 to 50 degrees northeast and strike southeast about parallel to a series of quartz veins in the granite to the west, and at a slight angle to the general more northerly trend of granite contact. The character of the faults is known only underground in the mine. The foot-wall fault there has a sharp slip surface with relatively massive rock on either side. The

hanging-wall fault is fairly sharp in places, but in other places branches and consists of a zone of intensely crushed and altered granite several feet wide cut by molybdenite-stained, gouge-filled slips. A horizontal shift eastward along the northeast sides of the faults is indicated by the duplication of the pegmatite border zone. This zone occurs at the muscovite-biotite granite contact in the inclined adit northeast of the ore-body, and at the face of the adit, west of the ore-body, separated from the foot-wall fault by a few feet of biotite schist. The fracture pattern between the faults suggests that they are of the reverse, or thrust, type.

Gently dipping quartz veins, 6 inches to a foot wide, connected by steeply dipping stringers, occur at intervals in the granite from the hanging-wall fault southwestwards across the greater part of the ore-body. In the crosscut near the bottom of the inclined adit the veins increase in number near the foot-wall fault, along which they coalesce to form a solid vein of quartz. This vein contains about 5 per cent red feldspar as scattered bunches of coarse crystals and is 12 feet wide in places. For 10 feet or more directly above this wide vein, granite occurs only as isolated lenses and blocks surrounded by quartz. Deformation after the introduction of the quartz produced a series of small slips in the quartz and intervening granite. These slips are roughly parallel to the foot-wall fault and have formed along the sides of many of the veins and about granite lenses surrounded by quartz. The slip surfaces are lined with muscovite and with fine-grained molybdenite, that along some of the slips occurs in conspicuous amounts. Some veins show little indication of deformation, and these, unlike the sheared veins, contain in places white feldspar (microcline) and hexagonal plates of molybdenite. Molybdenite also occurs to some extent disseminated as small flakes in the granite distant from any veins.

The extension and character of the ore zone on either side of the underground workings is known only in drilling. The drilling indicates that the ore zone ends southeastward where the faults pass out of the granite into or along the sides of a wedge of schist that comes in between the older biotite granite to the northeast and the main muscovite granite to the south. Northeastward the ore zone passes into relatively barren granite. A drift-filled depression 50 feet wide and 400 feet long extends northwest from the ore zone, at the surface. This probably marks the northwest extensions of the ore zone faults. The blocky, fractured character of the granite at the northwest end of the depression suggests that the faults tail out in a wide fracture zone in passing away from the contact into the granite.

The new orebodies found by the diamond-drilling recently carried out by Preissac Molybdenite Mines, lie down the dip of the muscovite-granite contact from the old Indian Molybdenum orebody. According to information supplied by the company, the ore-bearing zone has been tested by diamond-drilling and found to contain bodies of ore-grade over a length of 2,000 feet and to a depth of at least 600 feet. The zone is curved in plan but extends roughly east-west and dips at 35 to 40°N. It is about 200 to 300 feet thick. Within it, two main veins have been delineated. These vary from 3 to 20 feet wide, averaging 11 feet. They pinch and swell both along strike and down dip. Some of the lenses are very rich; one hole gave two sections of 20 and 23 feet carrying 1.4 per cent MoS_2. According to J. D. MacNeill, company geologist, the drilling indicates that the granite contact flattens considerably in depth and that there is a possibility of a 'roll' upwards in the granite mass. This would not be unexpected as the Indian Peninsula granite mass is a part of the much larger Preissac-Lacorne batholith which underlies most of the rest of Preissac township at depth.

The ore indicated by diamond-drilling and the small amount of underground work already carried out in the old Indian Molybdenum mine is estimated at about 1,300,000 tons with an average content of 0.53 per cent MoS_2 and low values in Bi. This is to an average depth of 600 feet and the indications are that the zone carries down to at least a depth of 1,000 feet. Thus the northwestern contact of the Indian Peninsula granite mass is seen to be the locus of a considerable concentration of molybdenite ore.

Other Deposits

Indications are that the southern margin of the Indian Peninsula granite too may have similar concentrations of molybdenite. The Steeloy Mining Corporation holds claims in lots 6, 7, 8, and 9, rge. III, Preissac tp. (*see* Fig. 9). According to an article in *The Northern Miner* (April 24th, 1958), this company carried out a magnetometer survey and 8,246 feet of diamond-drilling there in 1943-44 and have since held the ground in good standing. The drilling was done along an easterly trending zone near the southern granite contact on either side of a prominent northeast-striking diabase dyke that cuts the granite in the middle parts of lots 7, 8, and 9. A consultant for the company estimated an ore length of 550 feet averaging 0.88 per cent MoS_2 over 4.9 feet, with a parallel vein 250 feet long averaging 0.54 per cent MoS_2 over 32 feet.

The drilling showed mostly pink and grey granites with biotite, a red type mostly well mineralized with pyrite, and a coarse red granite containing molybdenite. The molybdenite was mainly carried in the usual quartz and pegmatitic quartz veins. No. 5 hole in lot 6 was drilled through the southern contact of the granite into alternations of granite and micaceous schist with some greenstones and amphibolite. This interbanding at the contact seems to be typical for the granites of the area; it is visible at the Preissac Molybdenite mines and to a lesser extent, at the Lacorne property of Molybdenite Corporation. The diamond-drill holes drilled by Steeloy northwest of the diabase dyke were mostly in granite with few quartz veins and little mineralization. This area is away from the granite margin. Southeast of the dyke, the holes drilled in a southerly direction, that is towards the contact, show more quartz veins and markedly higher Mo values. There also the holes indicate a 'sheeted' contact, consisting of interbanded granite (gneissic in parts) and chloritic schists. These results again emphasize the importance of the granite-schist contact zone as a locus for the more economic molybdenite mineralization.

Several more occurrences of molybdenite of the same general type have been investigated from time to time in the general area of Preissac township.

The old *O'Brien claims* on the west shore of Lake Preissac, about due east of the Steeloy claims, appear to lie in the granite mass itself. Eardley-Wilmot (1925, p. 126) mentioned that the bismuth content there is much higher than at any other deposit on the Indian Peninsula. The element occurs in the form of bismuthinite (Bi_2S_3).

Minor Occurrences Associated with the Preissac-Lacorne Batholith

Figure 7 (p. 106) shows a molybdenite-bearing belt around the western 'nose' of the Preissac-Lamotte part of the Preissac-Lacorne batholith, to the north of

Lake Preissac. Norman (1944, p. 10) mentioned that in this region "siliceous pegmatites contain crystals and punches of molybdenite 1 inch or more in diameter in places." About 1,200 pounds of molybdenite is reported to have been cobbed and shipped from one of these pegmatites at the *Height of Land property*. Eardley-Wilmot (1925, pp. 129-130) described this property in rather more detail.

The old claims once held by the Height of Land Mining Company lie on the west bank of the Kewagama River about 2 miles north of Kewagama Lake, in lots 22 and 23, rge. X, Preissac tp. The pegmatites and quartz veins occur in schist to the west of the large granite batholith and, according to Eardley-Wilmot, they owe their origin to this batholith. The pegmatite dykes are very irregular in length and width and outcrop at intervals along the river-bank. At the southern end of a succession of outcrops, where a shaft has been sunk, a 15-foot-wide quartz vein, cutting granite, shows an irregular seam of muscovite containing large flakes of molybdenite along its walls. Bismuthinite is irregularly scattered throughout the middle part of the vein. A shaft 80 feet deep had been sunk to intersect this vein, on the west bank of the river. From the bottom of the shaft, two adits had been driven in opposite directions. The easterly drift, under Kewagama River, found the quartz vein which there contained muscovite, a little biotite, some flakes of molybdenite, and a little beryl. According to Eardley-Wilmot the material in the dump from this shaft would not average more than 0.1 per cent MoS_2. In the dump from a water-filled shaft north of the one mentioned above, the quartz contained molybdenite crystals and a fair amount of chalcopyrite. Other old dumps showed crystals of beryl and some phenacite. Eardley-Wilmot concluded that "the area is not very encouraging." Mineralogically these quartz-pegmatite veins at the Height of Land property closely resemble those of the Lacorne mine, particularly with regard to their beryl content.

The McClaren claims on the west side of Kewagama River, north of the Height of Land property, are mentioned by J. A. Bancroft (1912, pp. 195-196). A few flakes of molybdenite are said to occur in pegmatitic granitic dykes cutting biotite schist.

The Lavandin Mining Company property is in rge. I, N½ lots 30-33, and rge. II, lots 30-37, Villemontel tp. Amos is 18 miles by road to the northeast, and the village of Preissac lies 3 miles southwest of the property. The Kinojevis River flows through the northeastern corner of the block of claims. Part of the northwestern margin of the Lamotte batholith extends across the southern part of the property. The granite intrudes early Precambrian sediments (now mainly biotite schists) which lie under most of the central part of the property.

No exposures occur on the property except for two outcrops of a late Precambrian diabase dyke. The occurrence of molybdenite was known by the results from four short diamond-drill holes put down by former operators across the contact zone. The main rock in all the holes was biotite schist invaded by numerous dykelets and veins of pegmatitic quartz, some mineralized with small amounts of molybdenite.

During 1958, according to reports in *The Northern Miner,* another four holes were drilled by the present company. Molybdenite was encountered in all these holes, from scattered specks to the assayable quantities listed below:

No. 6 hole	1.23% MoS_2	over	2.0 feet
No. 7 hole	0.44% MoS_2	over	1.0 foot
No. 7 hole	0.70% MoS_2	over	2.0 feet
No. 7 hole	0.52% MoS_2	over	4.0 feet

The molybdenite occurs in pegmatitic quartz veins in the sedimentary schist near the granite contact.

Abitibi Territory

Molybdenite, together with pyrrhotite, pyrite, and chalcopyrite, occurs in a rusty, carbonated zone in volcanics on the southeastern flank of the Hébert Hills, Carqueville township (Dresser and Denis, 1949, p. 26).

At the *Mount Plamondon prospect,* on the southern slope of the mountain, Céloron township, a small amount of molybdenite occurs in a pegmatitic quartz vein (Tanton, 1919, p. 57).

On the property of *Northern Chibougamau Mines, Limited,* McKenzie township, Mawdsley and Norman (1935, p. 64) mention the presence of molybdenite as a minor constituent of quartz veins carrying chalcopyrite, pyrite, pyrrhotite, and traces of gold.

At *Opawica Lake,* small specks of molybdenite were reported from fine-grained aplite dykes intruding granite gneiss (MacKenzie, 1935).

At rge. VII, lot 26, Perron tp., molybdenite is reported in a quartz vein (Dresser and Denis, 1949, p. 70).

Témiscamingue County

From the *Twin Lake occurrence,* rge. X, lots 14, 15, Beauchastel tp., Robinson (1943, pp. 18-19) reported the presence of molybdenite and pyrite in quartz veins.

At the *Caron Lake occurrence,* Caire township, molybdenite is reported from pegmatite dykes in granite (Eardley-Wilmot, 1925, p. 161).

MacFort Gold Mines, Limited (McLaren claims), Dasserat township, lie around Sarnia (McDonald) Lake, and from them Ambrose and Ferguson (1945, p. 26) reported the presence of molybdenite, chalcopyrite, and pyrite, with gold in veins of grey quartz.

The Lorraine Mining Syndicate owns a property in rge. XII, lots 21-23, Laverlochère tp. There, quartz veins carry minor molybdenite together with pyrite, chalcopyrite, sphalerite, sericite, magnetite, and epidote (Retty, 1930, pp. 86-88).

The Cheabella Mine Company's property lies in rge. IV, lots 19 to 22, Montbeillard tp., near Montbeillard village 20 miles southwest of Rouyn. From there Auger (1940, pp. 37-38) described occurrences of molybdenite in pegmatites cutting gneiss. The pegmatites trend easterly and dip between 70°N and vertical. A marked feature is the concentration of biotite in the gneiss along the pegmatite walls—Auger reported that the wall-rock in places holds up to 75 per cent of the dark mica (cf. *Acme Molybdenite property*, p. 208).

According to a report from the Ore Dressing Laboratory of the Mines Branch, Ottawa, a sample of 3,807 pounds of ore from this property was submitted by the company. No difficulty was met with in separating the molybdenite. The tested sample contained 1.94 per cent MoS_2.

From the *Evain Lake occurrence,* Wilson (1912, p. 57) reported the occurrence of molybdenite in granite pegmatites.

From the *Dransfield claims,* Rouyn township, Hawley (1934, pp. 49-51) reported the presence of pyrrhotite, pyrite, arsenopyrite, stibnite, and molybdenite, together with gold, in quartz veins.

Molybdenite has been reported as an accessory mineral in various gold mines in Rouyn township. Examples are: the McWatters gold mine (Wilson, 1948, pp. 788); Granada Gold Mines, Limited (Hawley, 1932, pp. 30-31, 39-41); and the Don Rouyn mine (Wilson, 1941, p. 73). The orebodies are mostly veins of quartz and carbonate or carbonated shear zones in schist. Accompanying minerals are pyrite, pyrrhotite, arsenopyrite, galena, sphalerite, native gold, and, in one instance, hessite.

Ungava (New Quebec)

From *Paint Hills Islands,* on the east coast of James Bay, Low (1899, pp. 145-146A) and Hoffman (1902, p. 23R) reported the occurrence of molybdenite and pyrite in syenite dykes cutting trap rocks.

On *Great Whale River,* R. Bell (1879, p. 22C) reported examining a specimen containing molybdenite that was "said to have been found in the neighbourhood" of the Hudson's Bay Company trading post.

Newfoundland (Coast of Labrador)

On an island 52 degrees west from the centre of Saddle Island, north of Kikkertarjote Islands, in the *Nutak area,* molybdenite occurs in small amounts in a sulphide zone with pyrite, chalcopyrite, and pyrrhotite (Douglas, 1953, pp. 40-41).

Christie (1952, p. 14) reported two other occurrences of molybdenite in this area. On the south shore of Operngeviksoak Island it occurs in fine disseminated flakes in an aplite. On the south shore of Okak Bay the mineral occurs in an amphibolite-bearing pegmatite.

At a locality 7 or 8 miles south of Black Island Harbour, *Aulatsivik Island,* molybdenite occurs in thin lenticles in gabbro and in small pegmatite and aplite dykes (Douglas, 1953, p. 38).

At Duck Island in Kaipokok Bay, 15 miles south-southwest of Aillik, in the *Makkovik area,* disseminated pyrite and molybdenite occur in granite (Douglas, 1953, p. 29).

On the west coast of Big Bight, south of Cape Strawberry, about 8 miles southeast of Makkovik, granitic tongues and pegmatitic quartz veins cutting a brecciated zone carry molybdenite, chalcopyrite, pyrite, hematite, magnetite, and fluorite (Douglas, 1953, pp. 28-29).

At Tuchialic (Tessivjâluk) Bay, 22 miles southwest of Cape Harrison, "insignificant" blobs of molybdenite in pegmatite are reported by Douglas (1953, p. 28).

At Domino Harbour, *Island of Ponds,* molybdenite, magnetite, and malachite occur in a pegmatite (Douglas, 1953, p. 13).

Grenville Province in Ontario

The Grenville province in southern Ontario is comparatively rich in deposits of molybdenite; about 120 in all have been recorded from time to time. On the whole, the deposits are very small and erratic in values, and few are of more than mineralogical interest. Production from this area, nearly all during World War I, amounted to the equivalent of about 170,000 pounds of MoS_2 concentrates; by far the most of this came from deposits in Renfrew county. At the present time there are no active molybdenum-producing properties in this area.

The general geological characters of the deposits of the Grenville province have already been discussed (Chapter V). The descriptions that follow cover the main areas, especially those with which the writer is familiar. Information on additional deposits has been obtained from published accounts, although many known occurrences have probably been omitted.

Parry Sound District

Molybdenite has been noted from a few localities in the Parry Sound district, but no production has been recorded.

Satterly (1943b, p. 48) states:

> A showing known locally as the *Bloor mine* is located in lot 9, concession XII, approximately half a mile north and northwest of the road corner at the boundary line between lots 8 and 9, concession XI, Christie township. There are three openings from south to north: (1) a trench 25 by 4 feet and 6 feet deep, now largely caved in; (2) a pit or shaft 10 by 10 feet filled with water; (3) a pit 10 by 16 feet, with water in the deeper west half of the pit.
>
> The country rock is a dark-green hornblende gneiss containing irregular, lenticular bands of red garnet rock, such as seen in Lount township. The pits expose a coarse-grained (one-half inch) greenish crystalline limestone, containing bands of red garnet rock, and a hornblende-garnet-carbonate-quartz-feldspar rock. In the latter a few small clusters or flakes of molybdenite were found.
>
> This occurrence is of no economic importance.

Ellsworth (1932, p. 175) reported the occurrence of rare molybdenite in a radioactive pegmatite containing uraninite and calciosamarskite from near a bay in *Blackstone Lake,* con. XI, lots 9 and 10, Conger tp.

From con. II, lot 18, *Lount* tp., Satterly (1943b, pp. 48-49) reported:

> In a sandy field in lot 18 half a mile south of the boundary line between concessions II and III, seven pits have been put down to explore an occurrence of molybdenite. These pits are scattered over a length of about 140 feet. It is reported that the work was done in 1940. No exposures of rock are to be seen in the field near the pits, which expose dark-green hornblende gneiss containing bands and irregular masses of red garnet rock and a minor amount of pegmatitic material containing hornblende, garnet, and titanite.
>
> The main pit is 10 by 15 feet and from 4 to 5 feet deep and is sunk in a shallower pit 37 feet in diameter. It exposes hornblende gneiss containing irregular masses of red garnet rock as much as 10 by 20 feet in dimensions and containing coarse (half-inch) aggregates of white calcite and hornblende. Molybdenite in small clusters of scales is irregularly distributed. It occurs disseminated in the garnet rock, or as streaky disseminations in schisted, chloritized hornblende gneiss. Even in this main pit much of both the garnet rock and hornblende gneiss shows no molybdenite. The schisted hornblende gneiss appears to be the more favourable host rock. A very little molybdenite was seen in two of the remaining pits, but in the other four none was found.
>
> The occurrence is apparently just a local dissemination of molybdenite of uneconomic proportions. The lack of any well-defined structure in the occurrence does not lead one to expect that a body of any size of the same grade as the best material to be seen in the main pit would be found nearby.
>
> Nevertheless, the association of molybdenite with garnet rock and hornblende gneiss here and also in Christie township would suggest that prospecting of the garnet rock, which is not uncommon in Lount township, might lead to more finds.

In addition to the above, Satterly (1943b, p. 48) mentioned that a few flakes of molybdenite occur, together with pyrrhotite, pyrite, and chalcopyrite, at a number of copper showings southwest of Parry Sound.

Haliburton Area

The Haliburton area of southern Ontario contains a considerable number of small molybdenite deposits which in the past have been explored and mined on a small scale, mostly during World War I. According to Satterly (1943c, p. 60) the mining was carried out at a loss and the total production from all the deposits did not amount to more than 10,000 pounds of molybdenite concentrate. The prospects for further economic molybdenite production from the area do not seem to be promising. In nearly all the deposits the molybdenite distribution is very erratic and the average grade is low. A comparatively recent sampling campaign, carried out on what is probably the most promising of the deposits, has shown that the average grade to be expected is low, even from deposits that apparently carry a considerable amount of large flakes.

A few deposits are found in Laxton and Somerville townships, Victoria county, and in Lutterworth, Glamorgan, and Harcourt townships, Haliburton county. But most lie in Cardiff and Monmouth townships, Haliburton county.

The most comprehensive account of the molybdenite deposits of the Haliburton area is that by Satterly (1943c), based on his investigations in the area in the summer of 1942. Two earlier reports—A. L. Parsons (1917) and Eardley-Wilmot (1925)—contain detailed descriptions of most of the properties. The following account is based on the writer's study of four of the deposits and on the above-mentioned publications.

The area to be dealt with lies in the eastern part of Haliburton county, mainly in the townships of Cardiff and Monmouth. Its general geology and the location of molybdenite occurrences are shown in Figure 10, which is based on the map (No. 52A) accompanying Satterly's (1943c) report. Of the 22 deposits known in the area, about half lie in or close to the belt of sedimentary and metamorphic rocks (limestones and dolomites with minor amphibolite and paragneiss) that runs in a northeasterly direction from Gooderham to near Mumford. A special concentration occurs near Wilberforce village in the northeastern corner of Monmouth township. Within this belt is a zone about 13 miles long—from Gooderham to just south of Wilberforce—of alkali syenite with minor bands and bodies of nepheline syenite. The occurrence of these alkali-rich rocks in the area of greatest concentration of molybdenite deposits is very interesting and, to the writer, significant, in view of the known geochemical associations of molybdenum and of the relations observed in other parts of the country. Satterly (1943c, pp. 17-18) believed that this belt resulted from the replacement of the tilted and folded paragneiss and limestone along a definite zone, possibly a fault, by nepheline-depositing solutions, resulting in the formation of nepheline-albite gneiss. Nepheline-pegmatite masses formed by the intrusion and partial replacement of nepheline gneiss and paragneiss. A later stage, according to Satterly, was the intrusion of alkali syenite with partial to complete replacement of much of the nepheline-albite gneiss, together with satellic intrusion of syenite-pegmatite.

It is very possible that molybdenite was introduced, into suitable host rocks, at some stage in this alkaline metasomatic or igneous activity.

A subsidiary concentration of molybdenite deposits occurs in central Cardiff township, south and east of Cheddar. There the deposits occur in belts of paragneisses or in the enclosing granite and granite gneisses.

Of the twenty deposits in the area on which information is available, eight are in pegmatites and six are pyroxenitic types; the others are disseminations, bands in gneiss, or other less-definite types. In the central Cardiff township area, six out of eight occurrences of molybdenite are in pegmatite dykes or sills and only one is of the pyroxenitic type. In the Gooderham-Mumford belt, five out of the twelve are pyroxenitic types and only two are pegmatitic. These figures seem to reflect the differences in the country rocks between the two areas.

In a few deposits, molybdenite is the only sulphide mineral present, but more typically it is intimately associated with iron sulphides, mostly pyrite, sometimes pyrrhotite. Chalcopyrite is only sparingly present in a couple of deposits. The association of molybdenite is, as mentioned, characteristic of the Grenville deposits and seems to be independent of the type of deposit involved. The proportion of the different minerals varies considerably. In some deposits the iron sulphides are accessory only, as at the American Molybdenites property on lot 32, con. XVI, Monmouth tp.; and in some deposits the molybdenite flakes are set in an almost solid matrix of pyrite and pyrrhotite, as at the Padwell property on lot 11, con. XV, Monmouth tp. This latter type is reminiscent of the typical sulphide-pyroxenite type of deposit in the Gatineau region of Quebec—a type that is not

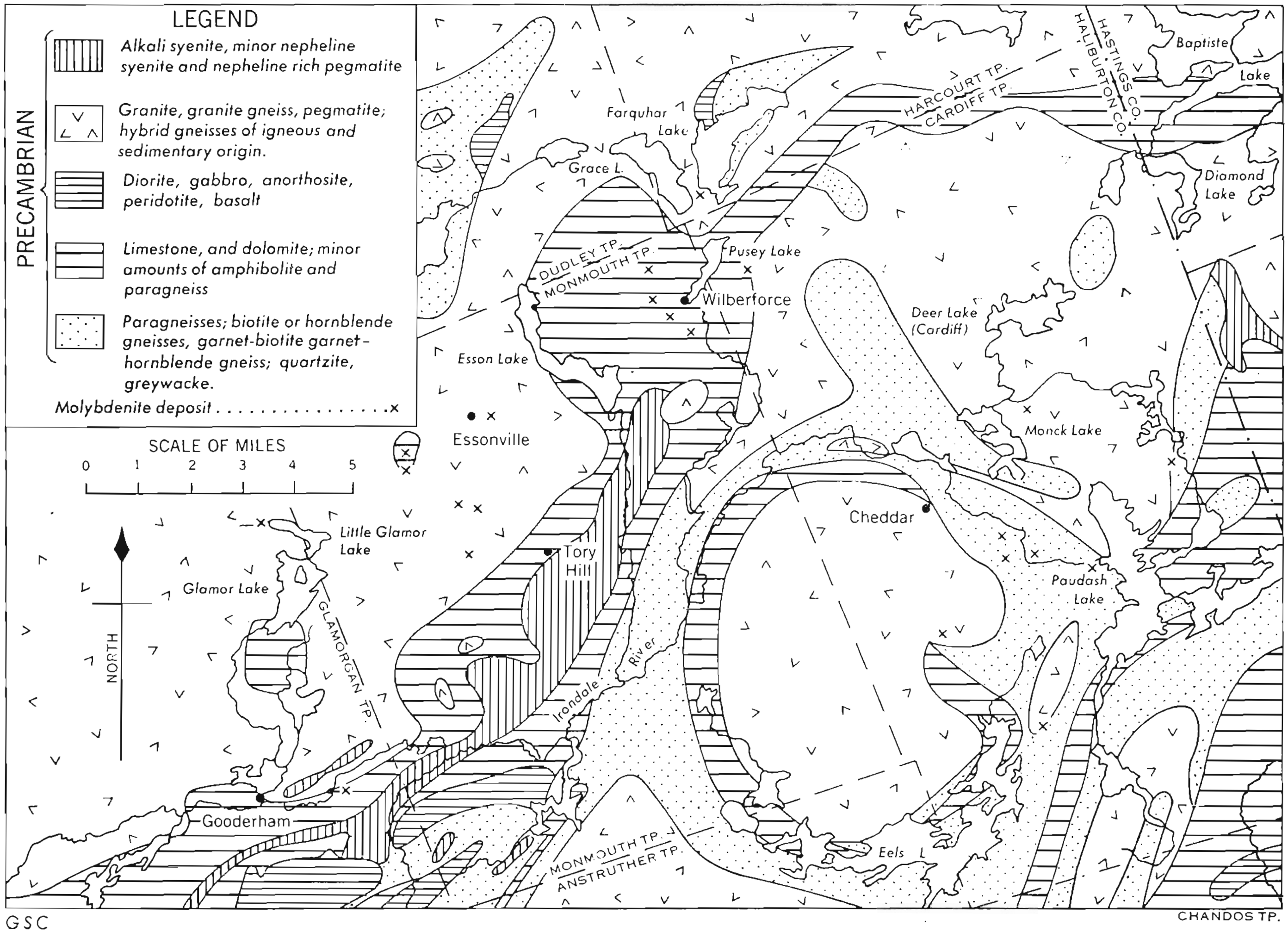

Figure 10. *Sketch map of Haliburton-Bancroft area, Ontario (after Satterly and Hewitt).*

so well-developed in the Wilberforce area. So far as is known no other base metals occur in more than trace quantities in the molybdenite deposits of the Haliburton area.

In one deposit molybdenite is associated with graphite in banded gneisses; in another pegmatitic deposit purple fluorspar is present.

As virtually none of the deposits has been followed to a depth of more than a few feet, none has been worked underground, and few have been diamond-drilled—little is known of their structures or of the behaviour of the mineralization in depth. Many of those occurring in the metasediments appear to be concordant with the layering of the country rocks.

American Molybdenites Ltd.

The workings on this property lie in lot 32, con. XVI, Monmouth tp., to the south of the Canadian National railway at a point about 0.4 mile west of the main highway at Wilberforce station. Access is by means of a gravel road running along the north side of the track from the highway. From this an old trail leads over the railway and across a beaver dam over a creek. The trail leads directly to the old mill site, a distance of about 150 yards. The outcrop and workings are about 90 yards to the west of the mill site.

The workings consist of a stripped outcrop, about 100 yards long and 50 yards wide, elongated in a north-south direction. Along the southern half of the eastern edge, a quarry face about 10 feet high has been opened. Most of the spoil from this appears to be in place. Judging by the freshness of the exposures, there appears to have been a considerable amount of recent blasting along this face, and perhaps up to twenty diamond-drill holes have been bored vertically behind the face, probably as a means of sampling the deposit. At the northern end of the outcrop are two water-filled pits, the larger of which has a face more than 20 feet high above water level on the south side. To the north the ground is flat and swampy. The second pit lies northeast of the first and is almost wholly off the outcrop. Eardley-Wilmot (1925, p. 75) mentions these two pits and also two shafts which are 30 and 40 feet deep respectively. These were not seen (unless they were, in fact, the water-filled pits just described).

The history of the property is described by Eardley-Wilmot (1925, pp. 75-76).

> The originally named Dominion Molybdenites Ltd., was incorporated in May 1917, for $1,000,000. In August of the same year the name was changed to American Molybdenites Ltd. In the summer of 1918 an option was given to the Molybdenum Products Company, which was incorporated in July 1918. This company did some development work and built the concentrator. The property has since reverted to the American Molybdenites, Ltd.

During 1918 the company built a 125-ton concentrator using the Callow oil-flotation process, and also erected office buildings, etc. Eardley-Wilmot (1925) gave this account of operations during the period of working.

> The ore is hoisted in a 1¼-ton skip from the mine workings, up a 10-degree tramway to a 200-ton mill bin. It is crushed by jaw-crushers and a Marcy ball mill, classified

and passed over Callow cells and the concentrates dried in a brick oven. Previous to the erection of the concentrator about 900 tons were mined in 1917, from which 86 tons of ore were shipped as follows: to the Mines Branch, Ottawa, 58.6 tons of 0.21 per cent ore and to Renfrew 27.2 tons of 0.39 per cent ore. About 320 pounds of molybdenite were recovered. Besides this, some ore was treated in the mill, which ran only for a short time, but no information concerning results was obtained. During the summer and autumn of 1921 more stripping was done and the concentrator ran for a short time, but as far as can be ascertained the results were not very satisfactory.

As can be seen from the above figures the grade of ore stripped (which must be presumed to represent the best available) ran around 0.27 per cent MoS_2. Eardley-Wilmot during his visit estimated that the ore exposed would run around 0.25 per cent. Satterly (1943c, p. 69) made this comment: "The deposit is too low-grade to be of any economic importance." Due to the nature of mineralization, which is sparse and erratic, any attempt to sample the deposit by ordinary means would not give a satisfactory result; but from a visual inspection it seems to the writer that the figures derived from the treatment of the ore give a fair indication of the best grade to be expected. Eardley-Wilmot's figure of 0.25 per cent MoS_2 is probably a fair estimate for the deposit as a whole.

The area of mineralized rock on the property is considerable. Trenching about 200 feet to the southeast of the southern end of the main exposure reveals molybdenite-bearing material of identical type. The deposit may be 500 feet long by perhaps 100 feet wide. This gives a large potential tonnage of mineralized rock that could be easily glory-holed with little or no stripping, but even under these conditions the low grade of the ore might not make mining worth while.

The rock exposed in and around the old workings is mainly a very characteristic pyroxene-albite rock, typically coarse grained with the individual grains ranging between ½ and 1 inch, but varying considerably in grain size. It consists of light green, subhedral to euhedral pyroxene (diopside) crystals set in a matrix of pure white albite grains. Within this granular rock occur irregular patch- or vein-like segregations of coarser albite and pyroxene. In these, especially the vein-like forms, albite predominates over pyroxene. These coarser bodies grade gradually into the surrounding granular rock and may be due to some form of metamorphic segregation. It does not seem likely that they represent separate intrusions of the same material. Patches of crystals and aggregates of a dark green pyroxene occur within the body of the pyroxene-albite rock; some individual crystals are up to several inches long. These may represent some form of alteration from the lighter green mineral. Light green euhedral crystals of apatite are present, scattered throughout the rock at random; one individual observed was at least 3 inches long. Sphene, as brown well-formed crystals, is another accessory mineral.

At the edge of the large pit at the north end of the outcrop a vein-like segregation of coarse pyroxene and albite carries large interstitial grains of a grey to white carbonate, probably calcite. Molybdenite occurs within the pyroxene-albite rock as individual flakes and aggregates ranging in size from 1 or 2 mm up to about 2 cm. Its distribution is very erratic—in some places it seems plentiful but much of the rock is practically free from the mineral. This erratic distribution would necessitate very close spacing of samples in order to obtain a true value for the deposit. The only other metallic mineral observed in the pyroxene-albite rock was pyrite, and this occurred mainly near the inclusions of gneiss (see below), which are particularly rich in pyrite and some pyrrhotite.

Within the mass of pyroxene-albite rock, numerous inclusions of a fine- to medium-grained gneiss occur, many striking in a common direction of about N45°W and dipping at high angles to the southwest. These inclusions vary in thickness from an inch or two up to two feet. They are nearly all very rusty, due to the weathering of pyrite and pyrrhotite. Satterly (1943c, p. 69) called this rock "a rusty biotite paragneiss", but biotite was not everywhere present in the inclusions examined by the writer. The gneiss is composed mainly of plagioclase and light green pyroxene, with the iron sulphides as accessory minerals, and possibly some quartz. The general grain size of the rock is about 0.5 mm. The main constituents of the gneiss are thus the same as those of the coarse, mineralized rock. The latter may have formed during processes that involved the pyroxenization of an original biotite-plagioclase paragneiss, or alternatively by metamorphic segregation within an original pyroxene-gneiss formed from sediments of the right composition under regional metamorphism. This process may be compared with that described by Satterly for the formation in the area of nepheline-syenite pegmatites from original nepheline-biotite gneisses.

The writer saw no evidence in the area of the workings that the pyroxene-albite rock formed directly as a replacement deposit in limestone. The gneiss remnants indicate that they formed the original country rock, and the nearest outcrop of limestone to be found was on the trail about half way between the mill site and the creek, well to the northeast of the deposit. The high albite content of the mineralized rock indicates a high Na_2O content, which seems to reflect the geochemical nature of the belt running through the Gooderham-Wilberforce area and fall in line with the known geochemical associations of molybdenum.

Other Occurrences

Padwell Property

This property lies in lot 11, con. XV, Monmouth tp., about 4 miles northwest of Tory Hill station. The one open-pit on the property is about 100 feet north of the old Essonville gravel road, along the boundary between concessions XIV and XV, about a mile west of the main Wilberforce-Haliburton road at Essonville.

The property has been described briefly by A. L. Parsons (1917, p. 307), Gwillim (1920, p. 121) and Eardley-Wilmot (1925, pp. 74-75). The latest published account is by Satterly (1943c, pp. 67-68), who said:

> It (the property) was first opened up in 1916 by G. Padwell, who shipped to the Mines Branch concentrator, Ottawa, 55.6 tons of hand-picked ore, grading 1.4 per cent MoS_2, from which 1,268 pounds of molybdenite was recovered; in 1917 he shipped 62 tons of 1.0 per cent MoS_2 ore to the International Molybdenum Company's concentrator at Renfrew.

> Additional development on this property and the lot to the south was performed by Canadian Molybdenite Mines, Limited, in 1940... it would appear that G. Padwell in 1916 and 1917 mined out a small body of ore and that later exploration has failed to reveal any commercial bodies of molybdenite.

The writer examined the trench on the site of the original Padwell workings in July 1958. It is 150 feet long, 10 to 30 feet wide and from 1 foot to 10 feet deep, with its long axis bearing N20°W.

The main rock exposed in the trench is a very coarsely crystalline, pink to cream calcite rock (meta-limestone) with various amounts of accessory biotite and/or phlogopite, light green pyroxene (diopside), and a pale yellow garnet. The meta-limestone is layered or bedded in units about a foot thick, which dip to the south at from 5 to 10 degrees. There are occasional interbedded layers of hornblende schist, up to 6 inches or so in thickness. These layers have been fractured and boudinaged, the more plastic calcite having flowed into spaces between the boudins.

Also present are thin concordant layers of a pink to red feldspar rock carrying very little accessory mineral, probably a coarse syenite. Many of these layers carry thin selvedges of green pyroxene adjacent to the limestone.

Very little molybdenite can be seen in the meta-limestone itself, just an occasional flake, but loose flakes occur sparsely scattered among the rock spoil in the trench. In the centre of the trench are large loose blocks of pyroxenite carrying pyrite, pyrrhotite, and chalcopyrite, with notable molybdenite as flakes up to an inch across. At one place a patch of this mineralized rock can be seen in situ, grading into the limestone on either side. It would appear that there had originally been a concordant lens-like layer of the pyroxenite in the limestone, most of which has since been removed. The sulphides are interstitial to dark green pyroxene crystals, in common with the normal Grenville pyritic-molybdenite mineralization. The pyroxene in these blocks seems to be distinct from the small light green crystals in the body of the limestone itself.

Satterly refers to the mineralized material as a "rusty basic pegmatite" which would seem to imply agreement with the ideas of Spence concerning the origin of Grenville pyroxenite. This mode of origin certainly seems to fit in with the field observations at the Padwell property. Although the wall-rock for the sulphide-bearing pyroxenite is a meta-limestone, there seems to be no genetic connection between the two. There is no evidence in the exposures to suggest a direct contact-metamorphic origin for the pyroxenite.

Joiner Property

This property lies in the north half of lot 3, con. XX, Cardiff tp. It is on the top of a high, northerly trending ridge in hilly and well-wooded country, about 1½ miles due northeast of Wilberforce station. The writer reached the property along an old and not too clearly marked bush trail that leaves the Canadian National railway along Pusey (Black) Lake, at a point 680 yards north of the bridge at the outlet of the lake. It takes about 30 minutes to walk along this trail to the property. Probably a better means of access is that taken by Satterly (1943c, p. 64).

> The route taken to reach the property in 1942 was northeast on the road that leaves the Wilberforce highway just north of Wilberforce Lake, then north through the farm of G. Barnes, and then following a wagon road on foot; the workings on the ridge were reached at between 69 and 97 chains from a field. This would be 5 miles from Wilberforce. The ridge is just over three quarters of a mile east of the Canadian National track.

The early history of the property is given by Eardley-Wilmot (1925, p. 69).

> A portion of the claims was staked by Mr. W. E. Joiner in 1917. In 1919 Cardiff Molybdenite Mines Ltd., capitalized at $40,000, with Mr. Joiner as general manager, was formed with the object of defining the ownership. In January 1922, a new company called United Molybdenum Corporation, Limited, capitalized at $750,000, was formed, 300,000 shares of stock being issued to the Cardiff Molybdenite Mines Ltd., for their properties consisting of 400 acres.

According to Satterly (1943c, p. 64), the property was acquired in 1935 by Shallberg Molybdenite Company. In 1936, Ventures, Limited, carried out a sampling program between June and September, under the direction of E. Y. Dougherty. No further work has been reported since.

Satterly summarized the results of the 1936 sampling by Ventures, Limited.

> . . . new trenches aggregating over 3,000 feet in length were opened up at intervals across or along a north-northeast length of about 1,600 feet and several old pits and trenches were cleared out. This work disclosed three main showings of molybdenite from 250 to 500 feet in length and a number of minor showings. A large number of chip and a lesser number of channel samples were taken.
>
> Nearly 50 assays were made on the samples taken and show a range from nil to 0.64 per cent MoS_2, but only 5 assays were greater than 0.20 per cent MoS_2 and over half the assays were below 0.10 per cent MoS_2. It is doubtful if, even by selective mining, any large tonnage of ore grading 0.5 per cent could be obtained. The property must be considered of no economic importance at present.

These conclusions were reached when molybdenite was worth 90 cents a pound; at the present price of $1.18 the property might be worth reassessing. The tonnage involved would probably be considerable and it could be mined fairly easily by open-cut, and later by driving an adit from the bottom of the valley to the west and using a glory-hole method. A necessary prerequisite to any operations would be a ¾-mile-long road down the valley, due north to the Canadian National railway and the highway at the head of Pusey Lake.

Satterly (1943c, facing p. 64) reproduced the geological sketch map of the Joiner property prepared by E. Y. Dougherty for Ventures, Limited. It shows all the trenches and other workings together with the main geological features. The ridge on which the property is situated is made up of a north-south-trending complex of interbands or interbeds of crystalline limestone, biotitic paragneiss, and a monzonite gneiss (augite-feldspar gneiss). Satterly interpreted the last-named unit, together with its associated pegmatitic phases, as being a sill rock intruded into the sedimentary series. This may well be, but from the writer's observations the gneissosity in the 'monzonite' gneiss and in the sedimentary gneisses seems to be the result of a common period of metamorphism. The planes of foliation are concordant and the direction of the plunge of the linear elements is constant over the whole area in all rock units exhibiting linear structure. The sills of monzonite, if such is their true nature (they may in part have been extrusives), must have been present in the sedimentary succession prior to the orogenic movements and metamorphism that changed the whole pile into gneisses and crystalline limestones.

Within the zones of monzonite gneiss are bands of augite-feldspar pegmatite of all sizes and all degrees of coarseness of crystallization. The normal monzonite gneiss exhibits a grain size varying between 2 or 3 mm and perhaps 5 mm. It is composed of black augite and flesh-coloured or yellowish grey feldspar. The augite is distinct from the metamorphic diopside seen in other Grenville molybdenite deposits (e.g. American Molybdenites deposit).

The lineation in the gneiss plunges at about S30°E, between 10 and 30 degrees from the horizontal. This value is constant over the whole area in all the gneissose units. The gneiss shows well-developed joints, striking at N80°W and S20°W.

The segregations of pegmatite within the gneiss vary from concordant lenses or layers only an inch or two thick to masses taking up the whole of exposures several feet across. Where the contacts with the monzonite gneiss can be seen they are invariably concordant with the planes of gneissosity. The contacts are gradational and the pegmatites seem to be replacements or metamorphic segregations within the gneiss, probably formed under a period of intense metamorphism. Their mineralogical identity with the gneiss suggests this local derivation rather than that they are later 'intrusives' into the gneiss.

Two other rock types whose origin is rather puzzling, occur in the trenches (especially well-exposed in the extreme northern workings which seem the most recent). The first, which is important as it seems to contain the largest amounts of molybdenite, is a very coarse grained augite-feldspar-calcite pegmatite. In places, well-formed feldspar and augite crystals up to 6 inches long occur in a coarse-grained matrix of white calcite. This type is best seen along a low working-face connecting the west ends of the four most-northerly trenches on the property. The contact with the monzonite gneiss there clearly shows a concordant attitude.

The second type, which apparently carries little molybdenite, is composed of perhaps 90 per cent calcite, with various amounts of augite and feldspar. Apatite was noted as an accessory mineral. The augite and feldspar occur in irregular segregations within the rock. In one of the trenches in the northern part of the property an outcrop showed that this calcite rock has a crosscutting relationship to the monzonite gneiss and, in part, to the monzonite pegmatite. However the contacts with the latter are gradational and calcite occurs interstitially to the silicates in a rather wide border zone. This border zone was in fact a small representative of the massive augite-feldspar-calcite pegmatite described above, and it seems to suggest that the latter has formed by the introduction of calcite into the monzonite pegmatite. The origin of these irregular calcite bodies should probably be sought in the beds of crystalline limestone in the metasedimentary series underlying parts of the area. These seem to have been mobilized under regional metamorphism at a fairly late date and to have invaded the other rocks, in places producing the peculiar hybrids described above.

The metasedimentary rocks exposed on the Joiner property consist of crystalline limestone and biotite paragneiss. These rock types are not as well exposed as those described above, but can be seen in random outcrops in the old trenches in the southern part of the property. The limestone is a coarse-grained calcite rock with various quantities of mica (biotite or phlogopite) in flakes 1 to 2 mm in diameter. Light green diopsidic pyroxene is also present in lesser quantities.

The paragneiss is a medium-grained rock, carrying much biotite. The outcrops of this are nearly all very rusty due to the weathering of small amounts of iron sulphides. In one good exposure, about the centre of the property, one can see 6 feet of alternating bands of this biotite paragneiss and gneissic to pegmatitic monzonite; the latter carries molybdenite flakes up to an inch across. The bands of paragneiss, which reach a maximum of a foot in thickness, can be seen to thin out along strike—the two adjoining monzonite bands come together as the paragneiss disappears. Thus the latter seems to form discontinuous inclusions or remnants within the monzonite. Another good exposure of the rusty-weathered paragneiss can be seen in a deep pit just south of the bush trail back to Wilberforce, at the point where it begins to descend from the ridge. There, the paragneiss overlies a 3-foot-thick band of molybdenite-bearing monzonite, which in turn overlies a thick band of massive crystalline limestone.

A minor member of the metasedimentary series, seen only in one trench, is a thin-bedded whitish quartzite. It overlies crystalline limestone in the trench, and both rocks have been thrown into small-scale folds whose axes plunge parallel with the general lineation direction (N38°W).

Molybdenite is the chief metallic mineral seen on the property. It occurs mainly in the monzonitic rocks and associated types. The writer found only one instance of it in a member of the metasedimentary series, although Satterly (1943c, p. 64) mentioned its occurrence "in the sedimentary gneisses and crystalline limestones where monzonite is near or in immediate contact with the sediments." The most spectacular development of molybdenite seen on the property is in the coarse augite-feldspar-calcite pegmatite described above. In this, molybdenite occurs in flakes and plates up to an inch or more across. This type is seen in the spoil heaps along the small working-face in the northeastern part of the property. At first sight, the material appears to be very rich ore, but closer examination shows that the plates occur only along a face of the blocks, not throughout them. The molybdenite-rich faces probably represent fracture or joint planes in the pegmatite, along which the sulphide was deposited.

Flake molybdenite is also present in the monzonite pegmatite. Molybdenite also occurs in parts of the medium-grained monzonite gneiss, but in this rock type it is sparingly distributed in small flakes, about $\frac{1}{4}$ inch in diameter, showing no relation to fractures or other openings in the rock. It appears to be an original accessory mineral of the rock.

The only metasedimentary occurrence of molybdenite seen by the writer was that of small sparse flakes in an outcrop of the biotite paragneiss not far from its contact with coarse monzonite pegmatite, from which the paragneiss may have been mineralized.

Pyrite is the only other sulphide seen on the Joiner property and it is only present in sparse amounts. In the coarse augite-feldspar-calcite rock, pyrite occurs as occasional well-formed crystals up to ½ inch across.

The close association of the molybdenite with the monzonite rocks seems to suggest a genetic connection. The sulphide probably was introduced in the monzonite magma in small amounts and crystallized in the original rock which later became monzonite gneiss. During the process of pegmatite formation the molybdenite appears to have been concentrated slightly, and coarsened, together with the other rock-forming minerals.

Farquart Lake Deposit

This occurrence, in lot 3, con. I, Harcourt tp., has been reported on by Eardley-Wilmot (1925, p. 72), A. L. Parsons (1917, p. 298), Satterly (1943c, pp. 65-66), and others. It was visited briefly by the writer in the course of investigating deposits in the Wilberforce area.

The deposit is approached from the highway northeast of Wilberforce village, along the gravel road leading north to Farquart Lake holiday camp at the south end of the lake. The workings lie on top of the high ground northwest of the camp.

According to Eardley-Wilmot the property was owned by the Canadian Land and Immigration Company of Haliburton, Limited, and most of the work was carried out in 1898 and 1901. A pit 12 feet deep was sunk on the southern part of the prospect without encountering much ore. A shaft 7 by 8 feet and 15 feet deep was sunk on the northern part, but the ore was of too low grade. From the second shaft, a surface trench was excavated eastward down the slope of the hill. This trench is 60 feet long, 6 feet wide, and up to 15 or 20 feet deep. It is the main working that is still open for inspection; the southerly shaft is now full of water. Eardley-Wilmot reported that the trench yielded the most promising amounts of mineral, the molybdenite occurring in pyrite veins and veinlets. A working to the south of this trench was also said to have yielded "promising-looking ore", but this was not seen by the writer.

In 1911, 50 pounds of flake molybdenite was reportedly taken out for experimental purposes by a British steel company. In 1925 Eardley-Wilmot estimated that about 2 tons of hand-cobbed, high-grade material was still lying on the dumps. This figure was also given by A. L. Parsons who stated that the material came from a nodular mass in the pyroxenitic country rock. He estimated the stockpile material "to be a 10 per cent ore", but otherwise "very little molybdenite was seen either on the dump or on the walls of (the) openings". This opinion was also expressed by Satterly who found very little molybdenite; in fact, "only three flakes of molybdenite were seen in the open cut". The writer's examination served to confirm the above reports. Only at one place near the eastern entrance to the main open-cut was any molybdenite seen in situ.

Satterly stated that "an open cut 3 chains to the south (of the main trench) on the east side of the outcrop showed pyroxenite carrying pyrite and a few 1-inch flakes of molybdenite." He concluded that "owing to the scarcity of molybdenite in this occurrence no additional expenditure would appear to be justified."

The deposit lies at the southwestern extremity of an area of paragneisses and limestones with basic intrusives, which forms the shores of Farquart Lake. This area is surrounded by the regional granite-gneiss, just to the north of the main limestone belt running through Monmouth, Cardiff, and Harcourt townships (*see* Fig. 10). Exposures at the property are scarce, so it is not possible to say whether the deposit lies in the granitic gneiss or the metasedimentary rocks.

The immediate wall-rock of the workings is a dark green, medium-grained pyroxenite. In places pegmatitic patches are developed with crystals up to an inch long. Satterly reported a granite pegmatite west of the south shaft. The exposures at both the main trench and the south shaft show an extremely well marked jointing striking between N85°E and due east, and dipping steeply north or vertically. A less-marked set occurs at right angles to this. The long axis of the main trench (at N85°W) very nearly corresponds to the major joint-direction.

The main mineral deposits on the property consist of veins and less-regular bodies of pyrite, striking almost north-south and dipping at 55 to 65°E. Satterly reported insignificant amounts of pyrrhotite in the veins with the pyrite. He quoted from a report by Mills (1902, p. 47) that more than a ton of pyrite was taken out of a vug occurring in one of these veins. The only molybdenite seen by the writer occurred as flakes and clusters of flakes, 2 to 3 mm across, distributed very sparingly in the pyrite of a 3-inch-wide vein, about 6 feet from the eastern entrance to the main open-cut. The pyrite could be clearly seen filling the interstices of large pyroxene crystals, indicating its later age of crystallization.

Although of no significance economically, this deposit falls into the general class of heavily pyritic molybdenite-bearing deposits so characteristic of the Grenville province in southern Ontario and southwestern Quebec.

Miscellaneous Properties

The following descriptions are taken from Satterly (1943c, pp. 60-71). The properties were not visited by the writer.

HALIBURTON COUNTY

Cardiff Township

Concession V, Lot 11

The Orr-Kidd prospect on lot 11, concession V, Cardiff township, was staked in 1914. Eardley-Wilmot reports that the deposit consists of two pegmatite dikes, 6 inches and 2 feet wide, cutting gneiss. The pegmatite contains finely disseminated pyrite, and a small amount of molybdenite in large flakes. An open cut 55 feet long and from 4 to 6 feet wide, with an average depth of 5 feet, has been made along the pegmatite zone.

In 1915 F. O. Orr sold 50 pounds of MoS_2 concentrates.

Concession IX, Lot 18

Development work on lot 18, concession IX, Cardiff township, was carried out by W. E. Joiner for Paudash Lake Molybdenite Mines, Limited, in the autumn of 1917 and consists of 3 pits with the following dimensions: 75 by 15 feet and 7 feet deep; 50 by 30 feet and 10 feet deep; 15 by 15 feet and 7 feet deep. The pits are 33 chains north of the boundary line between concessions VIII and IX and 17 chains N 50° E from the old farmhouse.

The country rock is a hornblende gneiss. In the pits there is exposed a rusty-weathering, coarse pegmatite containing molybdenite as sparse large flakes as much as 1¼ inches in diameter, much pyrite in vugs with smoky quartz, irregular splashes of pyrrhotite, and locally small amounts of purple fluorite.

The several tons of selected ore, averaging between 3 and 4 per cent, mentioned by Eardley-Wilmot as stored in a shed were still on the property in 1942. This material seems to be free of pyrite. The same author reports that several hundred pounds of pure flake averaging over 90 per cent MoS_2 was sent to the United States.

Concession X, Lot 11

The workings of the Evans, O'Brien, or Treasure Hill Mine are situated in the north half of lot 11, concession X, Cardiff township, 6 chains east of the Paudash-Cheddar road. A plan of the workings will be found in Eardley-Wilmot's report. Owing to the weathering of the large amount of sulphides present, the writer has nothing to add to Eardley-Wilmot's description, parts of which follow:—

'The deposit occurs near the contact of granite and gneiss in which bands of crystalline limestone are prominent. In the main showings, pyroxenite, pyrite, pyrrhotite, and molybdenite occur on the contact between a reddish pegmatite phase of the granite and the gneiss . . . the molybdenite is either pockety, or very low grade when it occurs with the other sulphides.

'The work done consists of a shaft 7 by 9 feet and 45 feet deep, started in 1907, and two open cuts 50 by 120 feet long, excavated in 1910 and 1914.'

About 150 tons of ore were treated in a small concentrating plant, and the resulting ton of concentrates was shipped to Toronto.

The showing was staked in 1907 by Alex Evans. In 1913 an option was taken by M. J. O'Brien, who completed sinking the shaft and dug some pits.

Concession X, Lot 14

In 1937 Brough Lake Molybdenite, Limited, carried out stripping and trenching at intervals over a length of 660 feet in a direction N 70° W on lot 14, concession X, Cardiff township. This surface work is 30 chains N 47° E from a farmhouse in lot 13, concession X. Diamond-drill casings indicate that at least four holes were put down, but no information on the results obtained is available.

The main showing is a rusty-weathering, coarse hornblende pegmatite sill from 2 to 7 feet wide, striking N 70° W and having an exposed length of 150 feet. It intrudes biotite-hornblende gneiss, which strikes N 70° W and dips 45°-65° S. The pegmatite is mineralized with pyrite and a few flakes of molybdenite, the latter being closely associated with the hornblende crystals. The mineralization is practically confined to the pegmatite exposed in three pits. No mineralization was observed in the other trenches.

From surface indications the grade of the mineralization is much too low to be of any economic importance.

Monmouth Township

Concession XII, Lot 14

The old Lillico mine is situated in lot 14, concession XII, Monmouth township, 16 chains S 15° W from the northeast corner of the lot. The main workings consist of one open cut 200 feet long, 100 feet wide, and 5 to 10 feet deep and another to the southeast 60 by 50 feet and 10 feet deep, nearly filled with water in 1942.

In the large open cut the floor exposes granite gneiss and hornblende gneiss. No molybdenite was seen. The shaft marked on the sketch in Eardley-Wilmot's report (1925, Fig. 14), was not found and must be filled in. On a 5-foot face at the southeast side of this open cut tourmaline pegmatite containing coarse pyrite, a little molybdenite, and pyrrhotite cuts flat-lying brownish granite gneiss.

At the northwest edge of the smaller open cut, pyrite and molybdenite were found in pegmatite. On the dump here pyrite was found in masses as much as 5 inches in diameter.

The deposit was apparently a flat-lying body, which has been largely mined out, and it is doubtful if any further exploration is justified.

R. J. Lillico for the Ontario Molybdenum Company, Limited, shipped in 1917, 55 tons of 1.01 per cent MoS_2 ore, from which 1,117 pounds of molybdenite was recovered; and in 1918, 102 tons of 0.533 per cent MoS_2 ore, from which 680 pounds of molybdenite was recovered. About 3,000 tons of ore and rock were mined to obtain the above amounts of shipping ore. Work ceased in August, 1918.

Concession XIII, Lot 13

In 1916 G. Padwell opened up a quarry face 50 feet long and about 10 feet high on lot 13, concession XIII, Monmouth township, and made a shipment of 1,300 pounds of hand-picked ore, running 3.85 per cent MoS_2, to the Mines Branch, Ottawa.

When visited by the writer in 1942, the quarry, which is 2 chains north of the south boundary of the lot and 4 chains east of the west boundary, had a length of 130 feet from east to west and a width of 120 feet from north to south. One pit in the northwestern part of the quarry floor measured 25 by 30 feet and 15 feet in depth; another in the southeastern part measured 40 by 25 feet and from 1 to 4 feet in depth. The enlargement of the quarry was made by Canadian Molybdenite Mines, Limited, in 1939.

The country rock is a flat-lying hornblende-feldspar gneiss with a few lit par lit stringers of hornblende pegmatite. The gneissic structure trends N 80° W and dips 10° S. The hornblende gneiss is slightly mineralized with large flakes of molybdenite, coarse pyrite, and pyrrhotite occurring in part in flat sulphide veinlets parallel to the gneissosity. The mineralization is very spotty, some bands of gneiss several feet thick showing none. Cutting the gneiss are several 1- to 4-foot wide pink pegmatite dikes.

A small stock pile adjacent to the pits actually shows very little molybdenite, and the deposit is considered to be of no economic importance.

Concession XV, Lot 33

A molybdenite prospect on lot 33, concession XV, Monmouth township, was opened up by the Wilberforce Molybdenite Company, Limited, in 1917. The workings are on a bare knoll just west and south of some farm buildings. At 2½ chains north of a side road there is a trench trending N 65° E, which is 100 feet long, 10 feet wide, and 10 feet deep and has a pit at the west end 20 feet deep. At 5 chains north of the road, stripping and small pits expose rusty-weathering mica-pyroxene gneisses. The trench exposes a complex of banded gneisses containing bands rich in phlogopite and pale-green pyroxene; one band consists of calcite, actinolite, and minor quantities of fluorite and titanite. The gneisses are cut by a dikelet of feldspar-apatite-pyroxene rock. Rusty gneisses contain pyrrhotite, and one 1-inch flake of molybdenite was found.

No further development would appear to be justified in view of the negligible amount of molybdenite present. It is reported locally that some additional pitting in the trench was carried out in recent years, but little or no molybdenite was found.

Concession XVI, Lot 31

In 1942 B. E. MacDougall prospected lot 31, concession XVI, Monmouth township. The work consists of stripping and shallow test pits or trenches on a low ridge trending N 10° E. The showings are reached by going west from Wilberforce for three-quarters of a mile, north on a bush road for one-quarter of a mile, and then 12 chains northeast to the top of the ridge. The rocks exposed are pyroxene crystalline limestones showing a pronounced banding and injected by narrow sills of albite-smoky quartz pegmatite. Stringers of calcite-apatite-pyroxene rock cut these rocks. A few flakes of molybdenite and pyrite occur in the pyroxene-calcite rock. Lower down the ridge graphic granite-pegmatite is exposed. Since the pyroxene crystalline limestones are flat-lying, it would appear that the pyroxene-calcite rock is a contact zone developed adjacent to a mass of graphic graphite-pegmatite and is possibly not more than 20 feet thick at this locality. The occurrence is not considered of any economic importance.

Work on the property had ceased at the time of the writer's visit in August, 1942.

An isolated area of small, scattered molybdenite deposits occurs in the southern part of the Haliburton area—in Lutterworth township, Haliburton county, and in Laxton and Somerville townships, Victoria county. The following descriptions are again from Satterly (1943c).

Lutterworth Township

Concession II, Lots 7 and 8

Occurrences of molybdenite on lots 7 and 8, concession II, Lutterworth township, were not seen by the writer. Parsons reports that A. Y. Hopkins opened up a quartz vein with a maximum width of 3 feet containing a little molybdenite. The vein occurs in gneiss a short distance from the shore of Davis Lake. Some molybdenite occurs on a small island a few hundred feet from the shore. These occurrences appear to be of no economic importance.

Concession V, Lot 23

Hamilton Molybdenum Alloys Company, Limited, is reported to have sunk, in 1916 and 1917, on lot 23, concession V, Lutterworth township, a shaft 6 by 12 feet and 30 feet deep. When the writer visited this occurrence in 1942 he found the shaft caved in. The rocks on the dump consist of a biotite-poor, quartz-rich granite gneiss with inclusions of an epidote-tremolite rock. A little pyrite, but no molybdenite was found. This shaft is at the edge of a wagon road adjacent to the east bay of Moore Lake. Points on this part of the lake expose crystalline limestone cut by pegmatite dikes. This occurrence is of no economic importance.

Victoria County

Laxton Township

Concession XI, Lot 5

Parsons (1917, pp. 299-302) has described and illustrated two old mines in lot 5, concession XI, Laxton township, adjacent to the shore of Mud Turtle lake, and the writer has nothing to add to his report.

The workings at the Horscroft mine consist of a trench 70 feet by 20 feet and 10 feet deep put down in soil and decomposed pyroxenite. In 1916 T. Horscroft shipped to the Mines Branch, Ottawa, 36.33 tons of 2.0 per cent MoS_2 ore, from which 864 pounds of molybdenite was recovered.

Adjoining the Horscroft and right at the shore of the lake is the Ponton-Russell mine. A shaft 7 by 9 feet and 50 feet deep was sunk by D. Ponton and A. J. H. Russell, and was full of water when Parsons saw it in 1916. The ore was a micaceous pyroxenite containing much molybdenite.

Owing to the location of the showings it is doubtful if the properties could be worked economically. The writer does not think that further exploration would be justified under the circumstances.

Somerville Township

Concession A, Lot 3

T. Horscroft put down several pits in lot 3, concession A, Somerville township, just north of the road at the north end of Mud Turtle lake. The writer saw only one pit, 3 chains north of the road, now overgrown with moss and nearly covered by fallen trees and slash. Pink granite gneiss is exposed on the east wall and a rusty quartz-mica-pyroxene rock on the west wall of the pit.

A little pyrite and small flakes of molybdenite were found in fragments of the latter on the dump. This appears to be a mineral occurrence of no economic importance.

North Hastings Area

Several small occurrences of molybdenite have been reported from time to time from the northern part of Hastings county. No production has been recorded, and most of the occurrences are of mineralogical interest only.

Bancroft Area

Molybdenite has been reported as an accessory mineral in some of the uranium ores of this area. At the Centre Lake property of *Bicroft Uranium Mines, Limited,* Satterly (1957, pp. 33-34) reported the occurrence of molybdenite together with uranothorite, uraninite, zircon, allanite, titanite, and pyrite, in cataclastic quartz-rich pegmatite of intrusive origin. At the Croft property of the same company, accessory zircon, pyrite, and molybdenite were seen with uranothorite in coarse biotite pegmatite (Satterly, 1957, p. 40).

At the Basin property of *Silver Crater Mines, Limited,* in lot 31, con. XV, Faraday tp., rare molybdenite is associated with pyrite and betafite in a carbonate body (Satterly, 1957, pp. 130-131).

Dungannon Township

Eardley-Wilmot (1925, pp. 76,77) described the Stoughton property in con. XVI, lot 5, N½, as follows:

> This property, which is 8 miles northeast of Bancroft, was worked for short periods from 1917 to 1920, by Messrs. J. Waring of Madoc and A. A. Stoughton of Bessemer.
> J. C. Gwillim, who examined the property in 1917, stated that a few shallow pits were sunk on the exposed main pegmatite ridges that intrude crystalline limestone and gneiss. . . .
> The ore bodies so far opened up do not appear to have much commercial value. . . .
> The Bancroft Mining Company took an option in 1917 and, early in 1918, 694 pounds of hand-picked ore, running 4.19 per cent, was sent to the Mines Branch plant, Ottawa, from which 28 pounds of molybdenite was recovered and sold.

Faraday Township

J. E. Thomson (1946, p. 61) said that:

> A little disseminated molybdenite may be seen in a small test-pit on the farm of Walter Keller in lot 21, concession XII, Faraday township. The ground adjacent to the pit is drift-covered. The molybdenite occurs in pyroxenite near the contact with pegmatite.

Herschell Township

Eardley-Wilmot (1925, p. 77) described a property in con. IV, lots 27, 28, as follows:

> The showing occurs just north of the railway, 2 miles west of Baptiste Station. No work has been done outside of putting a few shots into the outcrop and extracting 200 or 300 pounds of ore running high in molybdenite, which was sent to the Tivani ferro-molybdenum plant in 1918. Mr. J. W. Evans, the manager of the plant, who visited the property, found much molybdenite float in the area. Because of the amount of overburden present, considerable work would be required to prove the extent of this deposit.

J. E. Thomson (1946, p. 62) reported that he searched for this property but could not find it. He mentioned an old pit near the north shore of Baptiste Lake (*con. V, lot 31*) which showed disseminated areas and stringers of coarse flake molybdenite in pyroxenite. He reported that further work was supposed to have been carried out on the property in 1942, after he had visited it.

Monteagle Township

The McDonald property of Genessee Feldspar Company, Inc. of New York, is in con. VII, lots 18, 19. In a large feldspar (microcline perthite)-quartz pegmatite dyke, molybdenite was found as an accessory mineral, with ellsworthite, uranothorite, rutile, magnetite, titanite, pyrrhotite, and fluorite (Osborne, 1930, p. 41).

In *con. XIII, lots 23 and 24,* a deposit of graphite occurs in a silicated limestone within an area of gneisses. The limestone is cut by calcite veins containing pyrrhotite, molybdenite and apatite (Osborne, 1930, p. 35).

Renfrew Area

Molybdenite deposits are fairly abundant in the Renfrew area. According to Satterly (1945, p. 70), more than 30 occurrences have been found in Renfrew county. Many of these were worked during the 1914-18 war period; the total production during the three years 1915 to 1918 was about 150,000 pounds of molybdenite concentrate. Two concentrating plants were operated during this period—one at Renfrew (International Molybdenum Company, Limited) and one near Mount St. Patrick (Renfrew Molybdenum Mines, Limited).

During the second world war only two properties in Renfrew county carried out any development work. According to Satterly (1945):

> About a car lot of ore was shipped by Major Molybdenite Mines, Limited from Mount St. Patrick to be treated in the mill at Quyon, Quebec. Wartime Metals Corporation leased the Zenith Mine and carried out considerable underground development, but owing to disappointing results, operations ceased early in 1943.

So far as known, all the occurrences are small, and although some of them are fairly high grade, the distribution of molybdenite in them is rather erratic (Quinn, 1952, p. 55).

Two main centres of molybdenite mineralization may be recognized. The first is in central Brougham township, in the neighbourhood of Condon, Mason, and Jacktar Lakes; the second is in northeastern Bagot township, northwest of Hond Lake. On the border between Griffith and Brougham townships the deposits of the Spain and Sunset mines may be considered to form a third, minor centre of concentration. Other deposits are scattered throughout the area.

The three main types of deposits in which molybdenite has been found, in order of their importance as judged by past production, were listed by Quinn (1952) as follows:

1. Bodies of metamorphic pyroxenite.
2. Sulphide-quartz veinlets paralleling the foliation in granitic and hybrid gneisses.
3. Disseminations in granite-pegmatite.

Of seventeen deposits, said Quinn, "seven are in pyroxenite, seven in pegmatite, and three in sulphide-quartz veinlets in gneiss. About 90 per cent of the molybdenite produced in the . . . . area has been derived from deposits in pyroxenite."

Central Brougham Township

An area in which occurrences of molybdenite-bearing deposits are relatively abundant lies along a belt trending almost due northeast, in con. XI, between lots 8 and 17—a distance of about 2½ miles. At the eastern end of this belt is the Hunt mine, which has produced concentrates totalling nearly 97,000 pounds, 85 per cent of which averaged about 95 per cent MoS_2 (Eardley-Wilmot, 1925, p. 94). At the western end of the belt, grouped relatively close together, are three occurrences of lesser importance; from two of these there has been a small production of hand-cobbed ore (*see* Ross and O'Brien Properties below).

The area concerned is underlain by a series of schists, gneisses, and metamorphosed limestones, with a general northerly or northwesterly strike. In the northwestern part of the area are large outcrops of alkali syenite, and smaller ones of nepheline-albite gneiss. To the south of the three westernmost deposits is a boss-like body of granite or granodiorite. Coarse granite pegmatite occurs in the immediate vicinity of the Hunt mine (*see below*).

The various deposits in this area are of three, separate morphological 'types' of molybdenite-bearing deposits. But they contain a single mineral assemblage which is met with time and again in the Grenville province, namely pyrite, pyrrhotite, and molybdenite.

The descriptions of properties that follow are based on previous reports and on the writer's visits in July 1958.

Hunt Mine

This mine is situated on the south slope of a high ridge to the north of Condon Lake in lots 8 and 9, con. XI, Brougham tp. The mine is reached by a gravel road of varying quality from Mount St. Patrick village, a distance of 3½ miles. The underground workings of the mine are now inaccessible, except for an adit, but the mineralized zone may be studied at intervals along the steep hillside. The history and geology of the Hunt mine have been described by a number of authorities, chiefly Wilson (1920), Gwillim (1920), Eardley-Wilmot (1925), and Freeman (1936). Satterly (1945) and Quinn (1952) summarize the older publications.

The Hunt mine has not been worked since 1918. The most comprehensive accounts of the early history of the property are given by Wilson and Eardley-Wilmot. Wilson (1920, p. 36) said:

> The discovery of molybdenite on this property is said to have been made by Cornelius Hunt, son of Daniel Hunt, to whom the farm on which the molybdenite occurs belonged. Shortly after the discovery an option on the property was sold to American capitalists who shipped a small quantity of ore but later allowed the option to drop. In the winter of 1912 a second option was taken on the property by F. R. Aufhammer, who sold the option to a Belgian company operating in Canada under the title Algunican Development Company. This company afterwards purchased the property and had completed some drilling and other development work when, owing to the outbreak of the World War, all development was stopped. In the autumn of 1915, a new company known as the Renfrew Molybdenum Mines, Ltd., was formed and operations were again undertaken and continued from that time until the mine was finally closed down in the

autumn of 1918. During this last period of operation a mill, having a capacity of approximately 25 tons a day, was erected and an electrical transmission line was built to connect the mine with the power plant of the M. J. O'Brien Company on Madawaska River at Calabogie.

The work carried out during the active life of the Hunt mine consisted . . .

. . . approximately of 1800 to 2000 feet of cross-cuts and drifts on four levels between the depths of 40 and 150 feet and they (were) connected by about 230 feet of shafts and raises. Besides this, about 400 feet of drifts have been widened out into stopes from 20 to 25 feet wide.

Eardley-Wilmot (1925, p. 89) reported that in 1909 a sample of ore from the Hunt property, sent to the Mines Branch, Ottawa, showed 3.14 per cent MoS_2. He(p. 94) also gave the following figures for the last 3 years of the mine's productive life:

	Tons of Ore		
Year	*Mined*	*Milled*	*MoS_2(%)*
1916	1,200	100.0	1.29
1917	4,500	3,656.0	0.75 (approx.)
1918	3,449	3,155.0	0.50 (calculated from mill-recovery figures)

The total concentrates produced, including hand-picked pure flake, amounted to 96,990 pounds, 85 per cent of which averaged about 95 per cent MoS_2. All the above ore, except 55 tons sent to Ottawa, was treated in the company's concentrator, and all the high-grade concentrates were sent to Paul Girod of the Société Électrométallurgie, Ugine, France, who specified a 95-per-cent product.

The writer took two systematic chip samples of a pillar of the original outcrop ore near the collar of a winze 80 feet west of No. 1 shaft. The molybdenite contents of these two samples were 0.60 and 0.27 per cent MoS_2 respectively. From these and the above production figures it seems that the grade at deeper levels in the mine was below that at the original outcrop, and perhaps the figure of 0.50 per cent MoS_2 may be taken as indicative of the grade of any ore remaining in the mine. Eardley-Wilmot (1925, p. 93) was of this opinion.

Although the information concerning the ore encountered in the lower levels is meagre, it would seem that it was not so wide or rich as that occurring in the upper workings. It would appear, however, that there is plenty of room for further lateral development along the line of strike.

The underground workings were not available for inspection at the time of the writer's visit and the surface outcrops along the ore zone are somewhat limited. Liberal use has therefore been made of the earlier publications, especially that of Wilson (1920), in the following account.

The molybdenite deposits so far discovered on this property outcrop on the southwesterly slope of a northwesterly trending ridge that parallels the northeast side of Condon Lake. The portion of the hill slope above the outcrops is occupied mainly by pegmatite, whereas the rock exposed beneath the outcrops is mainly crystalline limestone. Farther down the slope, hornblende syenite occurs. (NOTE: This is shown on Quinn's map as "hornblende schist and gneiss, hornblende-biotite schist, quartz-biotite-hornblende schist, amphibolite, dioritic, and gabbroic rocks.")

The pegmatite exposed on the hilltop forms the eastern end of a large mass of pegmatite that extends in a northwesterly direction for about ¾ mile. Wilson (p. 36) continues:

> The mine is thus situated near to the extremity of the pegmatite mass where it has been intruded more or less irregularly into the limestone. The position of the pegmatite mass on top of the limestone and its approximate conformity in strike and dip to the structural trend of the limestone indicates that the pegmatite has the relationship of a sill.

The pegmatite can be very well studied at the collar of No. 2 shaft, which lies some 260 feet west of No. 1. The rock is a pink feldspar(microcline)-quartz rock with no apparent ferromagnesian minerals. Scattered magnetite grains up to 3 mm in size occur in places. The grain size of the rock varies from a few mm up to 3 cm or more. Parts of the rock show an excellent medium-grained graphic texture. The pegmatite has a marked jointing, striking N70°W; a secondary set strikes N45°E.

The limestone, which can now be seen mainly on the waste dumps of the mine, is a medium- to coarse-grained, white calcite rock with disseminated accessory mica and some graphite. Pyroxene and iron sulphides are also present in places. Wilson (p. 37) mentioned the occurrence of masses and bands of pegmatite and diorite in the limestone.

> The deposits vary considerably in composition, consisting chiefly of green pyroxene or green pyroxene and scapolite at some points and of granular pyrite and pyrrhotite at others. On the whole the molybdenite is most abundant where the pyrite and pyrrhotite occur, and is only sparingly present where these minerals are absent. In some places the pyroxene contains a considerable proportion of microcline so that all the intermediate types between a pyroxenic pegmatite and a feldspathic pyroxenite are present.

Figure 11 shows that the deposits occur as zones along the contact between the limestone and the pegmatite—partly along the under side of the main pegmatite mass occupying the hilltop above the mine and partly along the upper side of a second mass of pegmatite in the limestone below. According to Wilson the zone on the under side of the main mass of pegmatite did not carry sufficient molybdenite to be mined profitably, except in a drift from the No. 1 shaft, whereas the zone overlying the lower pegmatite mass was mineralized throughout.

The only exposure of the ore zone that can be studied at the present time is near the collar of a winze, about 80 feet west of the No. 1 shaft and in a small open-cut to the west of this winze. The winze and open-cut lie at the foot of a 50-foot cliff of the granite pegmatite that overlies the mineralized zone. The footwall limestones are exposed around the collar of the winze, which is situated in a short adit driven into the foot of the cliff. At the base of the cliff and in the pillar at the entrance to the adit is a mass of sulphide-bearing pyroxenite, part of the original outcrop of the ore zone. In parts there is a liberal dissemination of molybdenite, as flakes up to an inch in diameter, in the other sulphides (pyrite and pyrrhotite). In the open-cut to the west of the winze the pegmatitic granite grades into the pyritic pyroxenite through a contact zone about 2 to 3 feet wide in which pyroxene is present in the normally quartzo-feldspathic pegmatite. Sulphides also

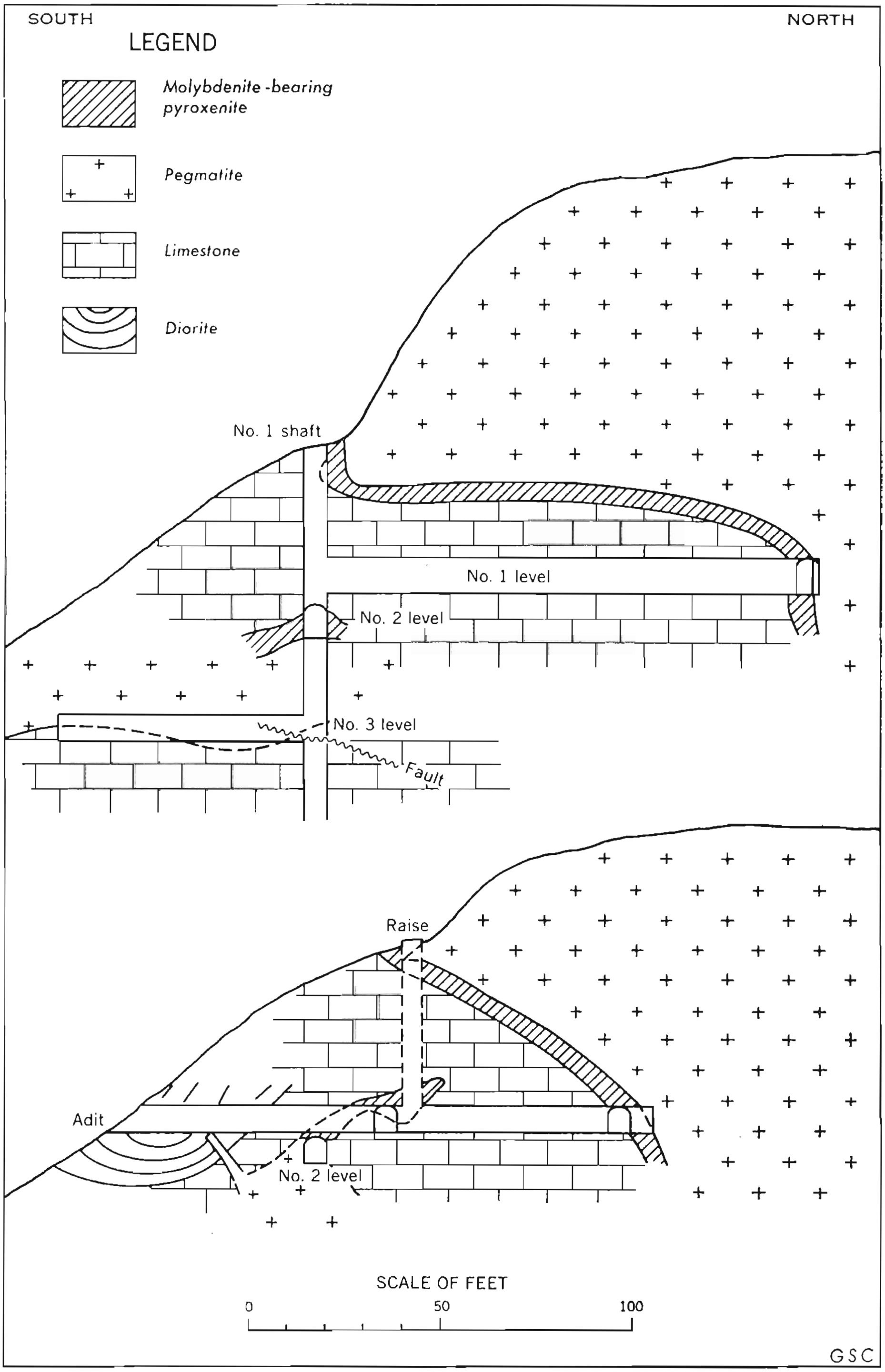

Figure 11. *N-S vertical cross-sections through the molybdenite-bearing zones at the Hunt mine, Brougham township, Ontario.*

occur in this transition zone. The contact zone there seems to be more or less vertical, although the outcrops are too limited to be sure. In the cliff above the entrance to the winze the granite appears to overlie the pyroxenite along a well-marked plane which may be a low-dipping fault.

In the adit to the raise, the mineralized pyroxenite is underlain by biotite-bearing, crystalline meta-limestone; the contact apparently conforms to the strike and dip of the limestone, which here are approximately due east and 50°S. The contact is sharp, with a 3- to 6-inch zone of loosely packed mica-flakes between the limestone and the sulphide-bearing pyroxenite. A few crystals of light green (diopsidic?) pyroxene occur occasionally in the limestone, but these are no more than the normal accessory minerals found in the limestone elsewhere. This absence of a transition zone between the limestone and the pyroxenite may be due to faulting, but there is no positive evidence for this.

Farther east along the strike of the ore zone, old trenches and pits have exposed the contact between the granite pegmatite and the rusted sulphide-bearing pyroxenite, but very rarely, if at all, is the pyroxenite-limestone contact visible. In all the exposures examined by the writer the pegmatite-pyroxenite contact was characterized by the transition zone where pyroxenes occurred in the granitic rock, accompanied by sulphide mineralization.

To the east of the line of the low-level adit, the mineralized zone appears to weaken somewhat, but it can be traced for some considerable distance. The zone can be seen to swing upwards, slightly, in elevation, and granite pegmatite forms both the foot-wall and the hanging-wall. Outcrops occur in which the pyroxenite is visible as detached blocks set in the pegmatite and intersected by tongues of the granitic rock. These facts seem at variance with the description previously presented of a contact deposit situated wholly along the granite-limestone contact.

The main structural forms of the mineralized zones are shown in Figure 11. Wilson also mentioned the presence of an almost-horizontal fault cutting the pegmatite and limestone in No. 1 shaft where this connects with No. 3 level, along which there seems to have been little displacement. He (p. 37) also remarked that where the limestone is near the included masses of pegmatite, the banding in the limestone bends around them, indicating that the folding to which the limestone was subjected occurred, in part at least, after the pegmatite was injected. "It follows, therefore, that the contact zones along the margins of the pegmatite masses have also been subject to folding."

Wilson and subsequent writers considered the Hunt mine deposits to be undoubtedly of contact-metamorphic origin. Indeed Wilson says:

> The mineralized contact zones that constitute the molybdenite deposits on the Hunt property so strikingly illustrate the type of ore deposits known as contact metamorphic that it is scarcely necessary to cite more than the principal data on which their classification as such is based.

Ross and O'Brien Properties

These properties, in con. XI, lots 16 and 17 respectively, are parts of a single mineralized area and show the same geological features. Since they have been worked as separate properties in the past, the history of each is given below.

They lie about 5 miles southwest of the village of Mount St. Patrick and are reached by following a rough country road and cart track to a point 6¼ miles from the village. The O'Brien workings lie on either side of the track at this point, and the Ross workings lie some 400 feet off the track in a N70°E direction.

The history, production, and geology of these properties have been described by Eardley-Wilmot (1925), Wilson (1920), Satterly (1945), and Quinn (1952). The following account is based on these reports and on the writer's own field observations. At the present time the workings are so overgrown or filled with water that relatively little information can be derived from a field inspection.

The workings available for inspection at the Ross property are two fairly large open-pits (*see* Eardley-Wilmot, 1925, p. 95) now largely filled with water and partly overgrown. The more easterly of the two is about 120 feet long in an easterly direction and up to 60 feet wide, with a western face up to 20 feet high. The ground slopes down to the east almost to the level of the water in the pit. According to Eardley-Wilmot, this pit is 30 feet deep in the centre. At its western end, separated from it by a 6-foot pillar of rock, is a 5-by-9-foot shaft, 30 feet deep, but now filled to the collar with water. The westerly pit, much smaller than the easterly one, is about 50 feet in diameter. At the time of the writer's visit it was filled with water, but, according to Satterly (1945, p. 80) it is 20 feet deep. Farther west, nearer the track, are some shallow trenches in the overburden, but these are largely overgrown and yield little geological information.

According to Eardley-Wilmot (1925, pp. 94-95):

> ......the property was part of some land purchased by Dr. B. G. Connolly from Mr. Austin Morin in 1908. About 1914 Dr. Connolly sold the mining rights to Mr. C. G. Ross of the Aldfield Mineral Syndicate. This syndicate, after doing some prospecting work, gave an option to a Belgian syndicate who are said to have shipped a little ore. During the war the Aldfield Syndicate sold out to Molybdenum, Limited, who later gave an option to Mr. F. G. Todd of Montreal. In 1917 the property was leased to the International Molybdenum Company, Ltd., for six months. These transactions were somewhat involved and no separate records of shipments appears to have been kept. Some of the ore shipped, which amounted to several carloads, was, however, apparently sent with that of the International Molybdenum Company to the Renfrew Concentrator, or the Mines Branch, Ottawa.

According to Freeman (1936, p. 12) about 720 tons of ore was shipped, from which about 7 tons of molybdenite was recovered, giving an average grade for the ore of about 1 per cent molybdenite. Eardley-Wilmot (p. 95) was of the opinion that the Ross deposit was "considerably more promising than that on the O'Brien, and by careful selection, it is probable that a large tonnage of ore can still be obtained from the present workings." He cites as disadvantages the steep haulage up the hill and the lack of water. Since Eardley-Wilmot examined the property, apparently no further work has been done.

The above figures give an idea of the average grade of the ore shipped from the property, although this of course was selected, hand-cobbed material. The average grade of the ore in situ would be much less, but Satterly (1945, p. 80) points out that "owing to the age of the workings and the extensive rust-staining it is impossible to estimate the amount of molybdenite present."

The veins and seams of sulphide are very rich in molybdenite flakes, and when hand-cobbed out would give a respectable grade of shipping ore. The writer saw several instances where seams of sulphides had decomposed and released large quantities of molybdenite flakes up to an inch in diameter. In general the veins do not appear to have been very thick and they are separated by bands of barren gneiss. It is therefore doubtful if the ore is rich enough to support a mining and milling operation on a suitable scale for present-day purposes.

The map accompanying Quinn's (1952) publication shows that the Ross and O'Brien properties occur in a small area of "mixed rocks" (hybrid gneisses, and migmatites in part) at the northern end of a rounded area of granite, about 1½ to 2 miles in diameter. The country rocks surrounding this "boss" are mainly crystalline meta-limestones and paragneisses. The general strike of the rocks across the properties is southeast with a low northeast dip. About ¾ mile south of the properties the granite is intersected by an easterly trending fault, without much apparent lateral displacement. On the walls of the larger, easterly pit on the Ross property, the country rocks are banded, rather heterogeneous augite-feldspar-quartz gneisses, with concordant lenses or schlieren of coarse quartzo-feldspathic material. Their strike and dip vary somewhat from place to place, but the general dip is eastwards at 20 to 30 degrees. They show a very well marked jointing, striking at N70 to 80°W. The ore minerals consist of pyrite, pyrrhotite, and molybdenite, occurring as veins or seams concordant with the layering of the gneisses and, to a lesser extent, as thin veins along the joints. Very little of this ore can be seen now in the exposures around the pit, and it is difficult to judge the average thickness of the veins; those visible today are not more than 6 inches thick.

The sulphides occur interstitially to the minerals of the gneisses and there appears to be no introduced gangue, or any development of the pyroxenite so commonly met in the deposits in the Grenville province. The control of the ore deposition within the area of gneisses is not apparent from the exposures available today. The area covered by both the Ross and O'Brien properties shows an identity of mineralization and, all in all, a considerable amount of molybdenite plus iron sulphides seems to have been introduced into the rocks. It was however relatively widely spread out and dissipated in small seams and veins in the gneisses. The lack of one strong controlling structure to concentrate the ore is very evident.

The workings of the O'Brien property yield even less geological information than do the two old pits on the Ross property. Eardley-Wilmot (1925, p. 98) gave a sketch map of the workings, which today are largely overgrown and water-filled. The main workings available for inspection now are three pits and a shaft or two on either side of the cart-track (a continuation of the gravel farm-road from Mount St. Patrick village).

Eardley-Wilmot (p. 97) gave an account of the early history of the O'Brien workings. The deposits were originally discovered by Joseph Charron, a prospector, on land originally owned by Austin Morin. In 1908, at the same time as he sold what is now the Ross property to Dr. Connolly, Mr. Morin sold the ground forming the O'Brien property to Mr. M. J. O'Brien of Renfrew. The latter worked the property in 1915 under his own name and in 1916 he financed the International Molybdenum Co., Ltd. That year, the company made small shipments of selected ore to the Department of Mines, Ottawa, and to Orillia.

According to Eardley-Wilmot, the best ore was formed in the eastern part of the workings where a 32-foot shaft was sunk at the bottom of an open-pit. The orebody, composed of "heavy pyrites and molybdenite" appeared to dip away from the shaft. Another shaft, sunk 100 feet to the southeast, failed in an attempt to intersect this ore.

Records of shipments appear to be rather sketchy and Eardley-Wilmot stated that the only definite records of recovery are from shipments sent to the Department of Mines, Ottawa. He estimated the total recovery to have been about 8 tons of pure MoS_2. After his examination in 1925, Eardley-Wilmot concluded:

> ... it would seem that the extraction of the ore on the International Molybdenum Company's property will always be a costly matter owing to the scattered and low-grade nature of the deposits, the lack of water, and the difficulty of transportation.

The subsequent history of the O'Brien property is recorded by Satterly (1945, p. 81):

> In 1942 the property was acquired by the Mount St. Patrick Molybdenite Syndicate, which carried out surface work and shipped 20 tons of ore to the mill at Quyon, Quebec, from which 423 pounds of molybdenite was recovered. In October 1942, it was taken over by Major Molybdenite Mines, Limited. In March and April 1943, 18 diamond-drill holes, aggregating 1,000 feet, were put down, and a little additional surface work carried out under the direction of the Mining Research Corporation, Limited. The drilling indicated molybdenite mineralization in the gneiss at shallow depths over an area 75 feet wide and 200 feet long in the vicinity of the old workings. H. T. Leslie (personal communication) estimated possibly 2,000 tons of ore, which might average 1 per cent MoS_2, could be recovered.

The disused workings of the O'Brien property yield very little geological information at present. The bedrock is composed of the same pyroxene-bearing gneisses as on the Ross property. These strike from north to northwest and dip 10 to 20°E. There is an extremely well developed joint-set striking west. Very little mineralization can be seen. In the southernmost of the three largest pits on the property, are occasional concordant seams of pyrrhotite, pyrite, and molybdenite, not more than 3 or 4 inches thick. On the whole the O'Brien property showings are not very encouraging.

The Ross and O'Brien properties present a small contiguous area of sulphide mineralization in gneisses that bears a strong resemblance to that of the Spain mine, Griffith township. In the latter locality, however, the sulphide veins are nearly vertical and controlled by jointing, whereas on the Ross and O'Brien properties they seem mainly to have been concordant with the layering in the gneisses. Also, there appears to be a complete absence of pegmatite, whereas pegmatite is present at the Spain mine. Meta-limestone is lacking from the immediate area of the Ross and O'Brien workings, though it occurs near and at the bottom of an old 40-foot shaft about 600 feet northwest of the main workings of the O'Brien mine (Satterly, 1945, p. 81).

Some distance to the east of the Ross property, near the shore of Jacktar Lake, is a showing of molybdenite mineralization that may be mentioned together with the above two properties.

Charron Property

This property, in con. XI, lot 15 S½, was not visited by the writer, and the following notes are taken from Satterly's account (1945, pp. 79-80). The main open-cut on the property . . .

> exposes biotite and hornblende paragneisses, containing a narrow interbed of limestone, cut by an irregular mass of rusty-weathering granite pegmatite containing coarse pyrrhotite, some pyrite and more rarely flakes of molybdenite. The gneisses strike N 30° W and dip 35° to 45° E. In the stripping northwest of the open cut are two bands of rusty pegmatite, 3 feet apart, ranging from 1 to 3 feet in width. Little molybdenite could be seen. The bands of pegmatite appear to dip west, although in the open cut they appear to lens-out downwards. In the far pit there is a 2-foot band of pegmatite in rusty paragneiss; limestone outcrops just west of the pit and would dip beneath it. In none of the workings is much molybdenite to be seen, although the rocks are heavily rust-stained.
>
> Although the mineralization is supposed to be an extension of the Ross and O'Brien properties, to the writer it appears that the molybdenite is confined to irregular masses of pegmatite which occur in the contact zone between the gneisses and limestone.

Thus within a small area of central Brougham township we have an almost identical pyrite-pyrrhotite-molybdenite mineralization occurring in three different 'types' of deposit—in pyroxenite at the Hunt mine, as veins and seams in gneiss on the Ross and O'Brien properties, and in pegmatite on the Charron prospect. It would seem strange if mineralization so similar was genetically linked to rocks so diverse in composition as pyroxenite and granite pegmatite. Rather the sulphide mineralization had a common source in the area and was emplaced in the three different host rocks due to structural controls acting at the time of mineralization. The alignment of the deposits along a northeasterly line may be significant, suggesting control by some deeper-seated lineal structure such as a fault or other zone of weakness.

Concession I, Lot 18, Brougham Township

This occurrence, to the south of the above-described properties, almost on the Madawaska River, has been opened up by pits and trenches. The following description is taken from Satterly (1945, p. 78).

> The main showing is exposed in a pit 10 by 12 feet and 12 feet deep, about 130 feet up the slope of a hill from a road at the Madawaska River. The pit is old and the rocks are heavily stained with rust. The rocks dip 45° SE, and southeast to northwest are found crumbly crystalline limestone, underlain by 12 inches of pyroxenite, 18 inches of pegmatite, 60 inches of pyroxenite, and lastly crystalline limestone. The pyroxenite is heavily mineralized with pyrrhotite and pyrite, and more rarely with coarse flakes of molybdenite.
>
> At the road and to the northwest of the possible extension of the pyroxenite bands is a trench across the strike, 50 feet long, 6 feet wide, and 5 feet deep. At its south end is a covered shaft, 8 by 6 feet. The trench exposes crystalline limestone, limestone, serpentinized crystalline limestone, and narrow interbeds of grey biotitic quartzite. The bed-

ding strikes N 40° E, and dips 55° SE. A litle scattered pyrrhotite was observed, but no molybdenite.

Up the hill, there are two other shallow prospect pits at 275 and 340 feet northeast of the road. These expose banded crystalline limestone containing a little disseminated graphite and a few grains of pyrrhotite.

The small amount of molybdenite seen in the main showing is not encouraging, and no further exploration would appear to be justified.

Spain Mine

This disused property comprises lots 31 and 32, con. IV, and lots 31, 32, and 33, con. V, Griffith tp. The old workings are in lot 31, con. IV, a few hundred feet south of highway 46, a distance of 6.3 miles northeast of Griffith.

Previous reports on the history of operations and the geology include those of A. L. Parsons (1917, p. 297), Wilson (1920, pp. 41-43), Eardley-Wilmot (1925, pp. 101-103), and Satterly (1945, p. 83).

Eardley-Wilmot described the early history of the mine. It was opened up in 1912 by Joseph Legree of Renfrew and sold in 1915 to W. J. Spain of New York. The mine was taken over in 1918 by the Steel Alloys Corporation.

> The work, which was nearly all done by Mr. Spain in 1915 and 16, consists of a large open cut, a shaft, and about half a dozen small pits. The shaft, which is 6 by 9 feet, has been sunk to a depth of 50 feet. It was started on two or three small molybdenite stringers, and is in gneiss for almost its entire depth.
>
> Almost the whole output has been obtained from the main pit, which is a large, irregular excavation about 75 feet long, 120 feet wide and from 10 to 25 feet deep...
>
> At the time operations ceased in December, 1919, a wide pocket of high-grade and more concentrated ore was encountered at the bottom of the southwest face. This new orebody which has been merely tapped, is said to contain large flakes of molybdenite and to be richer than any ore that has yet been extracted from the open cut. Investigation of this, however, could not be carried out owing to the depth of water in the pit at the time of the writer's visit...
>
> A 50-ton concentrator using a Hooper pneumatic machine was built by Mr. Spain in 1916. A few months later, a Wood water-film flotation unit was introduced, and the mill was run intermittently for about 2½ months. In 1919 the Steel Alloys Corporation discarded the Wood machine and installed the Callow oil-flotation system.
>
> ... the mine superintendent reported that up to November, 1915, about 5 tons of very high-grade picked flake—approximately 90 per cent MoS_2—was sent to buyers in the United States. Besides this, at that date there were on the dumps approximately 850 tons of 2 per cent ore; 38 tons of 12 per cent ore; and 2 tons of 90 per cent flake. This would give about 29 tons of pure MoS_2, extracted from the open cuts. Later, the following shipments were sent to the Mines Branch, Ottawa.

	Pounds of Ore	MoS_2 (per cent)
1916	61,198	1.09
	1,638	11.13
	7,151	84.20 (hand-picked flake not treated)
1918	66,390	2.10

> From this 64.6 tons of ore, 6,854 pounds of pure molybdenite was extracted and sold to the Imperial Munitions Board, and 1,213 pounds to United States buyers. In addition to this, about 40 tons of ore was treated in the mill in 1919, yielding 600 pounds of concentrates which were sent to the Tivani Steel Works. Besides the above shipments, there are between three and four tons of mixed low-grade ore and waste on the dumps.

At the beginning of World War II the property was investigated by The North American Molybdenum Corporation, Limited. An unpublished report on this work, by H. C. Horwood for the Ontario Department of Mines, is quoted by Satterly (p. 83).

> (The company) did some stripping and trenching and a considerable amount of diamond-drilling in 1939 and in the spring of 1940. The drilling outlined a flat-dipping zone of pyroxene limestone that contains some molybdenite and pyrite. This zone appears to lie along the contact of an injected biotite gneiss and Grenville limestone. Both formations have been intruded by masses of pegmatite. It is believed that the mineralization is associated with the pegmatite. The zone outlined has an areal extent of about 200 feet by 55 feet and an average thickness, as determined by diamond-drilling, of about 5 feet. Such a body should contain about 3,200 tons of material. As the flakes of molybdenum (?) are large and erratically distributed in the pyroxene limestone it was not possible to ascertain the percentage of molybdenite from the diamond-drill intersections.
>
> The attitude of the molybdenite-bearing zone, its thickness, irregularities, and interruptions in ore zone due to rolls and dike-like masses of barren rock, the small tonnage outlined by diamond-drilling (and the present low price of molybdenite) all indicate that the deposit is not of commercial importance.

The deposit outlined by the North American Molybdenum Corporation is obviously of a different morphological type from that originally worked in the open-pit of the Spain mine. It lies some 150 feet southeast of the latter and shows a generally parallel trend, i.e. about north-northeast. At the present time the old Spain mine workings consist of a flooded open-pit about 120 feet long by 75 feet wide and between 1 foot and 20 feet above water level. On the northwest wall of the pit is an old shaft, water-filled to the collar. This shaft is reported to be 35 feet deep (Wilson, 1920, p. 43).

The main geological units in the old Spain mine workings are:

(*a*) *An area of pyroxene-feldspar gneisses* that outcrop on all sides of the pit except to the south and southwest. This rock type is described by Wilson (1920, pp. 41-42) as a monzonite. According to him, the main constituents in thin section are "pale green pyroxene, partly or entirely altered into deep green to yellowish hornblende, orthoclase, and plagioclase (andesine or oligoclase)." These gneisses probably represent metamorphosed sediments and are, in the south part of the pit, interbanded with crystalline limestone. They exhibit low dips, undulating in parts, and a distinct mineral alignment, roughly in a N20°W to due-west direction.

These paragneisses show a variable, medium to coarse grain-size and a distinct banding, caused by segregation of the light and dark minerals. They are rusty coloured in outcrop due to the weathering of the small pyrite content. In places, concordant layers of quartzo-feldspathic material have segregated out under the regional metamorphism, giving rise to thin lenticular pegmatites; in other places, concordant lenticular veins of barren vitreous quartz were noticed.

(*b*) *A thick band of coarsely crystalline meta-limestone* concordantly overlies the gneisses along the south and southeast face of the old pit. This consists mainly of calcite with accessory mica (biotite and/or phlogopite) and light green diopsidic pyroxene. This bed was probably continuous in the area of the open-pit but due to its generally southeasterly dip it has either been eroded away or removed in the working of the pit. The diopside content appears to be a product of normal regional metamorphism in impure calcareous rocks.

Interbanded with the limestone are thin representatives of the paragneisses which indicate that both rock types are parts of an originally continuous sedimentary series that was later metamorphosed to produce the gneiss and crystalline limestone.

(*c*) *Granite pegmatites.* Large, coarse-grained, quartz-feldspar pegmatites outcrop at several places around the open-pit at the Spain mine. The most striking one can be seen on the east side of the open-pit at about its mid-point. It is between 1 foot and 3 feet wide where exposed, and can be traced for some 50 feet or more in a northeasterly direction until it disappears under the overburden. The dyke strikes N30°E and has a sensibly vertical dip. It is composed of large individual crystals of quartz, and pink and white feldspars; some of the crystals are well over 6 inches in size. The contacts with the wall-rock (gneiss) are sharp and clear. The pegmatite here and there exhibits sharp, wedge-like offshoots against the gneiss, and sharp, angular inclusions of the gneiss can be seen in the pegmatite. These facts seem to point to an origin as an intrusive dyke forced into a tension opening in the gneiss.

Another similar pegmatite dyke, less well-exposed, outcrops in the southwest corner of the open pit. It probably has a similar strike to the one described above, judging from the scattered outcrops.

These granitic pegmatites are completely unmineralized and in this respect are different from the pegmatite material occurring along the pyrite-pyrrhotite-molybdenite-bearing veins (see below), from which they also have a different strike. At one exposure on the northeastern corner of the pit, a thinner quartz-feldspar pegmatite, some 15 feet west of the large one described above, is intersected by one of the sulphide-bearing joint veins. This seems to prove conclusively the later age of the latter and to throw doubt on the genetic connection between the ore and the pegmatite suggested by previous reports.

(*d*) *Sulphide joint-veins.* The gneisses exhibit a marked, strong joint-direction, striking northeast and dipping vertically. In places the joints were seen to be 'coated' by pegmatite a few inches wide, leaving a central drusy opening into which euhedral crystals of feldspar projected. In some places these pegmatite veins widened out considerably and masses of the sulphides—pyrite, pyrrhotite, and occasional molybdenite—were present along the central opening, interstitial to the silicates. It would seem that the ore minerals are later than the pegmatites.

The joint veins are nowhere more than 6 inches wide and presumably are thinner representatives of the sulphide veins originally worked in the open-pit. Wilson, after his examination in 1919 when the pit was still open, described these veins as follows:

> Here and there in the pit irregular aggregates or veins consisting of molybdenite, pyrite, pyrrhotite, quartz and feldspar occur traversing the gneiss and pegmatite. The veins and

aggregates occur everywhere, but are most abundant along the north face and on the bottom of the pit at its west end.... The molybdenite-bearing veins and aggregates are most irregular and never more than 1 foot in width...

The northeasterly trending joints in the gneisses definitely seem to have been the control for the sulphide-bearing veins. They appear to be tension openings at a high angle to the lineation or stretch direction in the rocks.

Very little 'ore' remains in situ at the old Spain mine open-pit, but some of the original ore lies scattered around in the neighbourhood of the old mill buildings. Most of this carries massive pyrite and pyrrhotite, with commonly a little magnetite. The molybdenite is distributed erratically through the pyritic base, commonly as flakes up to several inches across. It is this erratic distribution that makes it next to impossible to estimate a grade for the Spain deposit as a whole. This is a characteristic shared by all the Grenville-type pyritic molybdenite deposits. Small amounts of green pyroxene occurs as gangue, scattered about in the otherwise-solid sulphide ore.

The original deposit worked in the old open-pit at the Spain mine shows the general 'Grenville-type' of pyrite-pyrrhotite-molybdenite mineralization common to many deposits in southwestern Quebec and southeastern Ontario. However the morphological nature of this deposit is somewhat uncommon. The sulphides have been deposited as vertical veins in joints within the monzonite-gneiss country rock. These joints appear to be tension fractures at right angles to the lineation direction in the gneisses. The narrow width of the veins and their comparatively wide spacing in the country rock means that the average grade is probably very low.

Sunset Property

The old, partly overgrown workings on the property known as the Sunset mine, in lot 36, con. XIV, Brougham tp., were visited by the writer in July 1958. The workings date from 1916 and no work has been done on the property since then. The main pit and shaft lie ¾ mile along a rather rough cart-track southeast of highway 41, at a point 7.7 miles northeast of Griffith. Very little molybdenite can be seen on the property either in situ or in the spoil dumps. A. L. Parsons (1917, p. 291), Eardley-Wilmot (1925, pp. 99-100), and Satterly (1945, pp. 81-82) have described the history, operations, and geology of the Sunset mine.

According to Eardley-Wilmot, the property was purchased in 1916 by the Steel Alloys Corporation who worked it in conjunction with their Spain mine, a mile to the west. Parsons states that there were about 8 tons of 3.0-per-cent ore on the stockpile in 1917 and about 300 pounds of pure flake. In 1918, about 20 tons of ore, ranging from 0.65 to 5.4 per cent MoS_2, was sent to the Mines Branch, Ottawa; from this, 936 pounds of pure molybdenite was recovered. The deposit appears to have been worked out.

The main working consists of a pit about 70 feet long by 30 feet wide, in the centre of which is an old shaft, said to be about 70 feet deep. Eardley-

Wilmot reported further workings about 1,200 feet east of the shaft but these were not visited by the writer.

The country rocks are not well exposed in and around the old main pit at the Sunset mine. They appear to be part of a series of metasediments, mainly paragneiss and crystalline limestone, striking between due north and N20°E. Dips vary between 20 and 30°E. The paragneiss (pyroxene-hornblende-plagioclase gneiss) shows a marked lineation plunging N70°W (similar in direction to that at the Spain mine). These rocks are flexed into low open folds with axes parallel with the lineation direction. Towards the southern part of the pit, opposite the old shaft, the dips appear to steepen markedly.

The metasediments are cut on the northeast face of the pit by a dyke or transgressive sill, 1 foot to 2 feet thick, composed of a very fine grained, dark grey igneous rock of basaltic composition (pyroxene-plagioclase). This rock is both concordant with, and transgressive at low angles to the metasediments. It does not appear to have had any connection with the deposition of molybdenite and is obviously much later than the folding and metamorphism of the enclosing rocks. Some of the limestone bands are very impure and carry a high percentage of quartz and diopside.

Very little molybdenite can be seen in situ in this old pit. On the southwest wall of the pit, opposite the old shaft, only one or two flakes can be seen in a band of impure limestone. Nor can much ore-bearing spoil be seen around the pit. Indeed most of the heaps consist of gneiss and, to a lesser extent, of meta-limestone. A good deal of the rock carries small quantities of fine-grained pyrite. Other blocks of spoil are of light green diopside rocks with small amounts of interstitial calcite and commonly books of phlogopite mica. Fine-grained sphene occurs as an accessory. Some blocks carry pyrite—as a few scattered grains or clusters of grains—but molybdenite was not observed. The diopside rock seems to be the product of the metamorphism of an impure limestone. This metamorphism would appear to be of the regional type and not due to contact effects of any body of igneous intrusive. There is no definite evidence to suggest the presence of such a body in the neighbourhood, though of course, most of the area is covered with overburden.

The rocks in the vicinity of the Sunset mine seem to represent, as at the nearby Spain mine, a concordant metasedimentary series. A rather thin band of impure limestone in this series has developed diopsidic pyroxene under the regional metamorphism, and this band has in places been mineralized by pyrite and molybdenite. This type of occurrence seems to be nearly similar to the molybdenite-bearing, pyroxene limestone discovered on the Spain property during the diamond-drilling carried out by North American Molybdenite Corporation in 1939-40. Horwood considered the mineralization at the latter place to be connected with the pegmatitic intrusions. However, the old Spain open-pit shows good evidence that the sulphides are later in age than the pegmatites. Two separate ages of molybdenite mineralization—before and after the pegmatites—might be assumed. But it seems to the writer that only one stage of such

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mineralization has occurred and that, as at many other places in the Grenville area, the ore minerals have been emplaced in two different hosts. In one case the hosts were joint fractures in gneiss; in the other, diopside-bearing limestone.

Northeast Bagot Township

Zenith Molybdenite Corporation, Limited

Molybdenite-bearing deposits are relatively plentiful in con. IV, lots 26 to 30, Bagot tp. The main property is that of the Zenith Molybdenite Corporation, Limited, in con. IV, lot 28 W½, which was explored extensively by the Wartime Metals Corporation in 1942-43. This property has been described by Freeman (1936, pp. 16-20), Satterly (1945, pp. 73-75), and Quinn (1952, pp. 58-59). The writer visited the area in July 1958 and examined the surface outcrops and workings, but is unable to add much to the above descriptions. Quinn describes the property as follows:

> Considerable molybdenite has been produced from the property of Zenith Molybdenite Corporation, Limited, in the west half of lot 28, con. IV, Bagot tp., about 5 miles southwest of Renfrew . . . only its main features will be referred to here. Freeman mapped the surface geology by plane-table on a scale of 1 inch to 100 feet in August 1935. In the same month he also mapped the geology of the 100-foot level of the mine on a scale of 1 inch to 20 feet. Horwood mapped the surface geology in 1940 on 1 inch to 250 feet, and his map is included in Satterly's report. The latter report also contains geological plans of the 100- and 200-foot levels and an east-west vertical cross-section all on a scale of 1 inch to 50 feet.
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> Mr. William Warren discovered the molybdenite when digging a well on his farm, and sold the mining rights to Sir Henry Pellatt in 1914. About 81 tons of ore were produced in 1917; from this 7,800 pounds of molybdenite and 472 pounds of flake running 65 per cent molybdenite were recovered. In 1931, about 12 tons of ore grading 5 per cent molybdenite were shipped to the Mines Branch at Ottawa for test purposes. The property was purchased by the Phoenix Molybdenite Corporation, Limited, in 1924. Between then and 1937 this company sank a shaft to a depth of 205 feet, and did considerable lateral development work from this at depths of 95 and 175 feet. A 100-ton mill was erected and was operated intermittently from 1934 to 1937. During this period a total of 8,579 tons of ore was hoisted and some 15 to 22 tons of concentrates grading 80 to 85 per cent molybdenite were produced. The Zenith Molybdenite Corporation acquired the assets of the Phoenix Molybdenite Corporation in 1938. From then until September 1940, when operations ceased, 4,800 feet of trenching was done as well as some diamond drilling and development work on the 175-foot level.
>
> The mine was operated by Wartime Metals Corporation for the Government of Canada from December 1942 to April 1943. During this period, 836 feet of underground diamond drilling and 874 feet of drifting and crosscutting were completed. Results of this work were disappointing, and only about 400 tons of ore estimated to grade 0.85 per cent molybdenite were produced. This ore yielded 14½ tons of material at the mine, composed of 22,523 pounds of lump ore grading 2.77 per cent, 4,355 pounds of fines grading 35.7 per cent, and 2,122 pounds of flake grading 4.51 per cent molybdenite. All of this was shipped to the Lacorne concentrator in northwestern Quebec where it yielded 2,274 pounds of molybdenite.
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> Grey to red gneissic granite of the Hond Lake mass is the most abundant rock type on the property. It includes a few bands of xenoliths of meta-sedimentary rocks of the Grenville series. Dykes of granite-pegmatite up to 375 feet wide cut rocks of both these types. Tabular to lens-shaped bodies of metamorphic pyroxenite are found along or near the contacts between gneissic granite and the included bands of meta-sedimentary rocks. The latter include crystalline limestone, biotite gneiss, and some pink and grey, banded hybrid gneiss.
>
> The most important molybdenite-bearing zones occur in the pyroxenite bodies near dykes, sills, and irregular masses of pegmatite. Satterly (1945, p. 75) notes that the mineralization discovered to date is mostly along the contact of pyroxenite and hybrid gneiss. The

molybdenite-bearing zones are relatively short, narrow, lenticular bodies striking approximately north and dipping vertically to steeply west. They range in length from 30 to 210 feet and in width from 2 to 5 feet. A typical ore shoot mined in 204 north drift was 50 feet long and 5 feet wide.

The molybdenite occurs in the pyroxenite as disseminated flakes up to 2 inches across, and as bunches, seams, or bands, commonly associated with irregular stringers of pyrite. Most of the ore is composed of pyroxene, calcite, quartz, pyrite, and molybdenite. A little disseminated molybdenite also occurs in some of the granite-pegmatite, in the paragneiss or hybrid gneiss adjacent to contacts with pegmatite, or pyroxenite, and in veins up to 4 feet wide composed of pink calcite, pyroxene, and some feldspar.

Minerals reported to occur in the ore include pyroxene of the diopside-hedenbergite series, uralite, chlorite, serpentine, red iron oxide, calcite, quartz, microcline, oligoclase-albite, tourmaline, scapolite, anhydrite, hornblende, biotite, sphene, apatite, garnet, magnetite, martite, pyrite, pyrrhotite, and molybdenite.

Lang (1952, p. 134) reports that one of six samples taken during an examination of the property by the Quebec Smelting and Refining Corporation showed radioactivity slightly above 0.05 R. The other five samples gave lower results.

Concerning the future of this property, Satterly (1945, p. 75) remarks:

> . . . the grade and size of the bodies found to date are not commercial, and further development would not appear to be justified. The mineralization discovered to date has been found by following the contact of the pyroxenite and hybrid gneiss. So far exploration has not indicated any other structural or mineralogical condition that might be used for finding additional concentrations of molybdenite.

Other Occurrences

Concession IV, Lot 28 E½

This is the site of the more important of two occurrences explored by the Buckhorn Mining Syndicate in the same area as the Zenith property. It has been described by Satterly (1945, pp. 72-73):

> A number of the pits and trenches were put down . . . near the north boundary of the lot . . . in 1939 and 1940.
>
> Near the northwest corner of the east half of the lot is an old pit, known as No. 1, 25 by 15 feet and 12 feet deep. A new pit, 10 by 8 feet and 5 feet deep, 25 feet to the northeast of No. 1 pit was put down in the autumn of 1942. This pit exposes hornblende gneiss containing a 3-foot band of rusty pyroxenite carrying a few flakes of molybdenite. The band strikes N 30° E and dips vertically. This same mineralized band is seen in the northwest part of No. 1 pit and is followed to the south by 3 feet of crystalline limestone and then by hornblende gneiss. To the northwest of the band is hornblende gneiss. Several trenches were put down on the strike to the northeast to intersect this zone but failed to disclose any significant mineralization.
>
> No. 3 pit, 1,750 feet northeast of No. 1, is 23 by 30 feet and 16 feet deep and filled with water to a depth of 10 feet. Horwood[1] reports that 'a series of pyrite-molybdenite stringers' were exposed in this pit 'across a width of 10 feet.' These stringers 'dip 30° NW and are up to 16 inches in width.' Material on the dump is of the following types: (1) coarse, greenish-grey pegmatite, rarely mineralized with molybdenite; (2) very coarse, dark-green, red-stained pyroxenite, mineralized with pyrite; (3) coarse- to fine-grained pyrite containing 1- to 3-inch flakes of molybdenite; (4) pink hybrid gneiss. A small ore dump in a lean-to just northeast of the pit contains about 2 tons of material consisting largely of pyrite and molybdenite. Gangue minerals present include garnet, drusy smoky and amethystine quartz, carbonate, and rosettes of specularite. The last three occur as repeated bands lining vugs.
>
> In February, 1943, 7 holes were drilled. The writer found 4 diamond-drill holes, dipping 45° NW at 50-foot intervals along a line N 55° E, 85 feet southeast of the No. 3 pit

[1] H. C. Horwood, unpublished report, *Ont. Dept. Mines,* 1940.

and lot line, and 2 holes dipping 45° SE at 22 and 72 feet S 55° W from the pit on the lot line. These holes should intersect any extension of the mineralized zone found in No. 3 pit. Pieces of the core from the latter holes left on the ground indicate that pink granite-pegmatite, hybrid gneiss, and stringers of carbonate carrying pyrite occurred in the holes. H. T. Leslie reports that the drilling indicated a mineralized lens, from which he estimated 1,500 tons of ore, averaging about 1 per cent. MoS_2 might be recovered by sorting.

Concession IV, Lot 30

Satterly's description continues:

Ten trenches trending at various angles have been put down adjacent to outcrops north and south of the road along the north boundary of lot 30, concession IV, Bagot township, by the Buckhorn Mining Syndicate, Limited. These trenches expose interbedded crystalline limestone, pyroxenite, and hornblende gneiss intruded by sills and dikes of granite-pegmatite. The pyroxenite is in narrow bands. Little or no mineralization was seen in any of the trenches except for a little pyrite and pyrrhotite in the pyroxenite. In one trench the limestone contains radiating clusters of actinolite with a maximum length of 4 inches.

Two other workings occur east and west of the road in the western part of the lot. A trench east of this road is 240 feet long and cuts across the strike of the formations, which include hornblende gneiss, biotite-hornblende gneiss, rusty biotite paragneiss, and bands of pegmatite. A little pyrrhotite was seen in the biotite-hornblende gneiss. On the west side of the road a pit 25 by 30 feet and from 4 to 6 feet deep exposes interbedded crystalline limestone, hornblende and biotite gneisses, and a 5-foot sill of granite-pegmatite. A little pyrite was observed but no molybdenite.

None of the mineralization seen in the above workings is of any significance, and no further work is justified.

Concession IV, Lot 26

Satterly (1945, p. 71) mentioned an occurrence of molybdenite about ½ mile west of the southwest end of Hond Lake. A pit 10 to 20 feet wide, 40 feet long, and from 2 to 7 feet deep, was sunk in 1940 on a band of hybrid gneiss included within the Hond Lake granite mass. A little pyrite and a few scattered flakes of molybdenite from ¼ to 1 inch wide occur in a band of pale green pyroxenite not more than 6 feet thick underlying a 5-foot sill of granite pegmatite. To the north of the pit, pyrite and scattered flakes of molybdenite from ¼ to 1 inch wide were seen in rusty pyroxenite on a small dump containing about 3 tons of material. Satterly considered the occurrence to be of no economic importance.

Concession IV, Lot 27

Workings at this occurrence (Satterly, 1945, p. 72) consist of two trenches and a 10 by 12 foot shaft reportedly 30 feet deep. Sixty feet southeast of the shaft a few flakes of molybdenite occur in a 2-inch pegmatite stringer cutting limestone which is interlayered with hornblende gneiss, rusty paragneiss, and pegmatite. At another trench no molybdenite was observed.

Concession IV, Lot 29

Regarding this occurrence Quinn (1952, p. 60) says:

In 1939 or 1940, lot 29, con. IV, Bagot tp., adjoining and northwest of the properties of Zenith Molybdenite Corporation and of Buckhorn Mines, Limited, was controlled by Bagot Molybdenite Mining Syndicate, Limited. A pit and a trench 40 feet long, 4 feet wide, and 1 foot to 4 feet deep expose granite-pegmatite and hybrid gneiss. A fracture zone from 2 to 4 inches wide in the pegmatite contains crystals of smoky quartz and coarse-grained pyrite and molybdenite.

Other Deposits in the Renfrew Area

The following descriptions of the main occurrences are taken from Satterly's (1945) and Quinn's (1952) reports.

Admaston Township

Concession IX, Lot 9 (Gorman Prospect) (Quinn, pp. 55-56)

The Gorman molybdenite prospect is . . . 1¼ miles northeast of Shamrock and just south of the highway from Dacre to Opeongo. Most of the molybdenite occurs with pyrrhotite in a body of coarse-grained, dark green pyroxenite situated along the contact between a red granite-gneiss and a northeasterly trending band of crystalline limestone.

The deposit has been described by Eardley-Wilmot (1925, p. 82) as follows: 'The main work consists of an irregular pit on the south edge of the road, about 80 feet long, 12 feet wide, and 6 feet deep, with a 30-foot cross trench at the west end. About 100 yards to the west and 50 feet south of the road there is another pit 30 feet by 6 feet and 3 feet deep, from which the richest ore was obtained. . . . A few pockets of high-grade ore were observed, but unless very carefully selected it is probable that it would average under 0.5 per cent MoS_2.

'The deposit was discovered about 60 years ago (about 1864), when the road was being made . . . In 1917, Mr. J. O. Gorman gave an option to Mr. A. J. Gravelle, of Ottawa, who with several others formed the Opeongo Mining Syndicate, and under this name shipped to the Mines Branch, Ottawa, in November, 1917, 21.72 tons of 0.38 per cent ore, from which 117 pounds of pure molybdenite was recovered.'

Concession XIII, Lot 8 (Quinn, p. 56)

Eardley-Wilmot (1925, p. 83) mentions a discovery of molybdenite during the digging of a well on the farm of M. P. Kiley in the east half of lot 8, con. XIII, Admaston township. The mineral was associated with heavy sulphide mineralization.

Satterly (1945, p. 71) describes a 3-foot dyke or sill of rusty pegmatite containing a few crushed flakes of molybdenite from ¼ to 1 inch in diameter exposed in a stripping and test pit, 4 by 4 feet and 3 feet deep, dug in 1918 just northeast of the farmhouse. He reports that the pegmatite cuts a band of hornblende gneiss containing a 1-foot interbed of crystalline limestone striking north 60 degrees east and dipping 55 degrees southeast, the country rock as a whole being banded hybrid gneiss. Freeman (1936, p. 12) considered this occurrence to be worth further investigation.

Satterly (1945, p. 71) also reports an occurrence on the farm of J. F. Kiley, in the west half of the lot. Here a shallow pit in a rusty, white pegmatite cutting hybrid gneiss exposes a few scattered flakes of molybdenite from ¼ to 1 inch in diameter.

Bagot Township

Concession I, Lot 29 (Quinn, p. 56)

An occurrence of molybdenite on the farm of Joe Kluck in lot 29, con. I, Bagot tp., is described by Satterly (1945, p. 71), but is not shown on the map accompanying this report. Two pits, one 16 by 18 feet and 7 feet deep, the other 35 by 17 feet and 6 to 12 feet deep, were sunk in hybrid gneiss in 1939-40 by the Buckhorn Mining Syndicate, Limited. The pits expose bands of amphibolite up to 6 feet wide associated with diopside-phlogopite crystalline limestone, and hornblende and biotite gneisses striking north 70 degrees east, dipping 80 degrees southeast, and cut by granite-pegmatite. The bands of amphibolite are mineralized with pyrrhotite, pyrite, and a very little molybdenite.

Concession XII, Lot 28 (Satterly, pp. 76-77)

A molybdenite occurrence on the farm of John C. Culhane . . . had a number of pits sunk on it in 1915. It is reported that about 200 pounds of picked flake were taken out in 1915, of which 35 pounds of 35 per cent ore was sent to the Mines Branch, Ottawa (Eardley-Wilmot, 1925, p. 87).

Four pits in the southwestern part of the lot, 3,000 feet by trail from the farm house, are within an area 50 feet square. . . . All these pits are very much overgrown. Material on the dumps consists of a coarse, pale- to medium-green mica pyroxenite. A few flakes of molybdenite from half inch to 2 inches in diameter were seen at the (largest) pit. In one pit the pyroxenite was seen to be overlain by biotite gneiss. It is believed there are several narrow bands of pyroxenite. Pink granite gneiss is exposed on the west of the pits. As so little molybdenite can be seen, the occurrence does not appear to be of any economic importance.

Blithfield Township

Concession I, Lot 29 W½ (Quilty Prospect) (Quinn, pp. 60-61)

The Quilty molybdenite prospect is . . . a little less than ½ mile west of Snake Lake and about 2 miles northeast of Constos Lake. The property is referred to by Eardley-Wilmot (1925, p. 87) as follows:

'In 1917 Mr. Quilty sold, through Mr. Christopher, of Pittsburgh, 500 acres of mining rights to the Schutz, Schreiner, and Clyde Company of the same city. During the same year they shipped to the Mines Branch, Ottawa, 19 tons of 0.45 per cent ore, from which 120 pounds of pure molybdenite was recovered.'

The occurrence is described by Satterly (1945, p. 77) as follows:

'The country rock is a white crystalline limestone intruded by a sill or dyke of pink granite or granite-pegmatite about 40 feet wide. The workings consist of 2 pits. The main pit is 50 by 70 feet and from 10 to 12 feet deep. In it the mineralized zone is a pyroxenite containing disseminated pyrrhotite, pyrite, and scattered large flakes of molybdenite. Cutting the pyroxenite are a number of stringers, which fill vertical joints from a quarter of an inch to half an inch in width and are composed of coarse pyrite and scattered flakes of molybdenite. The pyroxenite occurs between the granite-pegmatite and overlying pink crystalline limestone. The thickness of the pyroxenite is about 12 feet.'

The dip of the hanging-wall of the mineralized zone is reported to vary from 10 to 45 degrees southeast, and in most places it is 10 to 20 degrees. Satterly saw much pyrrhotite and pyrite in the pyroxenite but very little molybdenite.

Freeman (1936, p. 12) mentions one quarry and five pits. He states that the ore is low in grade, occurring in a flat, heavy-sulphide and pyroxene contact zone between red granite and limestone.

Bromley Township

Concession V, Lot 24 (Cole Property) (Satterly, pp. 77-78)

A molybdenite occurrence . . . is reached by walking in on a wagon road 2,500 feet west from the east boundary of the lot. The occurrence is 3 miles by road from Osceola.

The workings consist of 19 pits in an old clearing on top of a hill in an area about 250 by 300 feet. The pits are of all sizes, the largest being 15 feet across and 12 feet deep. To the west of these pits on the west slope of the hill and about 30 feet below its crest, an adit has been driven at N 85° E 300 feet under the pits.

As the workings all expose the same rock assemblage, a general description will suffice. The country rock is a pale-green, medium- to coarse-grained pyroxenite minutely veined with stringers of white albite and quartz-albite pegmatite. Coarse grey calcite in veins and lenses appears to be the latest gangue mineral introduced. Residual masses of pyroxene limestone and paragneiss are seen in some of the pits. Molybdenite, in flakes up to 1 inch in diameter, is erratically distributed in the pyroxenite and in the pegmatite. Pyrite and pyrrhotite are rarely present.

The amount of molybdenite present is too small to be of economic significance, and sufficient work has been performed in the immediate area to indicate that the prospect of finding an ore body is not encouraging.

Eardley-Wilmot reports that 1½ tons was formerly shipped from this occurrence. Some of the pits were put down in the years 1914 to 1918.

H. Edelstein did some surface work in the summer of 1939, and in October of that year Puritan Mines, Limited, took over the property and carried on operations till March 15, 1940. The adit was driven by them during 1939 and 1940. The property in 1942 was owned by Ajax Tungsten and Molybdenite Mines, Limited, and was acquired by Buckhorn Mines, Limited, in December, 1942. No operations were carried on in 1942 or 1943.

Griffith Township

Satterly, (1945, p. 84) described a molybdenite occurrence between Haley (Round) and Godin (Green) Lakes in central Griffith township:

Nelson Lepine, of Griffith, did some work in 1939 on a molybdenite occurrence in the unsurveyed area of Griffith township between Haley (Round) and Godin (Green) lakes. If the township were subdivided the approximate location would be the south half of lot 18, concession VII. The occurrence is reached by turning off highway No. 41 to the farm of T. Haley in lot 25, concession V, Griffith township, and then following a wagon road to Haley lake and around its north shore to the northwest corner to a trail leading to Godin lake. From the farm to the workings is 2 miles.

The trail to Godin lake is flanked on either side by high rock ridges consisting of hybrid gneisses cut by granite-pegmatite dikes.

About 1,350 feet southwest of Haley lake and 115 feet northwest of the trail, a trench, 50 feet long, from 3 to 5 feet wide, and from 1 to 3 feet deep exposes the contact between a diopside-phlogopite limestone and a granite-pegmatite dike, which forms the face of the ridge slope. The dike trends N 30 E and is 75 feet wide. At the northeast end of the pit the pegmatite is cut by two veinlets of pyrite. The weathering of these veinlets has caused much brown and black staining on the rock. A small dump shows a few large flakes of molybdenite in rusty pegmatite and in a pale-green pyroxenite presumably from the contact zone. No mineralization was seen in place.

Two small pits occur in rusty gneiss on the northwest side of the dike but show only negligible molybdenite and sulphide mineralization.

Another working on the same ridge is 400 feet northwest of the trail at a point 725 feet southwest of Haley lake. A small stripping and a pit, 4 by 5 feet and 3 feet deep, expose a rusty-weathering graphite-mica gneiss, striking N 25° W and dipping 35° NE, which is mineralized with finely disseminated pyrrhotite. No molybdenite was observed.

An examination of the rock ridges on both sides of the trail failed to reveal any mineralization in the numerous pegmatite dikes exposed.

The very minor amount of molybdenite present in the first showing indicates that the prospect is of no value.

Lyndoch Township

Concession II, Lot 34 S½ (McCoy Property) (Satterly, pp. 84-85)

The old McCoy molybdenite property is . . . about a mile south by wagon road from Bruceton. Eardley-Wilmot (1925, p. 103) has described the early operations as follows:

'During 1916, a 4-foot pit was sunk, and further prospecting work and trenching in 1917 resulted in the following shipments: In the first year, one ton of 0.5 per cent ore and 8 tons of 93 per cent picked flake were sent to Ottawa, and in 1917, one ton of 0.89 per cent ore was sent to Renfrew.'

The property was acquired by McCoy Molybdenite, Limited, in 1937, and early in 1938 a 2-compartment shaft was sunk to a depth of 40 feet and some 260 feet of surface trenching carried out. Workings seen in August, 1943 (see Fig. 7) were as follows: The main pit is 10 by 50 feet and 6 feet deep, with an oval pit in the centre 10 by 15 feet and 6 feet deep and filled with water. Just beyond the east end of the pit is a vertical shaft 4 by 7 feet and 40 feet deep. To the northeast of the west end of the main pit in the side of a hill is an open cut 45 feet long, from 5 to 8 feet wide, and 5 feet deep at the face. To the southwest is an overgrown stripping and trench 40 feet long, from 4 to 8 feet wide, and 5 feet deep at its southwest end. These workings are in the northwestern part of the south half of lot 34.

The main pit exposes a sheet of pink hornblende and pyroxene syenite-pegmatite. It contains accessory tourmaline and quartz as intergrowths. Very little molybdenite was seen in place. The ore dumps north of the pit consist of pegmatite containing 1 per cent molybdenite in flakes from half an inch to 1½ inches across. A little coarse pyrite was seen at one place on the north wall of the pit. At the northeast corner of the main pit the pegmatite is overlain by almost flat-lying, grey biotite paragneiss. The pegmatite appears to be thinning to the east. . . .

Concession VIII, Lot 5 (Jamieson Mine) (Satterly, p. 86)

In 1943, the old Jamieson mine . . . was reached from highway No. 41 at Griffith bridge as follows: Northwest by car 6.8 miles to the second crossing of Highland creek, then on foot 0.8 miles farther along the wagon road to the farm of Dan Maddigan, and then west on a trail 0.5 miles to the old workings on top of a hill.

The following excerpts are from a report by Eardley-Wilmot (1925, pp. 103-105).

'Work was first done on the property, in 1907, by the late Mr. R. A. Jamieson, of Renfrew, and later on, in 1915-16, was worked on lease by the International Molybdenum Company, Limited. Two 20-foot pits, which have been connected by an open trench, were sunk in the gneiss-limestone contact. Between these pits there is an inclined shaft.

'The country rocks are various kinds of gneisses, interbanded with crystalline limestone. The gneisses are cut in many places by intrusive granites and pegmatites, the molybdenite deposits occurring near their contacts with the limestones. The ore-body, which has been exposed for a length of 220 feet along its strike and consists of pyroxene and pegmatite, outcrops on a ridge of gneiss. Molybdenite in large flakes is intimately associated with pyrite and pyrrhotite, of which there is considerable quantity. The three minerals rarely occur in the gneiss or limestone, but are found on the contacts of these rocks or distributed throughout the pegmatite dikes.'

In 1943 the writer found samples on the dump of a late breccia and vug-filling mineralization. The breccia consists of fragments of calcite, and pink pegmatite from an eighth to a quarter of an inch across in a fine-grained greenish-brown groundmass. In this occur crystals of bright, translucent, green apatite from a quarter of an inch to 1 inch in diameter.

In the vugs the following order of mineral deposition was noted: (1) sphalerite in bands to half an inch thick; (2) pyrite as a film; (3) galena, not always present; (4) quartz in little, stumpy, white to translucent crystals; (5) calcite as rounded, semi-transparent crystals; and (6) chalcopyrite in minute crystals on the calcite. This material may have come from a galena vein noted by Eardley-Wilmot (1925, p. 105).

A summary of production is as follows:

'During the latter part of 1915 about 80 tons of hand-cobbed ore was sent direct to Orillia. The greatest part of this was cobbed to 20 or 30 per cent MoS_2, and 1½ tons was pure flake. In 1916 recorded shipments to Renfrew and Orillia amounted to 73 tons of 3 per cent ore, and 12.5 tons of hand-cobbed ore assaying 18 per cent MoS_2. It is stated that in all, 285 tons of ore, containing approximately 12,760 pounds of pure molybdenite was taken from this mine, but by whom and when the balance of this ore was shipped is not recorded' (Eardley-Wilmot, 1925, p. 117).

Raglan Township

Concessions IX and X, Lot 27 (Edgemont Molybendite Mines, Limited) (Satterley, p. 87)

A molybdenite-bearing pegmatite dike has been opened up by a shaft, pits and trenches. . . .

The workings are just west of the Wingle-Schutt road, and about three-quarters of a mile northeast of Schutt.

This property was originally known as the Windle-Liedke prospect and was acquired in 1939 by Edgemont Mines, Limited, the name of which was changed in November of that year to Edgemont Molybdenite Mines, Limited. Edgemont Mines by late in 1939 had done a considerable amount of trenching and test-pitting, sunk a vertical shaft 10 by 15 feet to a depth of 40 feet, and done 1,000 feet of diamond-drilling.

The most recent work, in 1942, by Edgemont Molybdenite Mines, consists of two trenches trending N 25° E at the north end of the workings. The south trench is from 2 to 5 feet wide, 4 feet deep, and 35 feet long. The north trench, 10 feet to the north, is from 10 to 15 feet wide and 45 feet long and now largely filled with waste rock.

The granite-pegmatite dike occurs along the contact between crystalline limestone to the east and paragneiss to the west. The dike trends N 25° E and can be traced south from the above workings for 700 feet to the old shaft. The dike ranges from 5 to 25 feet in width. Narrow basalt dikes cut across the pegmatite dike near the trenches.

At the trenches, the dike is 25 feet wide and the limestone is seen to dip from 10° to 70° E. In the dike is a fracture at N 25° E, dipping vertically, which ranges from 1 to 20 inches in width in the north trench. This fracture is filled with a coarse aggregate composed of calcite, pyrrhotite, molybdenite, and smoky quartz. Hornblende crystals occur in the pegmatite adjacent to the fracture. The average width of the fracture now exposed is about 1½ inches.

A shipment of 27 tons of low-grade ore, containing 243 pounds of molybdenum, was sent to the United States in 1942.

There are no indications that any body of a commercial size is present in the above workings.

Ross Township

Concession II, Lot 22 (Rose Property) (Satterly, pp. 87-88)

The old molybdenite prospect on the Rose farm is situated near the southwest corner of lot 22. . . . It is reached by following a road and trail 3,500 feet southwest from the farm-house, which is near Haley Station.

The workings consist of a trench, which trends N 40° E and has a length of 100 feet and a width of 15 feet at the northeast end. The northeast 60 feet of the trench is filled with water. The average depth of the trench is 7 feet. A shaft is reported to have been put down about equidistant from the ends of the trench. Eardley-Wilmot states that this shaft is 40 feet deep.

The country rock is a hornblende-feldspar gneiss, which strikes from north to N 40° E and dips 60° SE. It contains lit par lit stringers of feldspathic material and is cut by irregular stringers and dikes of pegmatite. On the walls of the trench remnants of a granite-pegmatite indicate a dike striking N 40° E and dipping 50° NW. The walls of the dike are feldspar-rich, but material on the dump indicates the presence of much pegmatitic quartz. Both the feldspar and the quartz contain clusters of large, thin, crushed flakes of molybdenite ranging from 1 to 3 inches in diameter. Pyrite cube aggregates occur in vugs in the quartz, and biotite books from 1 to 3 inches across are present in minor amount in the feldspar. In the southwestern part of the trench the dike narrows from 4 feet to 1 foot and beyond the trench pinches out.

The early history and shipments from this occurrence have been summarized by Eardley-Wilmot (1925, p. 106) as follows:

'The late Dr. J. A. Gant, of Ottawa, and Mr. T. E. Richardson of Portage du Fort, had an option on the property, and in the summer of 1917 the Maple Leaf Exploration Company of Toronto continued sinking the shaft. In the fall of that year, Mr. M. L. Foley sent about 6 tons to Ottawa.

'It is said that 10 tons of 3.64 per cent ore was shipped in 1916, of which 6.6 tons was sent to the International Molybdenum Company's concentrator at Renfrew, Ontario.

'The following are the shipments made to the Mines Branch, Ottawa: M. L. Foley, hand-picked, 6.2 tons, 2.19 per cent MoS_2; per Maple Leaf (J. F. Day), hand-picked, 1.3 tons, 1.08 per cent MoS_2. From the above shipments 316 pounds of pure molybdenite was recovered. Altogether about 18 tons of ore must have been shipped from the property.'

Frontenac, and Lennox and Addington Counties

Molybdenite-bearing deposits, mostly small, are relatively common in the southern parts of the counties of Frontenac, and Lennox and Addington.

Hinchinbrooke Township

Concession VIII, Lot 26 (Harding, 1951, p. 90)

Small flakes of molybdenite are present in a pink pegmatite dyke cutting granite-gneiss at this locality. The occurrence is stated to be of mineralogical interest only.

Concession X, Lot 18 (Eastern Part) (Harding, 1951, p. 90)

Flakes of molybdenite were identified in a lens of pegmatite cutting granite gneisses located south of the Fifth Depot Lake road about 15 chains southwest of the house on the farm of Mrs. H. Drader. . . The occurrence is of mineralogical interest only.

Kennebec Township

Concession I, Lots 14, 15 (Harding, 1944, p. 74)

Small flakes of molybdenite were identified on the west half of either (of these lots). The molybdenite occurs in quartz lenses enclosed in pegmatite. Some shallow trenching has been done in the vicinity.

Olden Township

Concession IV, Lot 19, SW¼ (Harding, 1951, p. 89)

A few scattered flakes of molybdenite were identified in a band of greywacke about 3 feet wide about half a mile north-northeast of the house on the farm of Percy Gray . . . The band of greywacke is flanked by Grenville crystalline limestone. The beds strike northwest and dip almost vertically. The amount of molybdenite exposed is very small and is of mineralogical interest only.

Concession VI, Lot 6, (Eardley-Wilmot, 1925, p. 65)

(This occurrence) was worked in 1917 by Ed. Smith of Perth, who states that there is a wide granite-limestone contact vein half a mile long.

According to J. C. Gwillim (1920, p. 117) this occurrence is in a patch of Grenville rocks in granite-gneiss. The pit, which is 20 by 4 and 8 feet deep, is in a hornblendic rock, granite occurring a few feet to the north and south of it.

In May 1917, 1,000 pounds of 0.27 per cent ore, and in June, 150 pounds of 0.6 per cent ore were sent to the Mines Branch, Ottawa. The grade of these shipments, as well as the opinion of the engineers, would indicate the improbability of obtaining good ore, in the immediate neighbourhood of where the work was done.

Concession VI, Lot 7 (Harding, 1951, pp. 89-90)

Scattered flakes of molybdenite occur in a shallow pit, where an inclusion of crystalline limestone is exposed in pink granite and syenite on the farm of Alfred Neadon . . . The molybdenite occurs both in the limestone and in the adjacent granite. The mineral rights were formerly held by G. M. MacDonnell, of Kingston, under whose direction a small amount of work was performed.

The showing was described by Eardley-Wilmot (1925, p. 65) as follows:—

'This property is situated 5 miles by motor road southeast of Mountain Grove. A 5-foot pit 12 feet long has been dug in a small patch of limestone and pegmatite near a granite contact. The ore is associated with pink feldspar and pyroxene, very little pyrites and no mica being observed. In 1915, Mr. G. M. MacDonnell sent 238 pounds of 0.4 per cent MoS_2 ore to the Mines Branch, testing laboratories, Ottawa. The occurrence is at present of no commercial value. Adjacent contacts might be prospected, but are not promising.'

Concession IX, Lot 24 (Harding, 1951, p. 90)

> The Avery molybdenite showing is situated in the eastern part of lot 24... The mineral rights on this lot are owned by Mrs. V. Avery, Sharbot Lake... Molybdenite was discovered on this lot about the time of the First World War. Only a small amount of work has been done.
>
> The country rocks consist of folded white crystalline limestones and dolomites, which are cut by masses of granite and pegmatite. The beds strike a few degrees north of east and dip from 30° to 50° SE.
>
> Two shallow pits about 50 feet apart have been sunk in the limestone. A few flakes of molybdenite were visible in each pit. No vein was exposed. The molybdenite was disseminated in the massive limestone. The largest crystals exposed were about 1 inch in diameter. A very small amount of graphite is also disseminated in the limestone. The mineralization may be attributed to emanations from nearby granite intrusions. The amount of molybdenite exposed is too small to be of economic interest.

Kaladar Township

Concession II, Lot 13

A molybdenite-bearing pegmatite dyke cutting granite-gneiss on the northeastern part this lot was described in 1939 by L. Marisette. This occurrence appears to be of mineralological interest only (Harding, 1944, p. 72).

Sheffield Township

Concession XII, Lots 9 and 10 (Calvert Prospect)

Eardley-Wilmot (1925, p. 78) states:

> In 1917, Mr. Kelly, of Tamworth, did some work for the Cameron Mining Company on a showing of molybdenite on Calvert's farm 5 miles northeast of Tamworth Station, and 3 miles west of the Chisholm mine.
>
> As a result of surface stripping, one ton of 0.91 per cent ore was sent to the Mines Branch, Ottawa, from which 13 pounds of pure molybdenite was extracted.

According to C. S. Parsons (1916, pp. 115-116) the samples from this property contained small flakes of molybdenite, with very little pyrite, in a quartz-pyroxene gangue.

Concession XIII, Lot 12 (Kellar Prospect)

Eardley-Wilmot (1925, p. 78) reported that this deposit, which lies about 5 miles northwest of the Chisholm mine, was worked in 1916; about 160 pounds of pure flake molybdenite was produced.

> There appears to be three series of deposits, one of which is on a contact between granite-gneiss and limestone. The molybdenite occurs in seams and fine cracks along this contact, but the mineral does not penetrate far into the rock. Another deposit is in a pegmatite dyke within the gneiss, where the molybdenite is confined principally to quartz stringers, together with feldspar, pyrite and calcite. The richest deposit is in the granite-gneiss about 50 feet from the contact; it seems, however, to be only a local concentration.

Concession XIV, Lot 5 (Chisholm Mine)

The deposit at this mine appears to have been the only one of any importance in the Sheffield township area, and the only one which had any production of note. It is 6 miles north of Enterprise Station on the Canadian National

Railways and 4 miles west of Wilkinson on the Canadian Pacific line. Eardley-Wilmot's (1925, pp. 78-80) account appears to be the latest of several reports on this property.

> The ore-bearing zone occurs within Grenville limestone surrounded by red granite. The granite outcrops several hundred feet to the east of the property. The original outcrop, which was located in 1904, was almost entirely covered by a capping of crystalline limestone, the remnants of which are still clearly seen on the edges of the pits. The orebody is broken by horses of limestone. The molybdenite is associated with a heavy sulphide ore, containing much iron pyrites and pyrrhotite, also pyroxenite. The flakes of molybdenite are large and the ore is much heavier than that obtained from the average Renfrew mines.

Eardley-Wilmot then gave a detailed account of the history of the Chisholm mine. Work was first carried out on the property in 1904 when a pit 10 feet deep was sunk. In 1915 another pit was sunk and later joined to the first. At the time of Eardley-Wilmot's report the two main excavations were each about 80 feet in diameter and 15 to 20 feet deep.

> During 1904, M. Chisholm mined about 600 tons of rock, from which 85 tons of picked ore was sold in the United States for $1,275. A sample of this ore assayed at the Mines Branch, Ottawa, contained 1.75 per cent MoS_2. In 1915 he shipped 18 tons to the Ottawa testing plant. This shipment . . . averaged 1.4 per cent MoS_2.
>
> During 1916 the International Molybdenum Company of Renfrew had an option on the property and sent about 235 tons of ore to their concentrator at Renfrew. Not much actual mining was done, as the ore chiefly came from picking over the stock piles.

Using a crude concentrating system, the company in 1917 sent about 5 tons of 5.8-per-cent-MoS_2 material to the Mines Branch, Ottawa. No further work appears to have been done.

All in all about 343 tons of ore has been shipped from the Chisholm mine; from this, about 8,000 pounds of pure molybdenite was recovered. Eardley-Wilmot estimated that about 10,000 tons of rock was removed.

> J. C. Gwillim in his examination in June 1917, estimated the area of the Grenville limestone to be, roughly, 200 by 300 feet, and that further extensions might occur in both directions of the strike. There is however, no certainty of the depth of the mineral zone, as the remnant of the limestone may be shallow, and granite may closely underlie the present pits, but there is still some promising looking ore at the bottom of the pits.

Concession XV, Lot 8

The Spratt prospect, 2 miles north of the Chisholm mine, was briefly described by A. L. Parsons (1917, p. 311) and Eardley-Wilmot (1925, pp. 80-81). According to the latter, a little molybdenite was seen in the open-cut excavated along an oxidized zone at the contact between gneiss and limestone.

Concession XVI, Lot 15 (Wager Prospect)

This property is 6 miles north of the Chisholm mine, near the boundary between Sheffield and Hinchinbrooke townships. According to Eardley-Wilmot (1925, p. 81), a narrow band of quartz and pyroxenite carrying small flakes of molybdenite occurs along a contact between gneiss and crystalline limestone. The band has been traced for about 1,500 feet. In 1915 some surface work was done along the contact and 286 pounds of 0.89-per-cent-MoS_2 ore was sent to the Mines Branch, Ottawa, for testing.

Grenville Province in Quebec

The Grenville province in Quebec contains many molybdenite deposits. The greatest concentration of them is in southern Gatineau county and southeastern Pontiac county, where altogether about forty occurrences of all types and sizes have been reported. A smaller concentration occurs in the northern part of Gatineau county, near and to the north of Maniwaki. Other deposits are more widely spread over much of the Grenville province.

Most of the deposits are small, though some have been worked during wartime. At one period in World War I the Moss mine near Quyon was the largest producer in the world.

The writer visited several of the deposits in the Pontiac and Gatineau areas during the summer of 1958. The following descriptions are based on this field work and published information.

Pontiac County

Aldfield Township

Kert Molybdenite Deposits

These deposits situated on ranges III and IV, lots 1, 2, and 3, have been described by T. L. Walker (1911, pp. 30-31), Wilson (1924, p. 85), Eardley-Wilmot (1925, pp. 140-141) and Ingham (1942b). Ingham's summary is quoted below.

> The Kert molybdenite property . . . may be readily reached by motor road from Wakefield station on the Gatineau branch of the Canadian Pacific Railway, a distance of 17 miles; or from Hull, a distance of 35 miles. Mr. Sam Kert of Duclos, P.Q, is the present owner of the mining rights of the ground.
>
> Development work at the prospect consists of 3 larger pits and 10 smaller pits and trenches sunk in zones of molybdenite mineralization. About 30 tons of ore have been shipped from the property.
>
> Geologically the area is underlain by bands of Grenville crystalline limestone and paragneiss, which are intruded by irregular masses of granite gneiss, granite and pegmatite. Some of the calcareous horizons of the paragneisses and parts of the crystalline limestone have been converted to a metamorphic pyroxenite or pyroxenite-tremolite rock in the vicinity of granite contacts; and the molybdenite mineralization is intimately associated with these alteration products.
>
> The molybdenite-bearing zones consist of scattered flakes, crystals and pockets of the sulphide disseminated in a matrix comprised mainly of pyroxene, tremolite and phlogopite. Molybdenite is found intermittently along a curving zone which trends in a northwest direction for a distance of some 1,800 feet. The separate areas of sulphide localization are not related to any single "break", but rather occur as isolated deposits. In general the mineralization in the individual pits is erratic with enriched pockets separated by lean ore.
>
> Pits No. 8 and No. 2 are regarded as containing the best showings of the property. On the basis of certain assumptions as to the depth extension of the ore bodies, a total of some 2,200 tons of 0.21 per cent MoS_2 ore are estimated. The nature of most of the ore is such that hand cobbing it to a grade of 1.0 per cent or better would be feasible. Further exploration would probably augment the above tonnage figure.

Ingham mentions that molybdenite has been known on the property since 1884. In 1894 the Foote Mineral Company took out about 1 ton of ore; from this, 100 pounds of molybdenite was recovered for use as museum specimens.

In 1917, Mining Corporation of Canada shipped 25 tons of ore from the range III pits to Ottawa, which carried 0.06 per cent MoS_2; and about the same time the Aldfield Mineral Syndicate shipped several tons of ore from the range IV area of mineralization. According to Mr. S. Kert, Quyon interests shipped 45 tons of cobbed ore to Ottawa in 1939. This is said to have yielded 383 pounds of concentrates carrying 39.5 per cent MoS_2 and 0.29 per cent Cu. In April, 1942, the Arctic Circle Mining Syndicate secured an option on the property, and in September Mr. B. Robson of Ottawa took a part interest in the option.

Other Properties

The Duclos property, range III, lot 12, is a pyroxenitic type of deposit mentioned by Obalski (1898, p. 16).

From *ranges IV and V, lots 1, 2 and 3,* Eardley-Wilmot (1925, p. 146) described occurrences lying to the north of, and adjoining the Kert property. The molybdenite occurs in pockets and seams in a flat-lying vein of pyrite on the edge of a gneiss-capped cliff. A 6-foot tunnel had been driven, exposing some flake molybdenite in green pyroxenite. During 1916 and 1917 the Aldfield Mineral Syndicate shipped several tons of ore.

At the *Moodie prospect,* range VI, lot 53, NE¼, molybdenite occurs in lenses of pyroxenite, disseminated in fairly large clean flakes and almost free from pyrite. The pyroxenite is in crystalline limestone traversed at some distance from the showings by dykes of pegmatite (Eardley-Wilmot, 1925, pp. 140-141).

Alleyn Township

At the *Heeney prospect,* range II, lot 1, molybdenite, with molybdite as a weathering product, occurs in a quartz-rich pegmatite dyke cutting hornblende gneiss (T. L. Walker, 1911, p. 30).

Bristol Township

At the *Dagg prospect,* range XII, lot 3, the mineralized zone occurs along the contact of a pegmatite dyke with limestone. It consists of green pyroxenite with a few stringers of pyrite. The molybdenite occurs in irregular patches in the pyroxene and along the pyritic stringers; in places it is sparsely disseminated through the pegmatite (Eardley-Wilmot, 1925, p. 142)

Clapham Township

Work on the *Farell prospect,* range II, lots 6 and 7, carried out in 1917, comprised about 70 feet of stripping, a pit 10 feet deep, and some irregular blasting. About a ton of hand-cobbed ore is said to have been shipped to the old Renfrew concentrator. The ore consists of small stringers of pyrite and pyrrhotite carrying molybdenite and cutting bands of pyroxenite in pegmatite and granite (Eardley-Wilmot, 1925, pp. 142-143).

Clarendon Township

Kirkham Property

This property, owned by Quebec Metallurgical Industries Ltd., Ottawa, lies in the northeast corner of Clarendon township, 9 miles north of Shawville. It covers about 2,700 acres, including lots 1 to 7 in range XII and lots 1 to 6 and the south half of lot 7 in range XIII.

The writer visited the property in the company of Mr. E. A. Hart, geologist of Quebec Metallurgical Industries, in June 1958. The property was then inactive. Thanks are due to Mr. Hart for his ready cooperation and for the information he supplied, much of which has been incorporated in the following report.

The Kirkham property was discovered in 1951, and, with the Tippin showing, was optioned by Quebec Metallurgical Industries in that year. Exploration and development commenced in 1952 and continued intermittently until 1957. The entire outcrop area of the property was picket-lined, mapped geologically, and surveyed with a ground scintillometer in the fall of 1955. During the period October 1952 to October 1954, all exploration was concentrated on finding and developing molybdenite ore. In the later stages an intensive search for uranium was carried out.

The exploration work consisted of stripping, the excavation of pits and trenches on the surface, and the driving of two adits (*see* Fig. 12). In addition 79 diamond-drill holes, totalling 11,440 feet, were drilled. The most promising molybdenite showing was opened up by No. 1 adit. The mineral zone was followed by drifts and a raise to the surface (*see* Fig. 13). A related zone, the 'hanging-wall horizon', was indicated by surface diamond-drilling and was later intersected in crosscuts from No. 1 adit.

Some 1,200 feet southeast of No. 1 adit zone, No. 2 molybdenite zone has been investigated by cross-trenching for a length of 550 feet, but has yet to be tested by diamond-drilling. Its grade is estimated to be less than that of No. 1 zone, but it may be considerably larger.

A further occurrence on lot 6c, range XII, was exposed by trenches and blasts during the early exploration work, but little further work was done on it. The molybdenite occurs in pyroxenite in a silicified limestone area.

During the driving of No. 1 adit, muck samples were taken of each round blasted in the ore zone. The grade of each round was weighted over the 180 feet of drift. Individual values ranged from 0.02 per cent to 3.03 per cent Mo—the higher content of molybdenum being where pyrrhotite was more abundant. Later the drift was chip-channelled over a length of 228 feet including the raise, for a total of 73 samples. The individual sample values also showed a wide range, due to the erratic distribution of molybdenite. In the latter part of 1957 the ore zone was slashed for a length of 243 feet and the raise for about 30 feet. The material was sent to the Mines Branch, Ottawa, for mill testing. Muck samples were also taken at the mine. The mill head sample was calculated

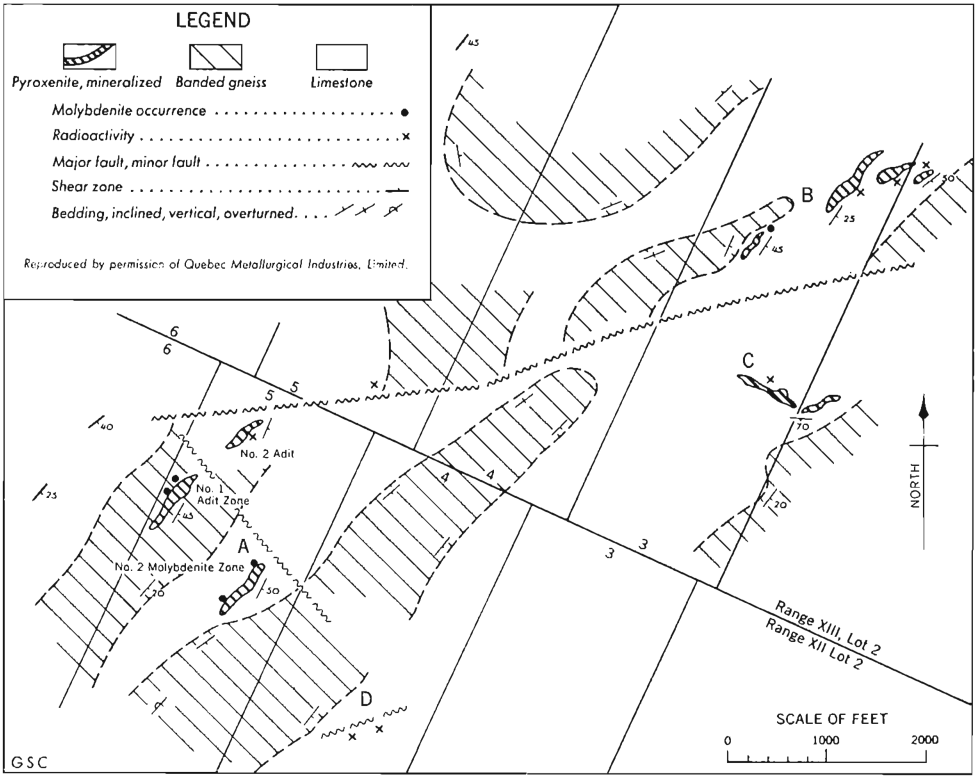

Figure 12. Geology of part of Kirkham property, Clarendon township, Quebec.

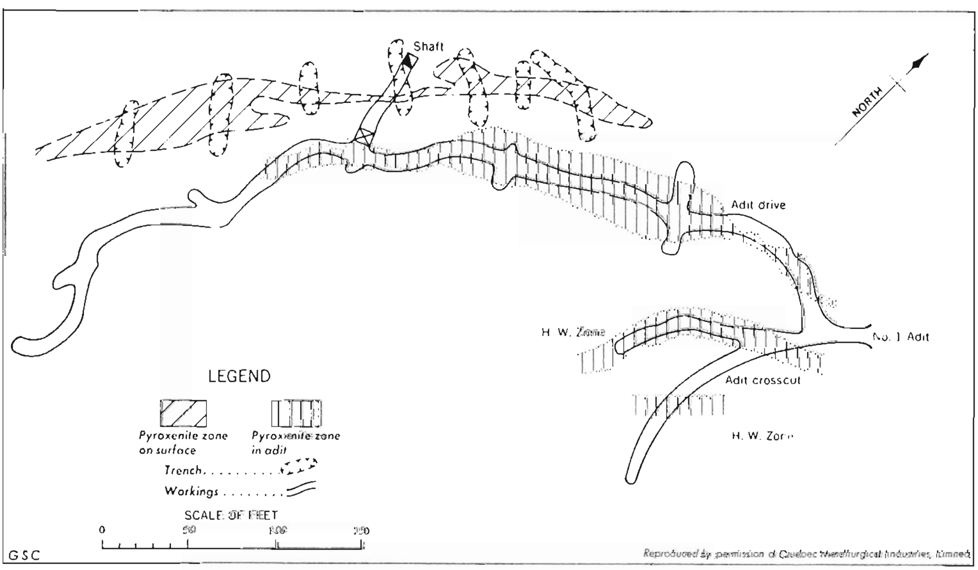

Figure 13. No. 1 adit zone, Kirkham property, Clarendon township, Quebec.

during the test run on a 90-ton sample. The following tabulation gives the results of the various sampling methods:

Average Grade of No. 1 Adit Zone

	Mo(%)
Drift muck samples	0.328
Channel samples	0.290
Muck samples from ore slash	0.252
Mill head samples	0.301

Milling showed a recovery of 83.9 per cent, but better results could be expected on a steady milling basis. Minor amounts of copper were noted in the ore.

Diamond-drill-core assays were found to be very erratic and thus drilling could only be used to indicate the presence of the ore zone, not to indicate grade. No. 1 adit zone is calculated as containing 50,000 tons of ore to a vertical depth of 175 feet. At the present price of molybdenite ($1.18 per lb contained Mo) the recoverable value is $6.37 per ton.

The hanging-wall zone was traced by diamond-drilling only, though a south crosscut from No. 1 adit intersected it at one point. It has an indicated tonnage of 230,000 and its extent is not yet delimited. Its grade is similar or possibly lower than that of No. 1 adit zone. Of the seven drill-holes through it, six contain molybdenite—and two of these assayed 0.13 per cent Mo, and 0.18 per cent Mo, respectively, over the whole zone. All the holes show a higher proportion of pyrrhotite than does the adit zone.

The Kirkham property lies within a series of folded Grenville sedimentary gneisses and limestones that strike northeast and dip southeasterly. Granite outcrops about 2 miles to the northwest and the Onslow syenite outcrops about 4 miles to the southeast. The predominant member of the series is a dolomitic limestone. Hornblende gneiss and biotite gneiss occur as bands interbedded within the limestone. Minor amounts of quartzite outcrop as narrow bands in a few localities.

Pegmatite dykes of various types have been intruded along bedding planes of the sediments. A very few cut across the formations. Most of the dykes appear to have been introduced at the time of folding as they have acted as incompetent horizons in many observed folds. The dykes are mostly of the dark red type and have a mineral composition comparable to that of the Onslow syenite intrusive.

The sediments are folded around a nose of the Onslow syenite that protrudes westward across Bristol township. The Bristol iron deposit lies along the south side of the nose within the sediments, and a smaller magnetite occurrence outcrops on the northwest side of the syenite at Caldwell post office.

A series of diopside-rich pyroxenite lenses occurs within the sediments. These are partly metamorphic and partly intrusive in origin. A large number occur across the northern part of Bristol township and the northeastern part of Clarendon township. Some contain molybdenite, pyrite, and pyrrhotite, and also uraninite and some minerals of the pyrochlore group. The Kirkham molybdenite deposit lies within a pyroxenite band.

A few pegmatites have narrow pyroxenite margins on one or both sides of the dyke. They may carry small amounts of uraninite in localized clusters. It is characteristic of the pegmatites of the region to be relatively high in thorium and low in uranium. None so far explored contains economic amounts of either metal.

Several regional faults are known in the area. These strike southeasterly, roughly parallel with the course of the Ottawa River. Less pronounced faults, of interest because of their radioactive mineralization, strike east-west and have steep to vertical dips.

The Grenville series—dolomitic limestone and hornblende gneiss—has an average strike on the property of N50°E; it dips at various degrees to the southeast (*see* Fig. 12). These sediments have been intruded by narrow pegmatite dykes along bedding planes. Lenticular masses and dykes of pyroxenite occur in the central part of the group. A bed of quartzite occurs on the west side, in lot 7, range XII.

The sediments are in the form of large folds. A large open anticline and a closed syncline lie in the north half of the property, and a large, closed, overturned fold occupies the south part. Between these two parts, a regional fault has been discovered by means of detailed mapping and a diamond-drill hole. The fault strikes east-west and seems to have a steep dip.

Dolomitic limestone forms the larger part of the Grenville series on this property. It is white, medium to coarse grained and contains small amounts of dark mica, some graphite flakes, and commonly pyrite grains. Original bedding planes may be recognized by fine bands of dark minerals. The limestone weathers to a rough, nodular surface, with solution fractures and sink-holes.

Metamorphism has developed bands of hornblende gneiss in the limestone. They may represent impure beds in which hornblende and biotite mica have developed as the principal constituent minerals. They are dark grey to black, often delicately banded, and may be rusty-weathering where pyrite or pyrrhotite are present.

The band of quartzite on the west side of the property is grey, with cemented fine grains, and shows bedding.

A series of pegmatite dykes lies within the bedding planes of the sediments. The dykes contain a pink to dark red sodic feldspar, quartz, some pyroxene, and minor amounts of allanite, sphene, magnetite, pyrite, and pyrrhotite, and uranothorite.

Alteration zones along the sides of some of the dykes consist of diopside-bearing pyroxenite. These may range from an inch to several feet in thickness. Some of the pyroxenite contains small amounts of uraninite and molybdenite. Several of these occurrences have been stripped, trenched, and bulk-sampled. Neither commercial tonnage nor payable grade are indicated. They are lenticular in both plan and section.

Bands of pyroxenite also occur within the limestone. These appear to be distinct zones and not related to the pegmatites. Some appear to be replacements within a fault or breccia zone.

A large fault passes easterly through the central part of the claim group. North of this, two large folds have been mapped—an open syncline and a closed anticline. South of the fault, the sediments appear to be part of a large overturned anticline with its axial plane lying across the range line on lot 4 and extending into the south part of lot 5, range XII.

Two faults with minor displacement cut the sediments south of the main fault. One passes between adits No. 1 and No. 2 and is marked by a straight, steep-walled valley. The other is in the middle of lot 4, range XII, and is exposed only in trenches; it is parallel with the large fault.

A shear zone has been observed in the north part of lot 6, range XII, and in the north part of lot 5, range XIII. It strikes northeast and dips about 40°SE.

These faults and the shear zone may fit into the strain-ellipsoid pattern. The ore lenses of pyroxenite in the adit area, in A area, and in B area (*see* Fig. 12), all seem to occupy gash fractures. Others may yet be found on either side of the main fault. The pegmatite-pyroxenite zone in area C occupies a tight fracture along its length, but openings are developed away from it in a northeasterly direction. Observations along the fracture between No. 1 and No. 2 adits also suggest that it is a tight break with slight movement. The large fault, however, which does not outcrop, and was found by detailed mapping and proved by a drill-hole, could contain openings, particularly in the region where it bends in the middle of lot 4, range XIII; it has appreciable relative displacement.

The break in area D, lot 4, range XII, roughly parallel with the large fault, is about 2 to 8 feet wide. At the time of the writer's visit it had been traced for 500 feet; the break is quite straight and dips steeply north or is vertical. It cuts across the sediments and appears to be a late structure. It contains diopside, tremolite, hornblende, possibly melilite, patches of pink carbonate, scapolite, uraninite, pyrite, and traces of molybdenite.

The south wall shows evidence of having been a shear plane; minute fractures within the zone are parallel with the walls. They are filled with carbonate and in places are lined with uraninite. They weather as bright to pale orange streaks. Uraninite also occurs disseminated throughout the zone, particularly in association with tremolite and scapolite.

This zone is in line with the old Tippin showing in lot 5, range XII, about 2,000 feet to the west, and may also be related to the Walsh deposit to the east in lot 1, range XIII.

It is significant that the uranium-bearing fault in area D is parallel with the larger fault that crosses the property, near which have been found large angular augite-hornblende float boulders containing much uraninite. This fault also has uraninite-bearing pyroxenite, just to the north in lot 5 beside a small spring. This length of about 3,000 feet of potential uranium-bearing structure has yet to be explored and is the most promising on the property.

The shear zone found in the north and west sides of lot 5, range XIII and in the north end of lot 6, range XII, contains a considerable proportion of graphite and some pyrite.

Several of the pyroxenite zones on the property contain concentrations of molybdenite. Four such zones have been explored by surface stripping and sampling and two of them by adits.

The most promising molybdenite zone opened to date is that of adit No. 1, at the north end of lot 5, range XII. It is a lenticular body of pyroxenite overlying a pegmatite dyke, with a zone of hornblende gneiss and limestone above it. It is part of a long pyroxenite band that has been traced 2,200 feet to the south. The mineralized part is about 300 feet long, has an average width of 20 feet, an average dip of 45°SE and a dip length of 200 feet indicated by diamond-drilling, with no change in character.

Two other zones are present—one on either side of the adit zone. The top zone is about 10 feet thick, is relatively higher in grade than the adit zone, and has been traced for 500 feet in length. The lower zone, where cut in a diamond-drill hole, is 5 feet thick, and is also well mineralized and of relatively higher grade. The upper zone does not outcrop on the hillside, but is wider in the deeper drill-holes. The three bands may be parts of a single body at depth.

The pyroxenite in these zones is medium to coarse grained, dark green, and is mostly diopside with some carbonate as interstitial grains and stringers. It has a chilled margin against the underlying pegmatite.

The sulphides—pyrrhotite, pyrite, molybdenite, and chalcopyrite—occur in fractures, breccia zones, and other areas, and also partly replace the pyroxenite. Mineralized zones tend mostly to be vertical and there is no concentration on either wall. Pyrrhotite may form as much as 50 per cent of the rock by volume. Most of the molybdenite is in association with the other sulphides and the higher-grade sections also carry much pyrrhotite. The molybdenite occurs largely as coarse flakes and plates, some up to 3 inches in diameter.

The ore has a rake to the east as noted from a study of the geology on the surface and in the adit, and from diamond-drill results.

Two radioactive occurrences have been found in No. 1 adit: one is in the pyroxenite zone in drill-hole No. 18 from 97.5 to 101.5 feet, associated with sulphides; the second is in the second south crosscut. There, several fine fractures strike N75°E with a steep to vertical dip, and cut through the pyroxenite and sulphide mineralized zones.

Microscopic examinations of the fractures and contained material by H. S. Spence showed that the sheared and granulated fractures are calcite-filled and that the pyroxene is partly serpentinized and altered to talc. Considerable granular pyrrhotite is present. Uraninite occurs in the calcite as anhedral grains, and granular aggregates.

A dark red coarse-grained pegmatite underlies the pyroxenite for a distance of 300 feet along strike on the surface and for about 120 feet down the dip. It contains a sodic feldspar, quartz, pyroxene, magnetite, sphene, zircon, allanite, uranothorite, and minute amounts of pyrite and pyrrhotite. Spence has also identified crusts of lanthorite coating allanite crystals and hyblite around uranothorite grains. The radioactive minerals are concentrated on the upper 1 foot of the pegmatite; they decrease in amount farther into the dyke. The pyroxenite contains no radioactive minerals, and the pegmatite has no molybdenite. Thus the dyke appears to have little relationship to the mineralization of the pyroxenite. The dyke ranges from 3 to 10 feet thick and the pyroxenite averages 20 feet. The dyke would appear to have been too small to have supplied the sulphide minerals. The replacement nature of the sulphides and the fact that they also occupy brecciated zones opened within the pyroxenite, suggest that they have migrated up from depth through the refractured pyroxenite host. The limestone and pegmatite on either side of the pyroxenite show no brecciation.

No. 2 adit has opened another band of pyroxenite across the valley 500 feet to the northeast of No. 1 adit. A band of pyroxenite lying within limestone has been traced on surface for 350 feet. It is 12 feet thick and contains some local concentrations of molybdenite. The zone has a series of vertical fractures that contain uraninite. The surface has been bulldozed and several vertical fractures have been exposed. They strike N40°E and cut obliquely across the pyroxenite. They are filled with a dark pink calcite and some coarse sphene crystals.

Uraninite has formed as encrustations on the walls, commonly in a dendritic pattern or as distinct crystals, some up to ½ inch in diameter. Spence has also identified bröggerite in the fractures. The raise through pyroxenite shows that the fractures are confined to the pyroxenite, and do not extend into the enclosing limestone. The uraninite has penetrated the walls of the fractures for a distance of an inch in places. The amount of radioactivity is in direct proportion to the degree of fracturing.

The pyroxenite is fine grained, pale green, uniform in texture, and contains diopside, scapolite, some feldspar, and a few sphene grains and finely divided molybdenite.

The showing does not constitute a profitable source of either molybdenite or uraninite.

A third band of pyroxenite has been exposed by stripping and trenching, 1,100 feet to the east of No. 1 adit, parallel with the adit. It lies within limestone and extends for 1,400 feet. It has been blasted and sampled but has not been diamond-drilled. Molybdenite is disseminated throughout, but in lesser amount than in No. 1 zone.

The fourth occurrence lies in the north part of lot 6, range XII; it is a plug of pyroxenite within limestone, on the top of a hill. Fine, disseminated molybdenite occurs throughout the fine-grained diopside. The showing is low grade and small (50 by 150 feet).

Huddersfield Township

Chabot Mine

The geology and workings of this property, on range V, lots 20-22, are described by Eardley-Wilmot (1925, p. 145):

> Molybdenite is sparsely disseminated throughout a mass of limestone, altered by contact with granite to massive pyroxene. The chief showing of the mineral, which is on the south half of lot 22, is closely associated with secondary pink and white calcite that occurs as segregations or gash veins in the main mass of the pyroxene. One of these calcite bodies is about 15 feet long and from 1 to 3 feet wide. The orebody, which is exposed in the bottom of a shallow pit, carries heavy flake molybdenite.
>
> In 1917 about 2 tons of selected ore, mining 4.63 per cent, and 14 pounds of pure flake (88 per cent MoS_2), were sent to the Mines Branch, Ottawa, from which 163 pounds of pure molybdenite was recovered.
>
> Prospecting was confined to a small area, but geological conditions are favourable to the occurrence of small deposits of molybdenite over a fairly large area. In mining such deposits, it is probable that the ore would have to be carefully hand-cobbed.

Squaw Lake Property

This occurrence, on range VIII, lots 19 to 26, lies along the north shore of the east arm of Squaw Lake. At the time of writing it was included in a block of claims comprising lots 20 to 27, inclusive in range VIII, held by F. Klock and associates of Ottawa. These claims cover 1,200 acres; the molybdenite showings are in the northeastern part. They are easily reached by a gravel road from provincial route No. 8 at Shawville, via Otter Lake and the Picanoc Valley road to a point 39 miles from Shawville, where the road to Squaw Lake turns off to the northwest. The property is about a mile from the turn-off. The distance by road from Ottawa is 90 miles.

The geology and workings have been described by J. A. Bancroft(1918), Gwillim(1920), Wilson(1924), Eardley-Wilmot(1925), Ingham(1942c), and Kretz (1957, p. 6).

The property was originally staked about 1906 by Mr. J. T. Farell of Otter Lake. Later the mineral rights were taken over by the Wood Molybdenite Company, who in 1917 opened up the property and built a 25-ton concentrator, using a water-film flotation machine. In 1918, about 700 pounds of concentrates, averaging 72.0 per cent MoS_2, were sent to the Mines Branch, Ottawa, for retreatment; from this, 457 pounds of pure molybdenite was recovered. During the winter of 1917-18 the Mining Corporation of Canada purchased the Wood property and bored three diamond-drill holes, but the proportion of ore cut was very small and all operations were stopped. Eardley-Wilmot reported that "it would appear that all the available ore in the immediate vicinity of the workings has been exhausted."

According to Wilson the molybdenite deposits consisted chiefly of masses of syenite gneisses in which bands and elongated masses of limestone are intercalated. Eardley-Wilmot mentioned in addition to "igneous gneisses", "bands of intensely metamorphosed sedimentary rocks including crystalline limestones, paragneisses, and quartzites." The zone of rusty-weathering gneisses in which the molybdenite deposits occur contains numerous small irregular masses and bands of coarsely crystalline white to pink calcite, which Wilson considered were "almost certainly fragments of an originally continuous mass of Grenville limestone that has been broken and transformed as a result of the intrusion of the associated granite-syenite gneiss." This gneiss is a medium-grained, foliated and banded type—the foliation and banding strike N40°W(magnetic) and dip 25°NE. Wilson examined the rock in thin section and concluded it lay on the borderline between granite and quartz-syenite.

The actual mineralized zone carrying the molybdenite varies greatly in composition, ranging from granite-syenite gneiss to a pyroxenite composed entirely of green diopside. The rusty appearance is the result of the weathering of contained pyrite and pyrrhotite. Irregular masses and dykes of pyroxenitic pegmatite are common throughout the belt, and in places a banded structure resulting from the alternation of zones bearing pyroxene, feldspar and scapolite could be observed.

According to Wilson the molybdenite deposits consisted chiefly of masses or zones of molybdenite-bearing pyroxenite, some of which could be seen to lie along the margins of masses or bands of crystalline limestone. The rich molybdenite ore exposed in the bottom of the main (No. 1) pit was underlain by a flat mass of limestone lying almost parallel with the bottom of the pit, so that the actual deposit there—the most extensive discovered on the property—was in reality not more than 2 to 3 feet thick. Eardley-Wilmot likened the molybdenite-bearing zones to elongated shallow saucers occurring in a layer of pyroxene rock about 6 feet thick, extending over the side of the hill above the lake. According to him the molybdenite occurred in patches or streaks along a parallel system of joints. Wilson observed that the molybdenite occurred as scattered flakes, crystals, and aggregates, and at some points constituted a considerable part of the rock. The principal associated minerals that he observed were pyrite, pyrrhotite, scapolite, fluorspar, apatite, and titanite.

The three diamond-drill holes bored by the Mining Corporation of Canada in 1917 and 1918—two vertical and one inclined—cut through alternating bands of pyroxenite, gneiss, limestone, pegmatite, and quartz throughout their entire length. In No. 1 hole the first 30 feet was in pyroxenite and no assays showed more than 0.07 per cent MoS_2. Broad bands of pyroxenite were struck at 125 feet, 275 feet, and at the bottom at about 320 feet. The average molybdenite content was lower than in the uppermost band and the bottom was barren.

Most of the writers follow Bancroft's original ideas on the origin of the Squaw Lake deposit. According to Bancroft the molybdenite occurrences "have been developed under the influence of processes of intense contact metamorphism." He considered the "granitoid gneisses" as having been intruded into the metamorphic sedimentary rocks, in which the limestone and other calcareous bands had

... not only been converted into an assemblage of variable coarse grains of dark green pyroxene, phlogopite, scapolite, sphene, apatite, calcite, and quartz, but in a few places, relatively small portions of some of these bands have been irregularly impregnated with molybdenite, pyrrhotite, pyrite, and occasionally a few grains of purple fluorite; occasionally pyroxene is present to the exclusion of the other minerals mentioned . . . the occurrences of molybdenite are plainly the result of mineralizing fluids and probably gases which emanated from cooling granitoid magma and permeated portions of the then crystallizing sedimentary rocks. The mineral associations as well as the geological relations of these molybdenite occurrences indicate that they developed at great depth and under conditions of relatively high temperature and great pressure.

As mentioned above, Wilson also attributed a contact-metamorphic origin to the deposits, the molybdenite-bearing pyroxenite masses having been formed by the action of the intruding "granite-syenite gneiss" on original Grenville limestones.

Bancroft gave a detailed description of the geology at all the workings on the property. At the time of his investigation these workings had just been opened up and the exposures were presumably fresh. At present, after 40 years of inactivity, the old open-cuts and trenches are greatly overgrown; the outcropping rock is heavily rusted and much of it is decomposed, due to the weathering of the contained sulphides, mainly pyrrhotite. At the edge of the lake below the remnants of the old mill (*see* Fig. 14) is an outcrop marked on Wilson's sketch map as "granite-syenite gneiss". This is, in the hand specimen, a greyish, banded granitic gneiss of variable composition with segregations of pink feldspathic material, mostly as stringers and lenses parallel with the foliation. The latter strikes northwest and dips 25 to 30°NE. The rock exhibits a well-marked lineation plunging at 15 degrees in a S55°E direction. Up the slope to the northeast, this granite-gneiss is overlain, apparently conformably, by a medium-grained, dark grey hornblende or biotite gneiss. This in turn is succeeded by the rusty rocks belonging to the general mineralized zone. At a point about 25 yards from the lakeshore a flat outcrop of these rocks shows irregular open folds trending S60°E and plunging at 20 to 25 degrees—parallel with the lineation in the rocks. Irregular seams of pyrite are visible on the surface of the outcrop.

The rusted rocks are mainly very quartz-rich and gneissic—some are almost pure quartzite—and are impregnated with fine pyrite and pyrrhotite. Some bands are more feldspathic and some carry increased amounts of mica and/or hornblende. No molybdenite was observed in these rocks.

No. 1 pit—the main pit of the old workings—is a roughly circular opening excavated into the hillside, which rises markedly at this point. The bottom of the pit contained a depth of 20 feet of water at the time of examination, but outcrops occur at intervals all around the higher sides of the pit. The rocks observed were mainly fine- to medium-grained biotite schist, a green pyroxenite of variable grain-size, and a very coarse grained calcite rock with minor biotite. The rocks appeared to be in layers, dipping at fairly low angles to the west, i.e. with the slope of the hill. Generally the coarse calcite rock seemed to underlie the other types. This is the underlying 'limestone' layer mentioned in the earlier reports. However it also occurred in irregular masses and layers

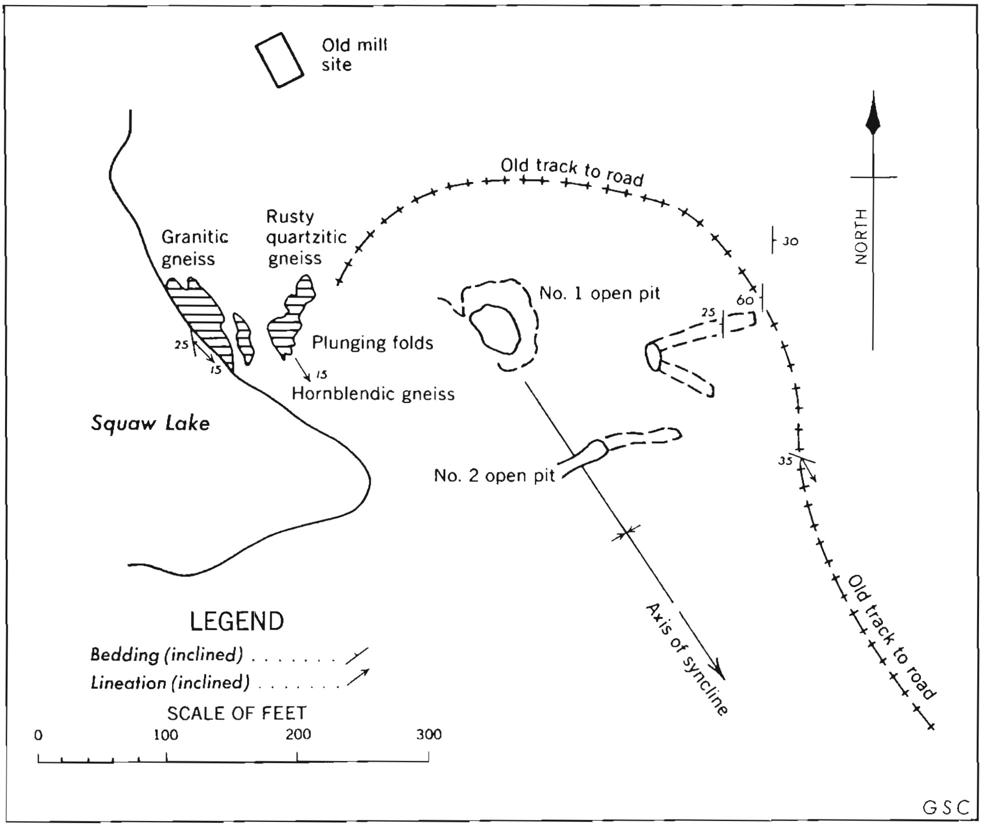

Figure 14. *Sketch of surface workings at Squaw Lake property, Huddersfield township, Quebec.*

between bands of other rocks, and an examination of the contacts between the two strongly suggested that the calcite rock is replacing the other. Thus, if the calcite rock was originally Grenville limestone, it was strongly mobilized after the formation of the pyroxenite and biotite gneiss and invaded them from below, crystallizing out in the very coarse form seen today—a virtual calcite pegmatite.

Up the slope of the hillside from the old open-pit, exposures are few and it is not clear what happens to the pyroxenite bands and why they were not followed farther. It must be assumed that either they petered out in this direction or they ceased to carry molybdenite. However a good exposure of the near-surface rocks is afforded by a long trench, about 3 feet deep and 3 to 4 feet wide, that runs down the hillside from the old wagon road to a point above and southeast of No. 1 pit (*see* Fig. 14). This trench has been excavated in grey to dark grey, thin-splitting quartzitic schist, now very rusty due to the weathering of contained iron sulphides. Some bands contain fine, evenly disseminated graphite flakes of the order of 0.5 to 1 mm in diameter. A random sample of this mineralized schist showed 0.002 per cent Mo. At the top end of the trench these schists had a strike of about N10°W and a dip of 25°W. This attitude was maintained more or less constantly down the trench. As the dip of the beds is almost the same as the slope of the hill, the trench is excavated in practically the same layer the whole way down and it is not possible to judge the thickness of the zone of graphitic schists. The trench culminates in a small, water-filled pit, mostly overgrown now but revealing in places more of the coarse calcite rock as loose blocks. Thus it is probable that the quartzitic schists there are not more than a few feet thick and are underlain by more of the calcite rock.

The graphite-bearing quartzitic schists seem to be identical to the rusty schists seen between the lake and No. 1 pit. Thus there would seem to be a shallow synclinal structure with its axis running about southeasterly through the open-pits (*see* Fig. 15). The lineation in the rocks and the minor folds all plunge in this direction, so that it may be assumed that this is also the direction of the main syncline. Thus the zone of mineralized pyroxenite worked in the past seems to be located along a synclinal fold and probably plunges with this syncline to the southeast. The localization of the main mineralization along a plunging syncline would suggest that any future exploration on the property should be directed to the southeast and at depth. However the evidence of the old workings and of the holes drilled in 1918 is that the mineralization is erratic in the extreme and may not reward any such exploration.

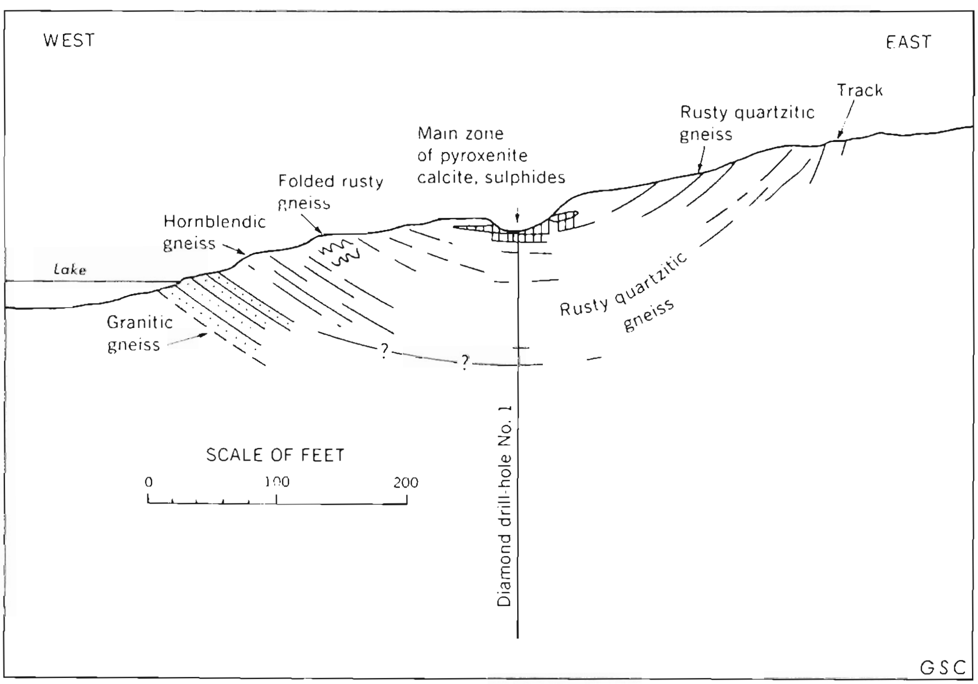

Figure 15. ***Hypothetical vertical section through No. 1 open-pit, Squaw Lake property, Huddersfield township, Quebec.***

The evidence presented by the writer's investigation does not lend much to support Bancroft's 'contact metamorphism' theory. The only granitic rocks revealed are those near the edge of the lake—the "granite-syenite gneiss". These are not, so far as could be seen, in contact with any limestone or pyroxenite; they are separated from the main mineralized zone by many feet of hornblende-biotite gneiss and the rusted quartzitic gneisses. This granite-gneiss seems to be part of the normal rock sequence of the area. It may underlie the syncline as suggested in Figure 15, but there is no evidence that it bears any intrusive relation to the other rocks. The sulphide mineralization seems to have been a late phenomenon that occurred after the regional gneissosity had been impressed on the rocks, and was localized to large extent by the shallow syncline. The role played by the coarse calcite rock is hard to determine. As mentioned above, it seems to have replaced more than one of the rock types in the mineralized zone and may possibly be even later than the sulphide mineralization.

Moyle Prospect

This prospect, range VIII, lot 27, lies to the west of the Squaw Lake property and shows similar geological features. J. A. Bancroft (1918, pp. 44-46) fully described the geology and workings. Considerable prospecting was done, but apparently very little molybdenite was found.

Leslie Township

On the *Stephens property,* range V, lot 45, an occurrence of molybdenite in pyroxenite is recorded by Eardley-Wilmot (1925, p. 160).

Litchfield Township

Bolan Property

Eardley-Wilmot (1925, p. 148) described the geology on this property, range IX, lot 26, as follows:

> Under a capping of granite-gneiss, also on exposed surfaces, there are irregular bands and patches of pale green pyroxenite. Portions of this rock carry well-formed flakes of molybdenite sparsely disseminated throughout. There are a few molybdenite-bearing stringers of pyrite, and a considerable quantity of biotite mica. Wherever mica forms a constituent in the pyroxenite, molybdenite is almost entirely absent.
>
> About one ton of 0.60 per cent ore was shipped to the Mines Branch, Ottawa, in June 1917, from which 7½ pounds of pure molybdenite was recovered.
>
> A large tonnage of high-grade ore should not be expected from any of the workings at this elevation, and all ore mined would probably have to be carefully hand-selected.

Crawford Prospect

The Crawford prospect, range IX, lot 28 E½, lies east of the Bolan prospect on the boundary between Litchfield and Thorne townships. Eardley-Wilmot (1925, pp. 148-149) states:

> The mineral zone consists of several small bands of pyrite and pyrrhotite in altered gneiss and pyroxenite that dip flatly to the northeast. The pyrite stringers are 3 to 6

inches wide and are separated by about 1 foot of metamorphosed material. The molybdenite is intimately associated with other mineral sulphides. Two of the stringers that are exposed in the workings seem to show that the mineralization is local and irregular, there being barren zones on the exposed surfaces. The mineral zone is cut off on the northeast by a wall of granite, which is visible in the small shaft. On approaching this wall the mineral zone becomes narrower and leaner.

Other Occurrences

On the *Davis property,* range X, lot 3, an occurrence of molybdenite in pyroxenite 6 miles northeast of Fort Coulonge is mentioned by Gwillim (1920, p. 110).

Molybdenite occurs in mica-bearing pegmatites on *range XI, lot 20* (Que. Dept. Colonization, Mines, Ann. Rept. 1901, p. 58).

The *Giroux prospect,* range XI, lot 21 SW½, has been described by Willimott (1904, p. 16) and by Eardley-Wilmot (1925, p. 149). According to the latter, molybdenite occurs within green pyroxene as large chunky flakes, aggregates, and well-formed crystals. In some places the mineral was found in contact with pegmatite dykes. A certain amount of surface blasting had been done.

Onslow Township

Moss Mine

At this mine, on range VII, lots 9 and 10, formerly worked by the Dominion Molybdenite Company, the deposits are representatives of a type of molybdenite occurrence that appears to be uncommon in Canada. Although they have not been worked since 1944 and there is little indication of much ore remaining, they must be included in any account of Canadian molybdenum deposits because of their geological interest.

The writer visited the main workings in June 1958. Most of the open-pits were full of water and outcrops were limited, so that the information obtainable was meagre. The deposits were investigated by Wilson when they were being worked and he has given a detailed account of their geology (1924, pp. 63-77).

According to Wilson the original outcrop of molybdenite-bearing rock had been known for some years on the farm of Robert Steel, on range VII, lot 9. But it was not until 1915 that any work was carried out. In that year the Canadian Wood Molybdenite Company was formed to purchase and operate the property. Wilson states:

> The newly organized company immediately began shipping ore to the concentrating plant of Henry Wood and Company in Denver and to the ore-dressing plant of the Department of Mines in Ottawa. A few car-loads were also shipped to the plant of the International Molybdenite Company at Renfrew, Ontario. In 1916 a mill having a capacity of approximately 50 tons a day was built on the property...
>
> Early in 1917 the property was purchased on behalf of an American syndicate operating under the name "Dominion Molybdenite Company". During the summer of 1917 this company carried on extensive diamond-drilling operations to determine the extent of the deposits and enlarged the capacity of the mill to 150 tons a day. Following these changes the Dominion Molybdenite Company operated the mine uninterruptedly until March 1919 when it was closed down.

During 1916, 1917, and the early part of 1918, mining operations were carried on entirely by the open-cut method (*see* Fig. 16). In the spring of 1918, an inclined shaft, 200 feet deep, was sunk at an angle of 70 degrees towards the east from a point 60 feet west of the northwest corner of No. 1 pit. From the bottom of this shaft a crosscut was driven 100 feet eastward to a

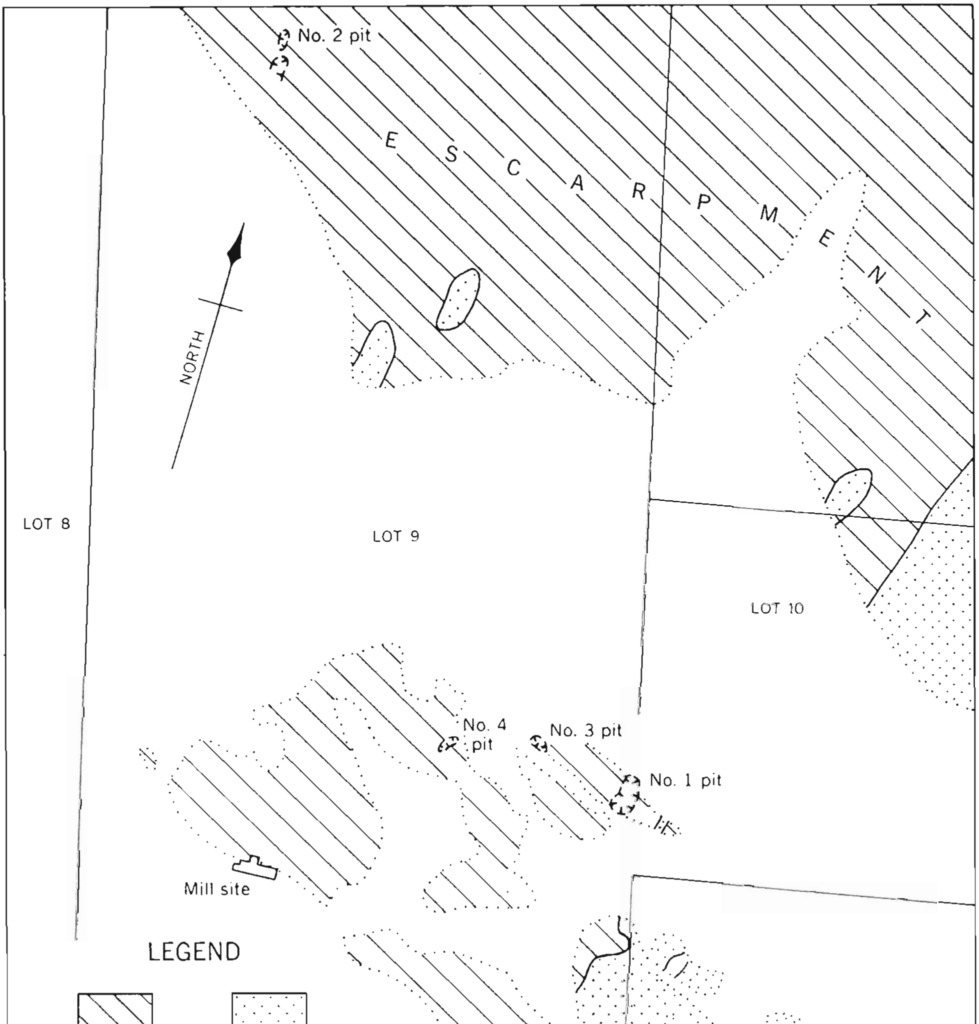

Figure 16. ***Sketch map showing location of main workings for molybdenite and main rock outcrops, Moss mine, range VII, Onslow township, Quebec.***

point almost directly under the northeast corner of the pit. When the mine closed down in 1919, No. 1 pit had a maximum depth at the north end of 125 feet, and drifts had been driven from the end of the crosscut for 100 feet towards the north and 60 feet towards the south.

Wilson made no mention of ore reserves at the time of the close-down, which must be attributed to the collapse of the market for molybdenum following the end of World War I.

During its fairly short life, the Moss mine became the leading world producer of molybdenite and it produced more than 80 per cent of the Canadian output between 1916 and the end of World War I. According to figures tabulated by Eardley-Wilmot (1925, p. 154), 61,206 tons of ore was mined at the Moss mine in the years 1916-1919; from this 765,091 pounds of MoS_2 concentrates was produced.

In 1938 the Quyon Molybdenite Company reopened the Moss mine, unwatered the workings and retimbered the shaft. A program of trenching and quarrying was carried out in the area of the No. 2 working in the northwest corner of the property. The company also commenced a geophysical survey. After the outbreak of war the company went into production and treated, on the average, about 150 tons of 0.2-per-cent-MoS_2 ore daily until May 1944, when operations ceased. The concentrate was converted to molybdic oxide in a small roasting plant on the property. It was then briquetted and shipped to steel manufacturers in Canada. Since 1944 the property has remained inactive.

At the western termination of the Eardley escarpment in range VII, Onslow tp., the Onslow syenite has been intruded into an older batholithic porphyritic syenite, in the form of masses and dykes, over an area approximately 2 miles long from east to west and 1 mile wide from north to south. The Onslow syenite, in most of its occurrences, is a fine-grained, pink, aplite-like rock in which the ferromagnesian constituents are visible only as specks, although, in places, variations from this normal type occur. The most striking variations are the siliceous, pyritic aggregates, bearing molybdenite, which formed the ore-bodies worked at the Moss mine. During the years 1916-1919, more than 400 tons of concentrates were recovered from these masses, which, according to Wilson, have apparently segregated from the syenite. Wilson indicated that there is a gradual decrease in the silica content of the Onslow syenite mass from a 'quartz-syenite' in the west to a normal syenite in the east, and that it is in the 'quartz-syenite' parts that the molybdenite deposits are situated.

The Onslow syenite is probably the youngest of the Precambrian rocks exposed in the area. In most places where it intrudes the older porphyritic syenite, dykes of at least three different ages are present but no definite order in the succession of these intrusions can be determined, according to Wilson. The syenite is an exceedingly massive rock with no signs of foliation or metamorphism. It is possible that it is late Precambrian and does not really belong in the basement complex. However, said Wilson, "The approximate north-easterly trend of most of the molybdenite ore masses associated with the syenite suggests that the regional deformation had not entirely ceased at the time the mass was intruded."

Five ore masses of this segregated type were discovered in the area, but most were too small to be of commercial importance. Most of the molybdenite produced was mined from two or three bodies occurring on a low northwest-trending ridge at the south end of lots 9 and 10.

The five deposits were known as Nos. 1 to 5, in order of importance. The first four were visited by the writer and their positions are shown on Figure 16. No. 5 deposit was a small irregular mass, 10 feet in diameter, exposed at the foot of the escarpment on lot 11. Wilson (1924, pp. 65, 66) describes these deposits as follows:

> The ore composing the deposits ... consists of grey or greenish grey feldspar and quartz in which pyrite, pyrrhotite, red fluorite, magnetite, and molybdenite occur partly in disseminated form and partly in aggregates or zones. The normal grey phases of the rock generally possess a granular texture and medium grain and resemble a granite in appearance. Here and there, however, the rock varies from the normal type and is coarsely crystallized and pegmatitic. In places within the deposits, crystals of dark green pyroxene, some of which are radially disposed, are abundantly developed and at a few points aggregates or crystals of coarse black mica up to 2 or 3 inches in diameter can be observed. Where masses of pyrite are present in the rock the pyrite is very commonly crystallized in cubes and has a peculiar net-like distribution. The molybdenite and other sulphides disseminated in the lean ore in places are distributed in zones parallel to the longer direction of the deposit.

The orebodies of the segregated type, like the Onslow syenite of which they form a part, contain inclusions of the older porphyritic syenite. Most of these are angular in form, except where mineralization has occurred, and are definitely though not sharply defined. They were observed to be most abundant at the south end of the west face, and on the east face, of No. 1 pit. At some points where the masses of older syenite occur in association with rich ore, the inclusions have been almost obliterated.

Intrusions of rocks later in age than the orebodies were not observed in the ore by Wilson, except at the southwest corner of No. 1 pit. There a pegmatite dyke, mainly composed of pink feldspar traversed by thin seams of quartz and feldspar, intruded the Onslow syenite and the ore mass. This dyke was probably intruded during the closing stages of the development of the orebody, for it contains some disseminated molybdenite and pyrite.

The masses of high-grade ore that occur in the orebodies, as seen in the hand specimen, consisted mainly of quartz, pyrite, fluorite, and molybdenite. The less-common constituents seen were hematite, magnetite, titanite, feldspar, mica, and pyroxene. In No. 1 deposit these aggregates were more or less irregular in form; whereas in No. 2 locality they were in lenses distributed with their longer direction parallel with the trend of the mineralized zone in which they occur.

No. 1 pit, at the time of the writer's visit, was about 120 feet long by 50 feet wide, and filled with water. The height of the almost-vertical walls, above water level, varied from about 30 feet at the north end of the pit to only a few feet at the south end, due to the southerly slope of the land. According to Wilson the dimensions of original outcrop of the orebody corresponded almost exactly to those of the pit, and to the east, south, and west there occurred outcrops of the Onslow syenite which were entirely free from molybdenite. The mining operations showed that the orebody was approximately 200 feet long, 50 feet wide, and 75 to 125 feet deep. Numerous small scattered masses of ore occurred in the syenite adjoining the main mass, which was really a nucleus in the middle of a zone of deposits. Diamond-drilling showed that this zone was 500 feet long, 60 feet wide, and at least 250 feet deep.

The walls of No. 1 pit are too vertical to yield much information on inspection at present. The Onslow syenite is mostly lightly rusted due to weathering of the contained pyrite. At places on the middle of the west wall can be seen odd flakes and splashes of molybdenite up to ½ inch in diameter, together with granular aggregates of pyrite. Some joint planes have spectacular but thin films of molybdenite. These show fine slickensiding, indicating post-depositional movement.

On the east wall of No. 1 pit, at about its mid-point, is a good exposure that shows blocks of the older porphyritic syenite caught up in the younger Onslow syenite. These blocks have a maximum dimension of about a foot, but most are smaller. The older syenite is dark grey and coarse grained, with porphyritic feldspars ½ to 1 inch long standing out distinctly on the weathered surface. The boundaries between the blocks and the younger syenite are distinct and clean-cut. Veins of coarse feldspar, seemingly from the younger syenite, intersect some of the bigger blocks of the porphyritic rock; some of these blocks contain quartz crystals large enough to form a granite pegmatite.

The syenite around No. 1 pit shows a well-marked joint direction of N15°W with a vertical dip, and a less-well-marked one striking due east and dipping at a high angle to the north.

On the east side of the pit is a pile of loose blocks, mostly of barren younger syenite, among which are a few blocks rich in molybdenite. They consist of a fine-grained, sugary-textured granite or quartz syenite with molybdenite flakes 1 to 3 mm in size scattered evenly throughout; and a coarse-grained, quartzose rock, almost a pegmatite, with larger 'splashes' and flakes of molybdenite and patches of pyrite.

No. 2 deposit outcrops on the side of the west-facing escarpment at the north end of lot 9 (*see* Fig. 16).

A long, benched trench, trending N15°E, has been excavated up the hillside along the strike of the deposit. The trench is 5 to 6 feet wide, narrowing towards the top of the escarpment and terminating just below its brow. At its lower end the trench widens to about 15 feet and terminates in a deep, water-filled shaft or pit. This pit is undoubtedly the No. 2 pit referred to by Wilson (1924, p. 68). It revealed, according to Wilson, two parallel mineralized zones separated by 10 feet of barren syenite. The more westerly of the two was 15 feet wide in the actual pit, but narrowed to 5 feet in the workings up the hillside. Its total length, as exposed in the workings, is approximately 150 feet.

The rocks exposed along the trench are very rusty, containing abundant pyrite with lesser molybdenite. The rusting and the minerals that gave rise to it do not extend into the wall-rocks which are of the normal younger Onslow syenite. The rocks, including those of the mineralized zone, show a very well marked joint direction of N40°W with a vertical dip and a subsidiary direction of about east. Thus the elongated mineralized zone cuts at almost right angles across the joint system. There does not appear to be any structure, such as a fault, striking along the trenches, that could possibly have had a localizing influence on the ore deposition.

Towards the top of the trench, loose blocks show high concentrations of molybdenite in coarse-grained patches or veins cutting the normally fine grained syenite. Molybdenite occurs in flakes up to ½ inch in diameter. There is also finely impregnated pyrite.

On the flat ground at the top of the escarpment are irregular, randomly scattered patches of mineralization, indicated by rusting of the syenite. Some are rich in molybdenite and pyrite, but are only a few feet across at the most. Some of the patches revealed scattered crowds of small yellow-green epidote crystals, apparently resulting from the alteration of the syenite, but this was the only locality at which they were observed.

The more easterly of the two mineralized zones at the No. 2 deposit—which according to Wilson was 8 feet wide and 25 feet long in the pit—is apparently also exposed on a 30-foot-high rock face above and to the east of the pit. On this, a small pit has been sunk at the foot of the face, but it is now mostly filled up. The mineralized zone is about 4 feet wide on the rock face and dips eastward at 60 to 70 degrees. About two thirds of the way up the face, the zone curves sharply to the west and rapidly wedges out and dwindles to a rusty streak near the top of the face. This lenticular shape seems to be characteristic of the ore masses at the No. 2 deposit.

The junction between the mineralized bodies and the normal syenite is generally well defined, though gradational. There is no sign of a break, or movement, on either wall. According to Wilson, the mineralized zones differ from the ordinary syenite "merely in their grey to green colour and in the presence of finely disseminated molybdenite, pyrite, fluorite, and magnetite".

No. 3 working consists of a steep-sided, water-filled pit situated about 300 feet to the northwest of No. 1 pit. It is about 100 feet long by about 40 feet wide at its widest point, and the long axis trends N30°E. When Wilson examined this working in 1917 he noted:

> ...the main ore-mass in the pit consisted of a band of rusty, weathered ore 10 feet wide extending transversely across the pit in a direction N25°E (magnetic) and disappearing beneath the overlying boulders, sand, and gravel, both to the north and south. The rock adjoining the ore zone on the east was the normal syenite, that on the north consisted of mineralized syenite and masses of pyrite, feldspar, quartz, molybdenite, etc., similar to that composing the other deposits of the segregated class.

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At the time of the writer's visit, working No. 3 revealed next to no mineralized rock; all the ore appeared to have been long since removed. Little further information is thus obtainable. The syenite around the walls showed well-marked joint systems, striking N35°W and N60°E respectively. Other features were inclusions of the older, porphyritic syenite and quartz-feldspar pegmatite veins cutting the younger syenite.

No. 4 working is about 200 feet to the west of No. 3. It consists of two separate, deep, water-filled pits; near one of them is a 5-by-5-foot timbered shaft, also water-filled. The workings may be connected beneath the level of the water. No ore minerals are to be seen around these workings, but a pile of spoil near the collar of the shaft indicates that ore was hauled up it from workings at depth. Wilson stated that the mineralized zone there had a maximum width of 4 feet, an average width of less than 2 feet, and a length of nearly 50 feet. Its principal feature of interest was the complete transition from pink syenite to ore—this occurred through an interval of about 6 inches.

Wilson's account of No. 5 working is as follows:

> This deposit is exposed in a pit approximately 20 feet long by 10 feet wide and 10 feet deep that has been excavated at the base of the Laurentian escarpment a short distance east of the west boundary of lot 11, range VII, Onslow township. The rock adjacent to the deposit is a coarse, pink phase of the Onslow syenite consisting almost entirely of microline, albite, and a few scattered grains of hornblende. The rock exposed in the deep parts of the pit is a grey to green phase of the syenite in which small scattered aggregates of molybdenite and pyrite are included. In the northeastern part of the excavated area a mass of pink to grey feldspar pegmatite is exposed, which also contains some aggregates of molybdenite and pyrite. On the southwest faces of the deep part of the pit two small masses of hornblende syenite, 4 and 5 feet in diameter, respectively are exposed. These are intersected by dykelets of the Onslow syenite and are evidently included masses of an older rock. On the whole, with the exception of a small mass about 4 feet long by 2 feet wide situated on the west margin of the pegmatite mass, the proportion of molybdenite present in the pit is relatively small. At the point where the high-grade ore occurs the rock is similar in composition to the high-grade ore occurring in No. 1 deposit and includes, in addition to the molybdenite and pyrite, some fluorite, magnetite, pyroxene, and biotite.

The average molybdenite content of the Moss mine ore shipped for concentration during 1916 and 1917 to the Ore Dressing Laboratory of the Mines Branch, Ottawa, is as follows (Wilson, 1924, p. 70):

Year	Pounds of Ore	MoS_2 (%)
1916	4,106,867	1.83
1917	1,320,483	1.01
1917	1,054,875	0.91

Most of this ore was taken out of No. 1 pit above a depth of 40 feet. Some of it was selected and did not represent run-of-mine material. Wilson estimated that, if an allowance were made for this, the average content of MoS_2 in the upper part of No. 1 deposit would have been between 0.75 and 1.00 per cent. The MoS_2 content of the ore mined from the lower part of No. 1 pit did not generally exceed 0.75 per cent, so that there was apparently a gradual decrease in grade with depth in this central ore-mass.

Four of the five principal deposits have a northeasterly structural trend. It would seem probable—because the foliation and banding in the rocks of the basal complex in the Arnprior-Quyon area have generally a similar northeasterly trend—that this uniformity of trend exhibited by the ore masses is related to regional deformation. However, foliation is entirely absent in the Onslow syenite. It may also be noted that the orebodies occur in a definite belt or zone that trends northwest (*see* Fig. 16), with the exception of No. 2. It is difficult to see any structure in the rocks that might link up with either the elongation of the individual orebodies or the trend of the belt.

The Onslow syenite and its contained orebodies are characterized by remarkably well developed joint systems. In the description of the individual deposits the main joint systems have been noted. There is no apparent link between the joint systems and the trends exhibited by the ore deposits.

Wilson lists these minerals present: molybdenite, pyrite, pyrrhotite, magnetite, hematite, titanite, fluorite, microcline, albite, biotite, pyroxene, and siderite. The molybdenite occurs partly as disseminated flakes and partly in aggregates. The diameter of the flakes ranges from an inch in the larger aggregates to less than 0.5 mm in the sparsely disseminated ore. In places the flakes exhibit a perfect hexagonal outline, but complete crystals are rare.

Wilson discusses the probable origin of the mineralization at considerable length. According to him, four possible methods have been proposed:

(a) contact metamorphism
(b) pegmatitic intrusions
(c) replacement
(d) magmatic segregation.

Wilson discussed each of these possible modes of genesis in turn and came to the conclusion that magmatic segregation best fits the geological facts. This conclusion is based mainly on the lack of evidence for the other methods, but also on the pronounced chemical and mineralogical similarity between the ore and the enclosing syenite. Wilson gave analyses showing this similarity. Both molybdenite and fluorite are constituents of the unmineralized syenite, which contains more feldspar than the ore but less molybdenite, pyrite, magnetite, fluorite, and quartz.

Other points in favour of segregation from the syenite are the complete gradation from syenite wall-rock into the ore masses and the presence in the syenite of small aggregates of quartz, fluorspar, and molybdenite a few inches in diameter. These aggregates are not connected with fractures and must be original parts of the rock in which they occur, having been formed there by segregation. The orebodies then, may represent large-scale versions of these small segregations.

Wilson pointed to the presence in the Onslow syenite of numerous inclusions of an older porphyritic syenite and suggested:

> ... these foreign masses, by reducing the temperature of the magma at the points where they occur may have caused consolidation to commence locally within the magma and

thus produce conditions that would be exceptionally favourable for local differentiation. As consolidation—commenced at these scattered centres within the magma—continued, molybdenum, iron, sulphur, fluorine, and other elements might become more and more concentrated in the remaining unconsolidated parts of the magma, so that finally material of the composition of the ore-masses may have become segregated at the points where consolidation last occurred. In this way the molybdenite-bearing ore-masses of the Quyon type may have been developed.

Foley Prospect

This property, range VII, lot 10 N½, lies about ½ mile northeast of the main pit of the Moss mine, on the Eardley escarpment. According to Eardley-Wilmot (1925, p. 155) the deposit occurs in a massive pink syenite somewhat similar to that found in the vicinity of the Moss deposits, but it is coarser in texture and contains small patches of pyroxenite. Molybdenite occurs on the contacts of this pyroxenite with the syenite. In 1917 about 12,600 pounds of ore, averaging 0.90 per cent MoS_2, was shipped to the Mines Branch, Ottawa. (*See also* Wilson, 1924, p. 64).

Thorne Township

At the *Welsh No. 2 prospect,* range I, lot 3, molybdenite was found in decomposed pyrite stringers in syenite gneiss and pegmatite. Five small pits were sunk on the occurrence (Eardley-Wilmot, 1925, p. 160).

Daly Property

Eardley-Wilmot (1925, p. 156) described the geology of this property, range I, lot 5, as follows:

> The country rock is white limestone and biotite-granite gneiss. The outcrop is in a creek bed and consists of a small stringer of quartz, calcite and pyroxene rock, carrying a little molybdenite. On the north of the outcrop is an irregular pegmatite dike. About 30 feet south of the outcrop a partly timbered shaft, 7 by 9 feet, was sunk vertically to a depth of 50 feet on a calcite vein, but scarcely any molybdenite was encountered. At the bottom of the shaft a crosscut was driven both north and south. A small pocket of molybdenite was found 25 feet north of the shaft, and a stringer followed for a few feet, but no more ore was located.

(*See also* Wilson, 1924, p. 81; and Dresser and Denis, 1949, pp. 409-410.)

Riley Prospect

This occurrence, range IV, lot 2, has been briefly described by Eardley-Wilmot (1925, p. 156). A much fuller account is given by Ingham (1942d), and it is from his report that these notes are taken.

> Development work on the ground consists of a few small pits sunk in zones of molybdenite mineralization. In 1917, 750 pounds of selected ore were shipped to the Mines Branch, Ottawa, and found to contain 1.03 per cent molybdenite.
>
> Molybdenite mineralization was observed . . . in five different places. The sulphide occurs as thin oriented flakes and seams in a pegmatite dike, and as disseminated impregnations in silicified and granitized paragneiss. Although dikes of pegmatite are of frequent

occurrence, only one was observed to carry molybdenite, and none of the other zones as exposed at present which are molybdenite-bearing can be regarded as important.

Waltham Township

At the *Waltham feldspar property,* range I, lot 29, molybdenite and pyrite occur in small quantities in a feldspar pegmatite (Retty, 1933, pp. 104-105).

Southern Gatineau County

Eardley Township

Norwin Molybdenite Mines, Limited

This property, previously owned by the National Molybdenite Company, is on ranges VII and VIII, lot 1. It has been described by Gwillim (1920, p. 111), Wilson (1924, p. 92), Eardley-Wilmot (1925, pp. 132-133) and Ingham (1942e). The latter's summary is reproduced below:

> The site of operations is within an area measuring 1,000 feet by 300 feet in the southeast corner of lot 1, range VII.
>
> In 1917, 35 tons of selected ore, running 0.77 per cent MoS_2, was shipped and 460 pounds of pure molybdenum was extracted.
>
> In 1941, 4 tons were shipped having an average content of 1.67 per cent of MoS_2 and 106 pounds of concentrate was obtained.
>
> The principal formations encountered in the vicinity of the deposit are Grenville paragneiss, metamorphic pyroxenite and intrusive granite and pegmatite. The paragneiss, which forms a band 900 feet wide, crossing the southeast corner of the lot, is regarded as a more favourable host rock than the pyroxenite. The pegmatites are closely related to the deposits.
>
> The molybdenite is found in small lenses, or in thin seams, and the erratic distribution and spotty nature of the occurrences make it extremely difficult to reach any estimate as to tonnage and grade.
>
> A rough calculation indicates that from the main pits alone (Nos. 1, 3, 4 and 5) 2,500 tons of rock have been mined. The total recorded production is 39 tons, and there are about 15 tons of ore in a pile beside No. 5 pit. This suggests that more than 50 tons of rock have been mined for each ton of ore. As the ore runs considerably less than 2 per cent MoS_2, the average grade seems to be extremely low. Since the data are very incomplete it would be unfair to jump to conclusions based upon the foregoing figures.

Ingham's conclusions after his inspection in June 1942, were:

> As indicated by the molybdenite exposed at the present time, pits No. 5, 1, 3, and 4 are respectively the openings which are regarded as showing the best possibility of ore production. Further exploration is warranted in each of these zones. Because of the very nature of the invariably irregular and spotty occurrences of the pyroxenite lenses in the paragneiss, and the discontinuity of the pegmatitic stringers and dykes, upon both of which the concentration of ore depends, it is extremely difficult to estimate the possible tonnage of molybdenum ore throughout the entire zone of mineralization. However, by hand cobbing the material excavated from pit No. 1, a rich concentrate could be secured. Since several high-grade pockets have been found in the No. 3 zone, there is a good chance of locating more ore in that area. On the bases of past results, it is probable that the No. 4 shaft would yield more molybdenite. The results obtained to date at the No. 5 pit are encouraging. If the pockets and lenses of molybdenite continue to appear as frequently and as close together, and as large as present exploration indicated, there is a promising possibility that this zone will make mineable ore.

Wood-Ormond Prospect

This prospect, range VIII, lot 6 S½, has been briefly described by Eardley-Wilmot (1925, pp. 133-134).

The ore occurs intimately associated with a massive band of dark green hornblende that intrudes red granite, outcrops along the face of the cliff, and dips flatly into the hill-side. It appears to be only a local body, varying from 3 to 10 feet in thickness.

The molybdenite is found as nugget-like, or chunky, well-formed crystals, disseminated through the hornblende, and for a short distance into the granite above, which is of a pegmatitic character. Several showings of molybdenite in these hornblende bands have been located at various points at this elevation in what would appear to be a continuation of the strike of the orebody in which the main work has been done.

Chatelain Prospect

This property is on range XI, lot 6 S½, near the south shore of Harrington (Mousseau) Lake. Eardley-Wilmot (1925, p. 134) reported that the country surrounding the deposit is underlain by red feldspathic granite.

The mineral zone is a flat quartz stringer, containing pyrites, pyrrhotite, pyroxenite and calcite, varying in width from 2 to 8 inches. The southern end of this stringer—where it is exposed—carries high molybdenite values; but because of its flatness and somewhat variable width, it has the appearance of a larger and richer deposit. Pieces of the broken ore are also scattered about for a considerable distance down the creek to the north, at which end the stringer enters the east bank of the creek and is almost barren. About 10 feet to the east there is a small pyritic stringer carrying a litle molybdenite, and dipping steeply in the direction of the creek. Some molybdenite may be encountered at the point where these stringers meet.

Other Occurrences

On *range XII, lot 6,* Willimott (1904, p. 15) reported the presence of molybdenite and pyrite, in a gangue of quartz, feldspar, and a little hornblende.

At the *Muldoon property,* range XII, lot 27B, Wilson (1924, p. 81) reported the presence of a molybdenite-bearing quartzose pegmatite in porphyritic syenite.

Hull Township

The *Payne prospect,* range X, lots 27 and 28, lies about ½ mile east of the Norwin property in Eardley township, and the geology of the two occurrences is similar. Molybdenite occurs as fine grains scattered through a hornblende gneiss. Eardley-Wilmot (1925, p. 137) estimated that about 4 tons of material, carrying about 0.5 per cent MoS_2, lay on the dump.

At the *Kirk's Ferry occurrence,* range XI, lot 13 N½, molybdenite is exposed in a rock-cut just south of the railway crossing, ¼ mile south of Kirk's Ferry station on the Maniwaki branch of the Canadian Pacific railway (Eardley-Wilmot, 1925, pp. 137-138).

The mineral occurs on and near the contact of a highly quartzose pegmatite with banded gneiss. Throughout the former are small stringers of pyrites, and numerous cracks, in both of which molybdenite is splashed as thin flakes. The mineralized area is at this point approximately 40 feet wide and is bordered on the west by gneiss and on the east by a band of white crystalline limestone.

Along the strike of the rocks, about 400 feet to the northeast, flakes of molybdenite were observed in a similar formation on the west shore of the Gatineau River, indicating that the intermediate rocks, which are covered by bush, are probably sparsely impregnated by the mineral.

At the *Winning Church mine,* range XIII, lot 12, molybdenite is reported from a mica-bearing pegmatite (Ledoux, 1916, p. 164).

The *Flynn mine,* range XV, lot 27, is a similar occurrence in a mica pegmatite (Ledoux, 1916).

At *Farm Point,* range XXV, lot 23, molybdenite occurs with pyrite in granite and limestone (Eardley-Wilmot, 1925, p. 158).

Masham Township

Indian Lake Property

The Indian Lake property, or Bain mine, lies in range X, lots 54 and 55. It is on the northern side of Indian Lake—a small lake some 13 miles northwest of Wakefield and 33 miles north-northwest of Ottawa.

The property is reached by road from Wakefield via Ste. Cecile de Masham and Duclos. At a point 3 miles north of the post office at Duclos, where the gravel road bends sharply to the west, a rough, but negotiable farm track leads north for about a mile to the farm of M. Bouchier. From there the property is another mile to the northeast over a rough track, impassable by car.

Eardley-Wilmot (1925) records the history of the mine up to the date of his publication. The earliest, and chief, development work was done in 1918 by J. Bain of Ottawa who opened up the molybdenite-bearing zones in several pits extending over a strike length of about ½ mile. In 1918 the Wood Molybdenite Company took an option on the property and shipped a ton of 1.97-per-cent ore to the Mines Branch, Ottawa, for testing. The methods of concentration used at the time did not work successfully on the ore and the recovery was so low that the company decided to drop the option. In 1921, according to Eardley-Wilmot, the Daley Molybdenite Company investigated the deposit under the direction of H. H. Claudet of Ottawa. Samples—believed to be representative—were taken from the stockpiles and tested at the Mines Branch, with the following results: heads, 3.66 per cent MoS_2; concentrates, 89.25 per cent; middlings, 19 per cent; tails 0.17 per cent. Recovery including middlings, was 94 per cent.

In Eardley-Wilmot's opinion the property was one of the most promising in the region. However, the depressed state of the market for molybdenum at that time did not encourage further work on the property until 1925, when Claudet and associates did some further prospecting; their results were not disclosed. The same interests worked the property in the years following. Surveys were made in 1927 and 1933. In the latter year a magnetometer survey was done to detect the continuation of the pyrrhotite-rich mineralized zone. This was said to have indicated the presence of bodies of ore not previously known. During 1935 the Mines Branch, Ottawa, received a lot of 26 sacks of ore from the Bain mine. These contained ore of 'medium flake' variety, with a large quantity of massive pyrite in a pyroxenite gangue. The ore was said to assay 0.74 per cent MoS_2. Flotation recovered 90.5 per cent of the molybdenite, the concentrate assaying 75.12 per cent MoS_2. The grade was said to be low because the size of the sample was not large enough to permit the test to continue long enough to arrive at the best operating conditions (Timm, 1937).

In 1937, Kindale Mines Limited, with Claudet in charge of operations, erected a small flotation-test mill on the property, in which a small tonnage of ore was tested. Eardley-Wilmot (1938) reported briefly that surface development, started in 1937, was carried on for a few months at the beginning of 1938. Ingham inspected the property in July 1943 and gave a detailed account of the workings and geology (Ingham, 1943). According to him 1,012 feet of diamond-drilling was carried out in 1939 and further exploratory drilling was in progress at the time of his visit. A flotation mill, expected to treat 50 to 70 tons of ore a day, was under construction by Vic-Ore Molybdenite Mines Limited, a subsidiary of Goodrock Mines Limited. This mill is now completely dismantled; only the concrete foundations remain.

When the writer visited the Bain property in June 1958 the operations had been dormant for some years. A series of open-pits and trenches has been excavated along the strike of two, and possibly three, mineralized zones, concordant with the strike of the enclosing rocks (*see* Fig. 17). The main, central zone is probably continuous for a distance of about 1,000 feet, but workings

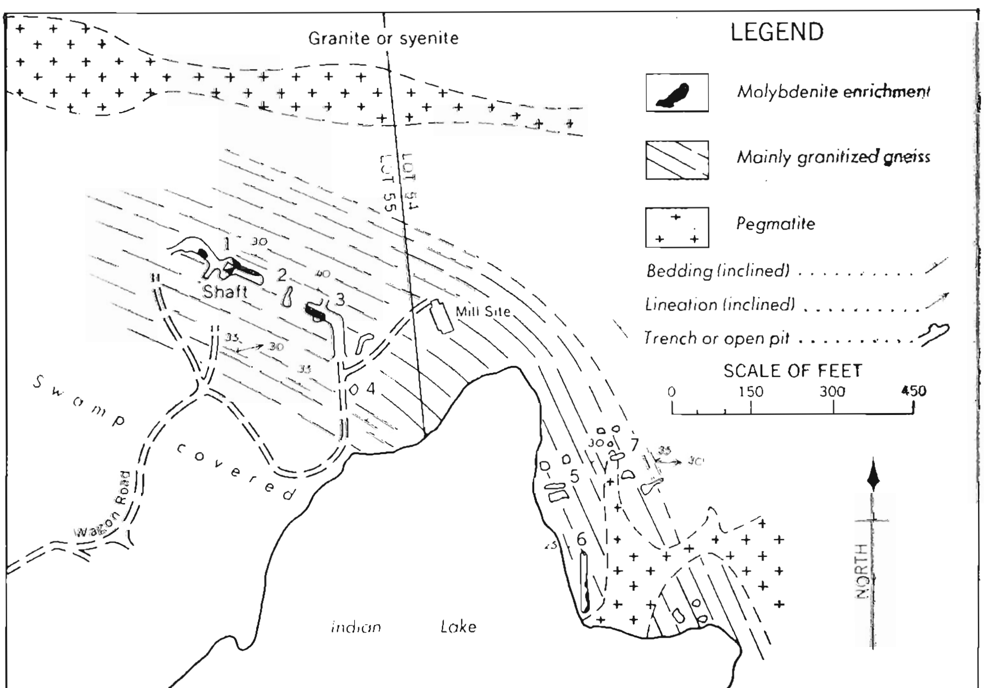

Figure 17. *Indian Lake property, Masham township, Quebec (after Wilson, 1924 and Ingham, 1943).*

on it have been confined to its western and southeastern extremities. In the west the workings marked Nos. 1, 2, and 3 are pits or trenches up to 15 feet deep, except for a now water-filled shaft on No. 1 working which was said to have been sunk for 30 feet. Workings Nos. 5 and 6 are essentially shallow trenches nowhere more than a few feet deep. South of this main zone, No. 4 working is a small pit a few feet across and about 3 feet deep in a rusty patch. No signs of a continuance of this mineralization were seen along strike. No. 7 working is a series of shallow trenches along the strike of a mineralized zone apparently lying parallel with, and some 140 feet to northeast of the main zone. The strike length exposed is about 300 feet. By far the most important workings are those marked Nos. 1 and 3 in the western part of the zone. It was from there that most of the ore was taken for testing.

Accounts of the geology of the mine and surrounding area have been given by Wilson (1924) and Ingham (1943). The writer has made use of both to supplement field observations.

The rocks with which the molybdenite deposits are associated are mainly grey to pink hornblende or hornblende-biotite gneisses, which Wilson terms "granite-syenite gneiss". Except for the ferromagnesian minerals, feldspar and lesser amounts of quartz are the main constituents. Most of these rocks are banded—the darker, ferromagnesian-rich layers alternate with the lighter feldspathic layers in units a few inches thick. In places irregular bodies of coarse feldspar-quartz pegmatite have been developed or have intruded the gneisses. The main pegmatite bodies are in the southeastern part of the area, as shown in Figure 17. Wilson mentioned two outcrops of crystalline limestone, neither of which was seen by the writer. However limestone was seen along the foot-wall of the 'ore zone' in No. 3 working, which was excavated after Wilson visited the property. On the hanging-wall side of the westerly part of No. 1 working the rock is a fine-grained, blocky non-gneissose syenitic rock, well-jointed and fresh. Its relation to the other rocks was not seen due to lack of exposures.

The structure of the area appears to be relatively straightforward. The strike, in general, swings from about N55°W in the northwest to about N10 to 20°W in the extreme southeast. Locally, small folds disturb this uniformity, but on the whole to no great extent. Dips are constantly to the northeast or east at around 30 to 40 degrees. The lineation in the gneisses shows a constant plunge of between 25 and 30 degrees at N70 to 75°E. The even swing in strike direction makes it probable that workings Nos. 1, 2, 3, 5, and 6 are on the same general mineralized band. The band does not necessarily constitute 'ore' all the way, but along it are concentrations of ore minerals or 'ore shoots'. The plunge or rake of these shoots is probably parallel with the plunge of the lineation in the enclosing rocks.

The ore deposits on the Bain property are typical of the pyritic pyroxenite type that is so widespread throughout the Grenville province. The molybdenite occurs commonly as large flakes or aggregates, irregularly scattered through bodies consisting mainly of pyroxene and pyrite, with some scapolite and pyrrhotite. The molybdenite is closely associated with iron sulphide, as it is for example, at the Kirkham property in Clarendon township, except that on the Bain property the associated sulphide is mainly pyrite instead of pyrrhotite. The pyroxenite varies considerably in grain size, from coarse pegmatitic parts to parts with a grain size of the order of 2 mm. The sulphides, especially the pyrite, occur in large, though varying quantities as veins up to several inches wide or as a network through the pyroxenite. The sulphides definitely appear to be later in age than the pyroxenite and to have been emplaced in it along fractures and in areas of brecciation.

At No. 1 working the mineralized zone has been excavated along strike in two trenches or shallow pits. The easterly pit is about 70 by 30 feet and the westerly pit is about 50 by 15 feet. Both are now filled with water. In the middle of the easterly pit a large shaft, about 40 by 25 feet, was sunk to a reported depth of 30 feet. Ingham mentioned that a crosscut extended 22 feet to the north from the bottom of this shaft. Both pits or trenches have been excavated on the same band of very rusty pyritic pyroxenite which appears to lie conformably between the wall-rocks on either side. In the easterly pit the mineralized zone reaches a horizontal width of about 40 feet, representing a true thickness of perhaps 20 or 25 feet. The area between the two trenches is occupied by a zone of unmineralized pegmatite cutting across the ore zone and apparently of a later age. The foot-wall rocks in the vicinity of the No. 1 working are banded gneisses consisting of layers of dark hornblende-biotite gneiss alternating with layers of feldspathic or granitic material. The same rocks appear in the hanging-wall of the easterly pit; the hanging-wall of the westerly pit is a massive, fine-grained rock of syenitic composition. The foot-wall gneisses show a lineation plunging at 20 to 30 degrees in a direction N70°E; this would also be the probable plunge direction for any ore shoot. The ore walls appear sharp and clean where exposed, but are somewhat obscured by rusting.

No. 2 working is a small water-filled trench in which no bedrock is exposed. However, rusty spoil indicates the presence of mineralized rock, and shows that the ore zone is most probably continuous from No. 1 working to No. 3 working, some 70 feet to the east.

No. 3 working consists of a trench about 80 feet long, 10 to 20 feet wide, and from 2 to 15 feet deep, following the ore zone. It is deepest at its eastern end, where it is joined by a foot-wall crosscut trench more than 100 feet long excavated at right angles to the strike of the rocks. At the western face of the deeper part of the trench the sulphide-bearing pyroxenite is well-exposed. It has a true thickness of about 5 feet lying conformably beneath a hanging-wall of banded gneiss that strikes N45°W and dips 40°NE. At the middle part of this trench a 7-foot-wide dyke of coarse feldspar-pyroxene pegmatite cuts almost at right angles across both the ore zone and wall-rocks. The pegmatite is unmineralized, which suggests that it is later than both the pyroxenite and the sulphides. Within the mineralized pyroxenite itself are marked planes conformable with the foliation of the wall-rocks. These may be relict structures. The pyroxenite carries the usual heavy pyritic mineralization with erratic flakes and splashes of molybdenite.

Along the trench the foot-wall is mostly obscured by rubble resulting from the mining, but the foot-wall crosscut gives a very good section through the rocks underlying the ore zone. The latter, at the eastern end of the trench, has narrowed to about 2 feet in true thickness, with most of the sulphides concentrated in the foot-wall half of the zone. Underlying the ore zone in the crosscut is a coarsely crystalline meta-limestone about 15 feet in true thickness. The rock is composed mainly of white calcite, but considerable phlogopite mica is present in parts. The grain size varies over a wide range. In places it is exceedingly coarse and the rock carries 2-to-3-inch-long prisms of green pyroxene. Where the grain size is smaller, i.e. on the east wall of the crosscut trench, the rock shows a distinct layering—a relict of the original bedding of the limestone. The strike length of this band of limestone cannot be determined because of the overburden. The limestone band is underlain to the south by banded gneisses of the type seen in the other workings and exposures.

No. 5 working lies along the eastern shore of the northern bay of Indian Lake. The trenches and pits there expose a composite band of mineralized pyroxenite overlain by banded gneisses with much coarse quartz-feldspar pegmatite. The lack of exposures prevents the relationship between the pegmatite and the pyroxenite from being studied. The main band of mineralized pyroxenite lies along the water's edge, dipping at about 30 or 40°E. It is separated from a thinner, upper band of the same rock by a 3- to 4-foot band of medium-grained quartz-feldspar gneiss. The contacts between the pyroxenite and the gneiss are sharp and are the loci of breaks, but it is not possible to detect any signs of movement along them. This composite mineralized band has a total true thickness of about 20 feet, including the band of barren gneiss. Within the pyroxenite the sulphide minerals are erratically distributed and less plentiful than in workings to the northwest.

Ingham (1943, p. 13) estimated that in the No. 1 pit area there was about 9,000 tons of molybdenite-bearing rock, which he judged to carry from 0.15 to 0.25 per cent MoS_2. The grade was based on the surface showings and on one drill-hole. By selective mining a better grade of material might possibly be recovered, and further exploration might reveal more high-grade zones,—such as the ore in the southeastern part of the pit where an additional 1,500 tons of 0.75-per-cent-MoS_2 ore is calculated to be present. In pit No. 3 Ingham estimated the ore present to be some 500 tons, not including a possible several hundred tons of leaner material that might be hand-concentrated to a commercial grade. In the area of working No. 5 Ingham estimated that there was about 4,000 tons of ore that, as a whole, might yield 0.20 per cent MoS_2.

Daly Occurrence

This occurrence, 4 miles west of Wakefield, is recorded by Willimott (1904, p. 15) but no details are given.

Northern Gatineau County

Baskatong Township

At *range II, W½ lots 22 to 24,* 5 miles by water from the south end of Baskatong Lake, a contact-metamorphic occurrence carries sphalerite, chalcopyrite, galena, and molybdenite, together with uranothorite, thorite, pyrochlore, and uraninite (Que. Dept. Mines, 1956, pp. 4-6).

Egan Township

At the *Roberts property,* range I, lot 4, molybdenite occurs disseminated through quartz and pyroxenite (Wilson, 1924, p. 133).

At the *Creagham property,* range II, lot 4, molybdenite occurs with pyrite in pyroxenite (Timm and Carnochan, 1920, p. 73).

Maniwaki Molybdenum Mines Limited

This property, on range III, lots 6-13, contains a series of small molybdenite deposits of the pyroxenitic type. They lie between 3 and 4 miles northwest of Maniwaki. Some were formerly worked on a small scale by the old Standard Molybdenite Company and later by Maniwaki Molybdenum Mines Limited. The deposits illustrate certain aspects of this type of deposit and its possible modes of formation.

The property is reached from Maniwaki along the Mont Carf road. At a point between 3 and 4 miles along this road from the Desert River bridge at Maniwaki, an old, partly overgrown cart-track leads off to the west. A 6-minute walk along this track brings one to three collapsed log cabins built on an area of white crystalline limestone. About 100 feet west of the cabins is a northerly trending zone of pits and trenches—the No. 2 zone of the property. From there a narrow trail leads to an area of old pits and trenches along the No. 1 zone, about 1,000 feet farther west. (*See* Fig. 18.)

According to Eardley-Wilmot (1925, p. 136) the deposit was apparently located by J. Callahan, and in 1917 the mining rights on range III, lots 6 to 13 were purchased by the Standard Molybdenite Company, which was capitalized at $150,000. After erecting a plant and carrying out surface work, this company went into liquidation in 1918. About 2 years later, lots 6 and 7 were taken over by McKerracher and Wanless of Ottawa; the remainder of the Standard Molybdenite Company's holding reverted to a Mr. Moore who owned the farm on which the property was located. During 1918, Standard Molybdenite shipped 24,985 pounds of 0.40-per-cent-MoS_2 ore to the Mines Branch, Ottawa; from this, 75 pounds of pure molybdenite was recovered. In addition 750 pounds of pure flake was collected and shipped. In all about 30 tons of ore is said to have been shipped, mainly from the No. 2 zone. According to Ingham (1942f), prospecting activity was carried out in various periods between 1935 and 1940. Since that time, apparently, no work has been done.

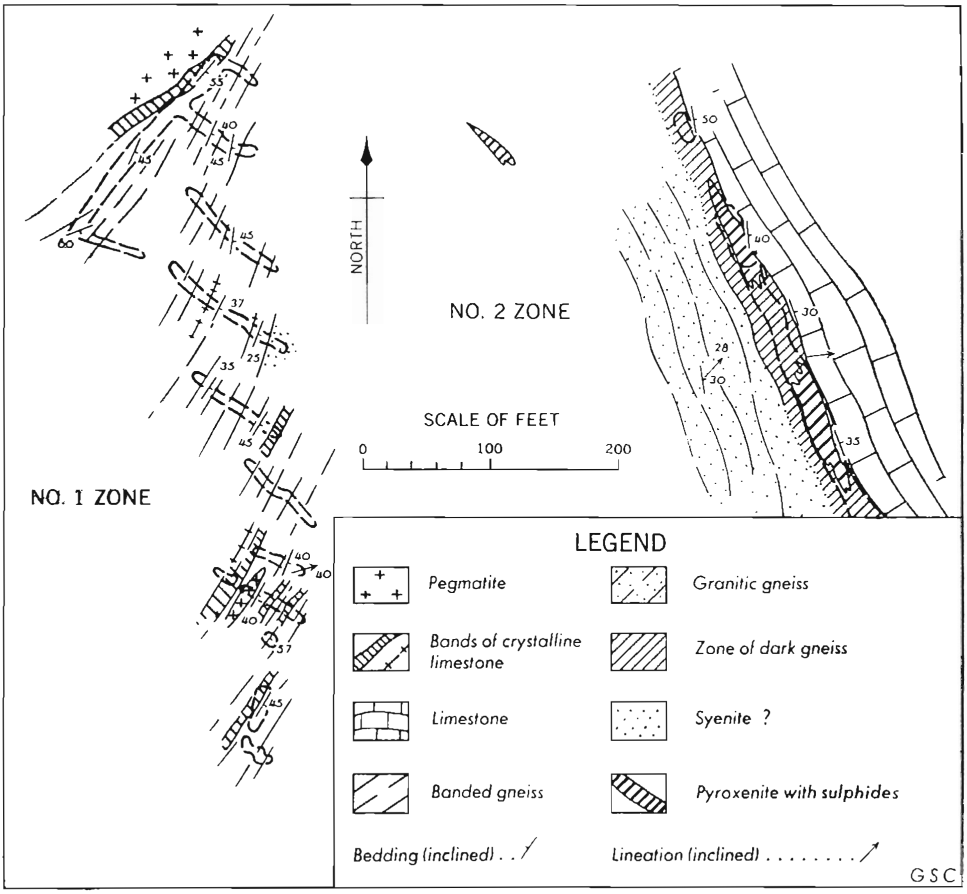

Figure 18. *Sketch map showing geology of workings, Maniwaki Molybdenum Mines Limited, Quebec.*

The geology of the Maniwaki area has been described by Wilson (1924), and others. The oldest rocks in the area—belonging to the Grenville series—consist of crystalline meta-limestones, sillimanite, garnet, other gneisses, and quartzites. Into these older rocks have been intruded masses of granite and granite pegmatite. Lamprophyres and pyroxenite outcrop at various points. Evidence of severe metamorphism of all the rocks older than the pegmatite, is their recrystallized or highly deformed character (Ingham, (1942f, p. 2). The rocks outcropping in the immediate vicinity of the former molybdenite workings are mainly crystalline meta-limestone, with some interbands of granitic gneiss and paragneiss, and some pegmatite. The rocks strike on the whole between N10°W and N10°E and dip between 30 and 50°E. There is a marked lineation in the gneissic rocks, plunging northeast at 30 to 40 degrees.

Molybdenite is very erratically distributed on the property and not very abundant. It occurs in small isolated patches which do not appear to have any connection with each other. The workings appear to have been excavated on small enriched pockets and the rock between is either barren or contains only a few scattered flakes of molybdenite. Ingham (1942f) remarked that, in places, trenching had been carried out on zones of iron-stained rock that do not contain any molybdenite but are well mineralized with flakes of graphite closely resembling molybdenite.

A considerable amount of surface trenching has been carried out on No. 1 zone, but so far as the writer's examination showed, molybdenite-bearing material was only found in the most northerly trench, shown in Figure 18. The series of trenches south of this one explored the country to the east of the molybdenite-bearing zone and failed to reveal the presence of any further mineralization on this, the hanging-wall, side. They do show a series of interbanded silicate gneisses and crystalline meta-limestones having a general south-southwesterly strike and dips varying between about 30 and 50°E. The individual bands, especially those of limestone, appear to be lenticular in shape, and commonly seem to pinch out between adjacent trenches. This may be a result of plastic deformation and flowage of the limestone during the regional orogeny and metamorphism. At one point towards the south of the zone a lenticular pegmatite was noted lying concordantly in the gneiss, and in another trench a massive syenitic rock was observed. The most northerly trench has been opened up along the strike of an irregular mineralized zone which lies concordant with the interbanded gneisses and limestones. A broad band of pegmatite underlies the zone to the northwest. The immediate foot-wall of the mineralized zone is a band of crystalline meta-limestone, probably not more than 10 feet in true thickness, lying directly on the pegmatite. Overlying this limestone is a layer of dark, banded, biotite-hornblende gneiss in which ore minerals have developed patchily at several places along strike.

At the time of the writer's visit, molybdenite was evident in two places along this northerly trench. In the north-central part, near where the trench is joined by a crosscut trench from the east, are outcrops of rusty pyroxenite with splashes and flakes of molybdenite. This mineralization is of very limited extent and has developed irregularly in the dark silicate gneisses. The northernmost part of the trench is a pit up to 5 feet deep and perhaps 20 feet across. The floor is concealed by a covering of rubble. On the west wall are exposed coarse-grained, white, crystalline meta-limestone striking N45°E and dipping at 55°SE. This forms the foot-wall of the mineralized zone, but the actual contact is not exposed. Overlying the limestone in the pit are dark, banded gneisses with feldspathic bands, striking and dipping concordantly with the limestone. Little of the original ore material is now to be seen in this working, but on the east wall of the most northerly part is a patch of coarse-grained, rusty pyroxenite carrying much pyrite, pyrrhotite, and molybdenite. The sulphides are clearly interstitial to the pyroxene crystals. The patch fades away on all sides into the dark gneisses in which the pyroxenite must have developed. Such an irregular and gradational body of pyroxenite could not have been intruded into the gneisses, nor does there seem much support for the theory (*see* Wilson, 1924) that it is due to contact metamorphism between the pegmatite and crystalline limestone, especially in view of the fact that the limestone lies between the pegmatite body and the ore zone.

No. 2 zone shows a similar relationship between the mineralized rock and the limestone-gneiss contact (*see* Fig. 18). Exposures are better in this zone, so that the relationships are easier to see. The ore minerals along this zone are localized along the contact between a crystalline meta-limestone to the east and gneisses to the west. The contact strikes about N30°W and dips 30 to 40°W. Workings extend along this contact for about 350 feet; the main one is a trench some 300 feet long with deeper pits at its north and south ends. The central section of the trench is shallow, apparently because the rock there contains little molybdenite. An east-west section across the central part of the zone between the two pits gives a good idea of the apparent normal rock succession before mineralization took place. A normal layered sequence is revealed—from feldspathic (granitic) gneiss in the foot-wall, through a minor (15-foot) thickness of dark hornblende-biotite gneiss, to a coarse-grained, white-grey crystalline meta-limestone. The junction between the dark gneiss is distinct and conformable; there are no signs of movement and no development of contact minerals. The only ore mineral present is disseminated pyrite, and that is in the dark gneiss only.

All these lithological units seem to form part of one conformable sequence and appear to have undergone the same regional metamorphism to give their present characters. Small patches of pegmatite in the granitic gneiss probably developed under the regional metamorphism by segregation of quartz-feldspathic constituents. There is no suggestion of the gneiss originally having been a granite intrusive into the limestone. At the northern end of the trench is an elongated pit about 55 feet long by 15 feet wide and at least 10 feet deep. The bottom of the pit is not exposed, being covered by rubble or water.

The eastern face of this pit is composed of white, coarse-grained crystalline limestone that contains occasional elongated inclusions of phlogopite schist up to a foot long. The calcite has a grain size of about an inch, which is much coarser than that observed in the limestone outcrops to the east of the mineralized zone. A few flakes of phlogopite are present. The limestone strikes N10°W and dips 40°E, forming the hanging-wall of the mineralized zone. The foot-wall of the pit is composed of the dark, banded hornblende-mica gneiss, very rusty in outcrops. Its strike is conformable with that of the hanging-wall limestone. In the southern face of the pit the crystalline limestone can be seen overlying the very rusty ore-zone which is there 3 to 4 feet in true thickness. The ore-zone rock is a very hard, tough, light green to green pyroxene-bearing rock, with much pyrite and pyrrhotite in thick crosscutting veins and as irregular patches. The pyroxene is very unevenly distributed and there is much quartz, feldspar, and commonly biotite in the rock. It demonstrably fades gradually into the foot-wall gneisses without any perceptible break, by a gradual diminution of the pyroxene content. Blocks lying about in the bottom of the pit are composed of nearly 100 per cent coarse green pyroxene, and these are probably representative of the most intensely altered part of the zone. The southern face of the pit seems to be situated towards the southerly termination of the mineralization in the northern part of the zone.

South from this northerly pit, for about 100 feet, the trench is very shallow, having just been excavated through the overburden. The exposures show a patchy development of coarse-grained, dark green pyroxenite in places, and an uneven, meagre distribution of sulphide minerals. South of this shallow part, another fairly deep pit has been excavated in the zone. It is about 75 feet long and in places up to 20 feet wide. The northern face is about 15 feet high, excavated in benches. This pit is in many places covered with spoil so that exposures are not common. The white crystalline meta-limestone of the hanging-wall outcrops on the east wall of the pit, overlying conformably the sulphide-rich ore zone, which there has a true thickness of about 5 feet. The hanging-wall strikes N15°W and dips 35°E. The ore-zone rocks in this southerly pit are pyroxenite, gneiss with minor pyroxene, and dark gneiss. The development of pyroxene there has been very patchy and all these types occur in intimate association. Sulphide minerals are much more abundant than in the northern part of the zone. Molybdenite occurs as flakes up to an inch or more across, both in the silicate rocks and associated with the veins of massive pyrite and pyrrhotite cutting them. The evidence appears conclusive that the sulphides are all later than the formation of the pyroxenite.

The most significant fact revealed by the investigation of No. 2 zone is that the pyroxenite—the host rock for the molybdenite-bearing mineralization—was developed in the silicate gneisses underlying the crystalline limestone, and not in the latter rock at all. The foot-wall of the limestone can be traced almost uninterruptedly along the whole length of the zone and nowhere can pyroxene be seen to have developed in it. It appears that pyroxene developed at two places—one at each of the pits—and each gradually faded out to the north and south along strike. The two patches of pyroxenite have acted as favourable hosts for the molybdenite-pyrite-pyrrhotite mineralization after fracturing and brecciation. Thus the central part of the zone, between the two pits, in which pyroxenite did not form, is only sparsely mineralized with pyrite and pyrrhotite.

The reasons for the localization of these two ore shoots along the zone are not clear; there is no sign of any cross-structures; nor is it clear whether the limestone-gneiss contact had any significance or whether its presence is merely fortuitous.

At both the No. 1 and No. 2 zones, pyroxenite has developed in banded dark gneisses, in close proximity to crystalline limestone, as patches along zones parallel with the strike. The sulphides have later formed in these pyroxenite patches, giving rise to small isolated shoots. The deposits seem to be of little economic importance but it is interesting to find that molybdenite occurs in pyroxenite that is present in silicate rocks independent of nearby limestone and away from any granitic intrusions.

The development of diopsidic pyroxenite from silicate gneisses must have been due to some form of basic metasomatism involving the addition of Ca, Mg, and possibly Fe. This is not an uncommon phenomenon in metamorphic terranes. The field relations certainly do not lend any support to the theory that the pyroxenite is of contact-metasomatic origin, and its irregular, patchy nature and gradational contacts with the gneiss seem to preclude it being any form of basic pegmatite. The deposit is typical of many other molybdenite deposits in pyroxenite in the Grenville province, e.g. the Kirkham and Indian Lake properties. The bulk of the sulphides are pyrite and/or pyrrhotite. The pyrite occurs mainly as veins up to 2 or 3 inches wide cutting through the pyroxenite, whereas the pyrrhotite tends to occur more as 'fillings' in and around the pyroxene crystals. Because of the removal of the 'ore', little can be said regarding the distribution of the molybdenite, but it appears to have been very erratic.

Other Occurrences

From the *Moore prospect,* range III, lots 8 to 13, Eardley-Wilmot (1925, p. 158) reported the occurrence of molybdenite in sulphide-rich zones along the contact between gneiss and limestone.

At the *Robitaille prospect*, range IV, lot 5, scattered molybdenite flakes occur in green pyroxenite and pegmatite (Eardley-Wilmot, 1925, p. 158).

Mont Cerf Occurrence (La Fleur Prospect)—This occurrence, on range IV, lot 69, is described by Eardley-Wilmot (1925, pp. 136-137):

> (The property) . . . is situated on the La France farm near Montcerf, 15 miles by good road north of Maniwaki, and 100 miles north of Ottawa.
>
> It is one of the oldest known deposits of molybdenite in the region, having been worked more than 25 years ago.
>
> The exposed mineral zone, which is on a contact between gneiss and limestone, consists of parallel pyritic stringers in a decomposed pyroxene and feldspathic rock. Within this decomposed zone large flakes of molybdenite occur. Weathering has converted some of the surface molybdenite into yellow oxide which is intermingled with flakes of decomposed mica as well as pyrites and pyrrhotite. The somewhat loose condition of the foliated aggregates of molybdenite that are found in the decomposed soil is attributed to the weathering and disintegration of a highly pyritiferous pyroxene.
>
> The old workings consist of a prospect pit, or cutting in the hillside, 20 feet long, and 10 feet deep with a 6-foot face, lying about 300 yards east of the road. Farther to the east, along the approximate strike of the vein, an 80-foot tunnel was driven into the hillside, but not far enough to strike the vein. Considerable quantities of flake graphite was noticed disseminated throughout the loose rock that came from the tunnel.

T. L. Walker (1911, p. 30) reported favourably on this prospect and considered it worthy of further prospecting. The La Fleur prospect is also described in more recent reports (de la Rue, 1948, pp. 41-44; 1953, p. 28).

From the *Villeneuve property,* range VI, lot 44, Eardley-Wilmot (1925, p. 158) reported the occurrence of molybdenite in a zone of massive pyroxenite in limestone.

At the *Donnie property,* range VII, lot 42, molybdenite occurs with iron sulphides in pyroxenite in gneiss (Eardley-Wilmot, 1925, p. 158).

56160-5—15½

Kensington Township

Moldor Exploration Syndicate

De la Rue (1953, p. 28) mentioned the occurrence of molybdenite in pegmatite dykes on range IV, lots 45 and 46. This appears to be the deposit recently opened up by the Acme Molybdenite Mining Company Limited of Montreal, in lot 46. The property is approached from Maniwaki via Deleage, a village along Route 11, 4 miles east of Maniwaki. A country road, locally known as 'Chemin de Joseph', leads northeast from Deleage to the Acme property, a distance of 3½ miles. The working lies on the partly cleared hillside above and to the east of the road. The dumps from the workings are clearly visible from the road and only about 150 yards away.

The working, at the time of the writer's visit in June 1958, consisted of a single trench or elongated pit about 140 feet long by an average of 25 feet wide, with the longer axis bearing S20° (*see* Fig. 19). The western, or downslope wall of the pit is 6 to 7 feet high and the eastern wall is up to 15 feet high. At the southern end is a deeper section, said to be 5 feet below the general level, but it was under water.

The geology of the deposit is fairly straightforward. The country rock is a fairly uniform, coarse-grained, mottled grey, biotite syenite with a granitic texture and well-developed joints. Along the axis of the pit is a series of inclusions of medium- to fine-grained, biotite-hornblende schist or gneiss. These seem to represent blocks of pre-existing rock caught up in the syenite. There may have been a certain amount of assimilation, but on the whole the boundaries of the blocks are sharp. A coarse-grained feldspar-biotite pegmatite, without quartz, has developed in and around the schist blocks and along some of the prominent joint planes in the syenite. It is the pegmatite that carries the molybdenite as erratic flakes and splashes.

In the hand specimen the syenite is seen to be around 3 or 4 mm in grain size and to consist of black biotite mica and grey feldspar. The biotite is typically segregated in clusters of flakes, up to 4 mm across, set in the feldspar groundmass, giving a mottled or speckled appearance to the rock as a whole. The main structural feature of this rock is its excellent jointing. The main joint direction is between N20°W and due north, and the joints dip vertically. Another marked set strikes about N60°E, and a third set of flat joints dips about 10°NW. It is in the main set that the pegmatitic veins have developed. This rock seems to form the country rock in the area around the pit, but its extent could not be determined due to the general lack of exposures.

The pegmatite consists dominantly of flesh-pink, very coarse grained feldspar (orthoclase). Vugs or central openings occur here and there in the veins, along which the crystals have grown euhedrally up to 6 inches or more in length. The only other silicate present in notable quantities is black biotite which has an erratic distribution in books up to a few inches across. It is present both in the zone of schist blocks and in the pegmatite veins along joints in the syenite.

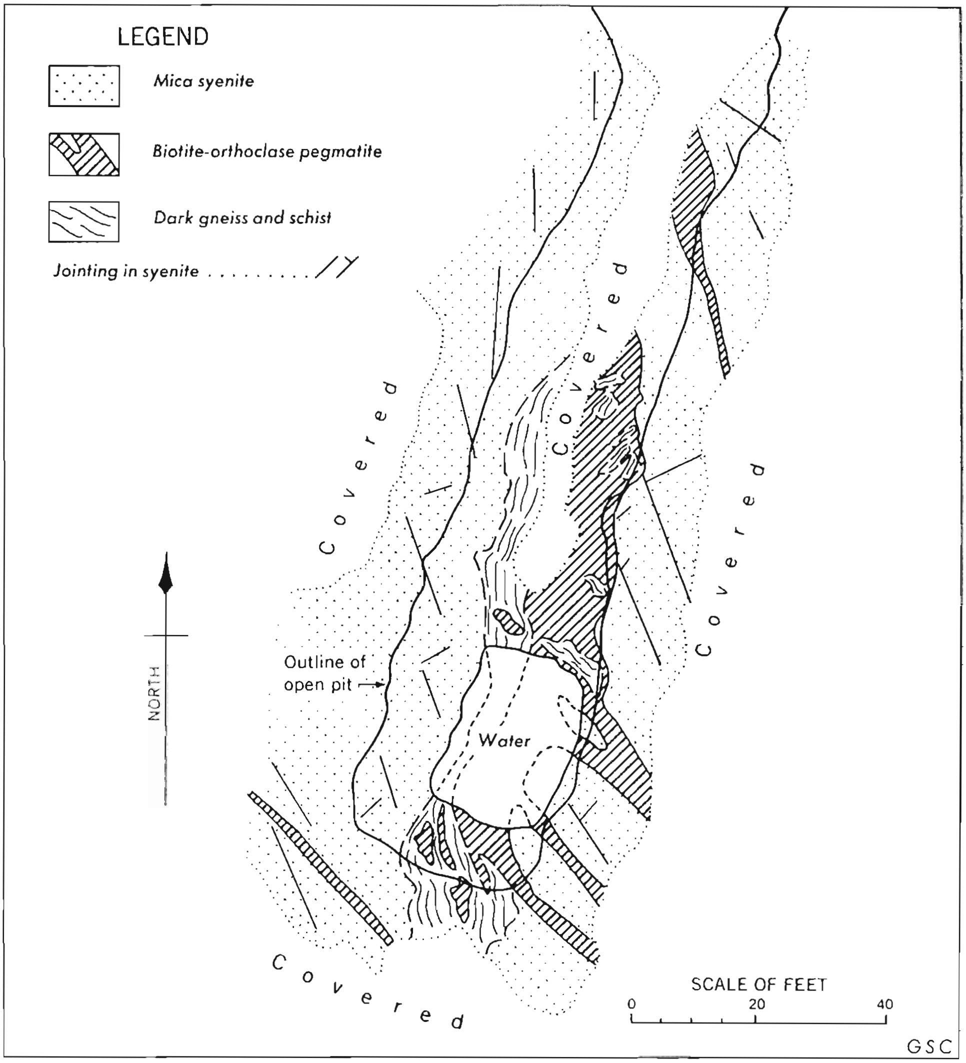

Figure 19. *Sketch map showing geology of Acme Molybdenite Mining Co. Ltd. property, Kensington township, Quebec (1958).*

Other minerals in the pegmatite are molybdenite, pyrite, calcite, apatite, and tourmaline. The calcite is minor in amount, except near the south end of the pit. It appears to be very late and fills the interstices between the biotite books, commonly along the central cavities of some of the pegmatite veinlets. Apatite occurs in small, relatively rare, green crystals, except in some of the schist inclusions along the east wall of the pit where it has developed in the schist, apparently as a late alteration, in large amounts of minute crystals. In occasional drusy cavities, the apatite forms well-developed crystals up to ½ inch long. Black tourmaline was noted in the feldspar at one point on the east wall of the pit;

it occurs there as well-formed prismatic crystals up to 3 inches long, in clusters that tend to have a radiating form.

The development of this pegmatite seems to have been initiated along the zone of schist inclusions in the syenite, and to have spread outward along certain well-marked joints. The fact that it occurs only in the joints of one set suggests that stress conditions at the time must have made this set more favourable for pegmatite formation. In the south face of the pit, just above the water-filled depression, is a good section across the pegmatite zone. There, for a width of about 13 feet, mixed pegmatite and schist occurs between walls of syenite. There are many drusy cavities in which fine euhedral crystals of feldspar have developed. Books of black mica up to 2 to 3 inches across are abundant, and around the schist inclusion are selvedges of coarse black mica. Molybdenite occurred very sparsely and erratically as splashes or thin coatings on the other minerals. Pink calcite was seen to fill some of the interstices between the silicates. About 9 feet to the east of this 'mixed zone' is a 1-foot-wide pegmatite vein lying in a joint in the syenite—apparently an offshoot from the central zone. This vein has a central, longitudinal, clay-filled open zone, whose width varies up to an inch or so. Along either side of this are developed large euhedral crystals, some 9 inches or so in length. The vein has a well-marked selvedge of coarse black mica along either wall. No molybdenite was seen in the pegmatites following joints.

The striking thing about the pegmatite is its petrological identity with its wall-rocks. Both syenite and the contained schist blocks are composed of feldspar and biotite, and the pegmatite too carries only orthoclase and biotite. Quartz is absent from both the pegmatite and country rock. The pegmatite may thus be termed a syenite pegmatite. This continuity of composition between the pegmatite and its wall-rock strongly suggests that the former was derived from the latter. Both the schist inclusions in the pegmatite and the walls of the veins in syenite have strongly marked selvedges of black biotite which is much coarser than that in either rock, but not as coarse as the biotite books in the pegmatite. Within these selvedges the feldspar of the schist or syenite is absent; it has apparently been 'abstracted' in some way. In extreme cases the schist blocks are reduced to 'ghost-like' areas of concentrated coarse black biotite and all the feldspar removed—it is suggested into the pegmatite.

The initial stages in the formation of the pegmatite veins can be seen at the south end of the pit along the joints in the syenite. There, a central rib of feldspar, 1 inch across, has been developed; and on either side is a zone of coarsened biotite and coarsening feldspar that fades into the normal syenite. It is suggested that by a continuation of this process, feldspar would move into the 'joint-vein' and the biotite would accumulate along both walls, gradually being pushed outward, coarsening in the process, until it formed the coarse mica selvedge as seen along the wide joint-veins. This method of growth of pegmatite, by accretion from the wall-rock, has been described in detail by Reitan (1958) for certain feldspar pegmatites along the south coast of Norway. The mode seems to be demonstrably applicable to the formation of the Acme pegmatites. It presupposes some form of intensified activity along the zone of schist fragments and along the predominant joints in the syenite, setting up a chemical gradient that started the movement of the feldspar to form the pegmatites.

The foregoing brings up the question of the derivation of the minor minerals in the pegmatite—especially the molybdenite. These could have been present in the wall-rocks and schist inclusions in minor quantities and have been concentrated in the same way as the feldspar; or they could have been introduced either at the time of the intensification of activity in the zone, or at a very late date.

The molybdenite occurs very sparsely and erratically in the exposures of pegmatite in the pit. Most of the information on its occurrence was collected from material in the dump below the pit. The mineral occurs nearly exclusively in the feldspar of the pegmatite as flakes or irregular 'splashes'. Typically it forms an extremely thin coating, covering a fairly large area but being small in actual quantity. Some of the richer 'splashes' may be 2 or 3 inches across, but their distribution is very erratic. Under such conditions, only bulk-sampling of the whole deposit would be at all accurate, and it does not seem practical to give a grade for such type of deposit. A large-scale pilot mill test of all the excavated mineral would be necessary.

The quantity of mineralized material can be ascertained more readily. The size of the mineralized pegmatite body in the pit is roughly 20 by 60 feet—an area of 1,200 square feet. Thus, for every foot of depth there would be 1,200 cubic feet or about 90 tons of 'ore'. However, the erratic nature of pegmatite must be taken into account and without close drilling the continuation in depth cannot be predicted.

Before the writer's visit, Mr. V. O'Neill, geologist with the Molybdenite Corporation of Canada, Limited, inspected the Acme property. The following notes are taken from his report, by courtesy of the Molybdenite Corporation. The tonnage of material on the dump below the quarry was estimated at 125. Samples taken from three pits dug into the central part of the dump gave assays of 0.25, 0.06, and 0.04 per cent MoS_2 respectively. Twelve samples taken at intervals in the quarry gave an average 'uncut' grade of 0.18 per cent MoS_2. The tonnage was estimated at 1,325. A 'concentrate' from the deposit was found to assay 0.6 per cent MoS_2 and 0.04 per cent Bi. It is interesting to note that the Mo:Bi ratio is thus about the same as at the Lacorne mine of the Molybdenite Corporation of Canada.

Laviolette County

Malhiot Township

At the *Montgrain showing*, a mile south by trail from La Tuque, molybdenite occurs in pegmatite.

Suzor Township

At the *Cloutier Creek group*, molybdenite and graphite are reported from mineralized zones in limestone (Faessler, 1936, pp. 34-35).

Papineau County

Templeton Township

From *McGregor Lake*, range XIII, lot 12, Eardley-Wilmot (1925, p. 158) recorded the occurrence of molybdenite with pyrite and apatite in pyroxenite.

Portneuf County

Chavigny Township

At the *Montauban Metal Corporation*, range I, lot 16, molybdenite occurs in a quartz vein in banded aplite (Que. Bur. Mines, 1930, p. 63).

Deschambault Parish

Portneuf Molybdenite Company

The following summary account of this property, con. II, lots 290 to 293a, is taken from Ingham (1942g):

> The showing lies 3 miles west of the town of Portneuf on the C.P.R. and the C.N.R., 40 miles west of Quebec.
>
> The rocks underlying the vicinity include Precambrian biotite gneiss and pegmatitic gneiss, adjoined to the south by Trenton limestone and Utica schist. The molybdenite occurs in a zone of pegmatitized biotite gneiss striking N35°E, which is exposed intermittently along a distance of 1,800 feet. The present workings, which consist of 3 pits and a number of shallow trenches, indicate that the southwestern portion of the zone contains mineralized rock along 600 feet. The pegmatitic zone appears to be from 50 to 60 feet wide and molybdenite occurs within it in the form of discontinuous streaks and lenses separated both across and along the mass by practically barren rock. The grade and tonnage are difficult to determine because of the erratic nature of the mineralization; but estimates based upon unproven assumptions suggest about 90 tons of less than 0.30 per cent MoS_2, per foot of depth extension. This is an estimated average grade, and doubtless small enriched pockets occur which carry a much higher proportion of molybdenite.

Lang (1952, p. 153) mentions the occurrence of a little uraninite and uranothorite in this deposit (*see also* Que. Dept. Mines, 1956, pp. 95-96).

Montauban Township

Ingham (1942h) has described an occurrence of molybdenite on *range I, lot 6*:

> The prospect is located 1½ miles north of the village of St. Ubald, which may be reached by driving some 11 miles from St. Casimir or St. Adelphe on the C.N.R. about 50 miles west of Quebec.
>
> In the vicinity of the showings the rocks exposed are east-west trending, gently warped but more or less horizontal horizons of bedded and foliated paragneisses, which are intruded by thin sills of granite gneiss and a few flat dikes of pegmatite.
>
> A number of short, discontinuous, lensing veins of quartz occur in lot 6, which are mineralized with a few scattered flakes of molybdenite. Nearby a pit in a flat-lying thin sill of pegmatite exposes low grade flakes of the sulphide. At the west side of lot 5a a pit and trenching about 70 feet long reveal a fluorite-apatite lead along a distance of 25 feet. The lead is from 2 to 12 inches wide, and consists of pure massive purple fluorite with an associated band of green apatite.
>
> As exposed at present the molybdenite mineralization is not considered of commercial importance.

Tetreault lead-zinc mine, range I, lot 40, lies 4 miles west of Mountauban village. The ore at this mine contains molybdenite as an accessory mineral. The main minerals are sphalerite, galena, pyrite, and pyrrhotite, with some tetrahedrite, stibnite, arsenopyrite, silver, and electrum (Dresser and Denis, 1949, p. 449).

The *Montauban Mining Syndicate* ore zone, range I, lots 43-45, lies ⅔ mile north of Tetreault mine. Molybdenite is an accessory mineral in a complex lead-zinc ore, similar to that of the Tetreault mine (Alcock, 1930, pp. 86-87; Smith, 1956, p. 28).

At *St. Thomas range*, lot 290, an occurrence of molybdenite has been reported from a pegmatite carrying pyrite and gold (Que. Dept. Mines, Ann. Rept. 1915, p. 127).

Roberval County

Pelletier Township

At *range VI, lot 41 and Mistassini range, lot 37,* quartz veins and lenses carrying molybdenite occur in a fine-grained, massive, quartz-hornblende-biotite rock (Denis, 1934, p. 85).

Dufferin Township

At *range VI, lots 43-44*, molybdenite occurs in pegmatites in Laurentian gneisses (Denis, 1934, pp. 84-85).

Lake Saint John County

Métabetchouan Township

Eardley-Wilmot (1925, p. 131) reported the occurrence of molybdenite and pyrite in a pegmatite dyke cutting granite gneiss, 1½ miles east of Chambord Junction on the shore of Lake Saint John.

Saguenay County

Bergeronnes Township

The *Coulée-à-Maltais occurrence,* situated 4 miles northwest of St. Zöe at the mouth of the Bergeronnes River, has been described by Faessler (1930, p. 86) and Greig (1952, p. 10). Molybdenite occurs in pegmatite cutting gneiss.

Letellier Township

At a locality 20 miles north of Seven Islands, uraninite and other radioactive minerals occur with molybdenite in pegmatite (Que. Dept. Mines, 1956).

Rochemonteix Township

Specks of molybdenite occur in narrow quartz veins in coarse porphyritic granite ⅓ mile west of Pigou River, at a point 1¼ miles north of the mouth of the East Pigou branch (Greig, 1945, p. 27).

Saguenay District

Boishebert Township

Molybdenite occurs in quartz veins with some pyrite, 1½ miles east of the mouth of Mecatina River and 3 miles west of Cape Mecatina (De Puyjalon, 1898, pp. 271-272; T. L. Walker, 1911, p. 25).

Brouage Township

The *Victor Bay occurrence* consists of isolated crystals of molybdenite in short veins of quartz (De Puyjalon, 1898, p. 270; Longley, 1950, p. 21).

Duchesneau Township

At the *Olomanoshiboo Harbour occurrence* (*Romaine deposit*), molybdenite and traces of chalcopyrite and pyrite occur in a quartz-rich pegmatite cutting grey sillimanite gneiss. One sample is reported to have assayed 1.89 per cent Mo (De Puyjalon, 1898, pp. 270-271; T. L. Walker, 1911, pp. 25, 26-28).

Johan Beetz Township

The *Quetachu Bay occurrence,* east of the village of Johan Beetz, has been described many times since its discovery in the last century. The chief references are De Puyjalon (1898, p. 267), T. L. Walker (1911, p. 23-24), Eardley-Wilmot (1925, pp. 131-132), Longley (1950, p. 21), and Cooper (1957, p. 48). Molybdenite occurs in a feldspar-quartz vein cutting coarse pegmatite and dark amphibolite.

Lalande Township

On the east side of *Washikuti Harbour,* molybdenite occurs in a quartz vein in fine-grained gneiss (De Puyjalon, 1898, p. 270; T. L. Walker, 1911, p. 25).

Terrebonne County

At the *St. Jerome occurrence,* molybdenite occurs sparingly as flakes disseminated in red gneiss near its junction with a band of crystalline limestone (T. L. Walker, 1911, p. 22).

APPALACHIAN REGION

The Appalachian region of Canada comprises Nova Scotia, New Brunswick, Prince Edward Island, the island of Newfoundland, and that part of Quebec that lies southeast of the Logan fault—this fault extends from Lake Champlain northeastward in a gently curving arc to Quebec City and from there down the St. Lawrence River and the Gulf of St. Lawrence.

Molybdenite deposits have been reported from all the provinces in this region, with the exception of Prince Edward Island; though as yet, no commercial production has been attained.

Various other metals, principally copper, tungsten, and occasionally tin, are associated with molybdenum in the Appalachian deposits, which were formed during widespread metallization in the Devonian.

Deposits of molybdenite—most of them small—are fairly numerous in New Brunswick and Nova Scotia. There appears to have been no commercial production, but during 1917-18 samples from three places in Nova Scotia (in all about 24 tons of ore), were sent to the Mines Branch, Ottawa, for testing. These were mostly samples of hand-picked ore, and they assayed from 0.50 to 2.50 per cent MoS_2 (Eardley-Wilmot, 1925, pp. 58-59).

Geologically, the molybdenite deposits are closely linked with the granites of the area. In New Brunswick and the mainland of Nova Scotia they occur, with only one exception, either in or on the borders of large areas of lower Devonian granites; and on Cape Breton Island they are spatially connected with large bodies of pre-Carboniferous (possibly Precambrian) granitic rocks.

New Brunswick

Restigouche County, Durham Parish

At Antinori Lake, 8 miles south-southeast of Jacquet River, molybdenite occurs in quartz stringers in fine-grained granite porphyry (N.B. Dept. Lands, Mines, Ann. Rept. 1950, p. 108; Geol. Surv., Canada, Maps 640A, 641A).

Gloucester County, Bathurst Township

Two occurrences on *Nipisiguit River,* south of Bathurst, have been reported rather vaguely in the literature. Bailey (1899, p. 126) mentioned the occurrence of the mineral in granite at this locality; the same author (1891, pp. 6-7) reported a similar occurrence below Pabineau Falls on the same river. These two may be the same. (*See also* W. J. Wright, 1940a, p. 2).

At *Pigeon (Pabineau) Lake,* 9½ miles southwest of Bathurst, molybdenite, accompanied by beryl, is disseminated in a pinkish, fine-grained Devonian granite. The occurrence has been described by Alcock (1936b, p. 131) and W. J. Wright (1940a). According to Wright it has been known since about 1905, but was not explored to any extent before 1932-33. The prospect lies near the western border of a lenticular granite mass which is about 9 miles long and 4 miles wide.

Wright (1940a, pp. 2-3) described the occurrence as follows:

> According to Alcock, there are no exposures within a three mile radius of the prospect, but the numerous large blocks and boulders indicate the presence of granite beneath the overburden. The general type of granite is slightly pink to brick-red in color, and coarsely granular to semi-porphyritic in texture. The microscope shows it to be a normal acid variety, consisting of orthoclase, albite, quartz and biotite with accessory iron ore and apatite and a little secondary chlorite. The general type is cut by dykes of pale pink fine-grained aplite, with muscovite instead of biotite.
>
> The granite intrudes strata of Ordovician age on all sides except the east where it is non-conformably overlain by sedimentary rocks of Pennsylvanian age. Elsewhere in New Brunswick there is evidence to show that the granite is of Devonian age.
>
> In the immediate vicinity of the prospect, the boulders and the red rock consist of medium-grained, porphyritic granite, and rock of similar texture is exposed on the western

side of the batholith on Little River, and Pabineau River. Apparently this texture is characteristic of the margin of the intrusion. At Pabineau Lake, the granite contains quartz phenocrysts in crystal form up to half an inch in diameter. Mr. L. E. Djingheuzian suggested that these crystals might be the beryllium-bearing mineral phenacite, but specimens examined by Dr. Maurice Haycock of the Mines Branch, Ottawa, proved to be quartz.

Granite boulders predominate over the area underlain by granite, and foreign boulders are rare. Thus the distribution of the boulders serves as a guide in mapping the geological boundaries. At Pabineau Lake, the boulders are similar to the bed rock exposed in the trenches. These observations point to the conclusion that most of the boulders have weathered in place.

Description of the Deposit

The surface is covered with tightly packed granite boulders which vary in size up to five or more feet in diameter, and extend to depths of five to ten feet. Molybdenite-bearing boulders occur as individuals and small nests which have been found at fifteen points over a roughly lenticular area whose greatest length (northeast and southwest) is 1,300 feet and greatest width is 400 feet.

In the bed rock at the bottom of the pits and trenches, molybdenite occurs at five points, one in each of the old pits, and three in the trench to the southwest. The largest body was found in the shaft, and it was from this point that Bourque obtained the 700-pound sample which was tested by the Ore Dressing Laboratory in Ottawa. It is estimated that two tons of ore were hand picked from about 50 tons of material taken from this pit. A few small segregations of molybdenite are still visible in the walls. Small segregations of molybdenite are also visible at the east end of the trench and at points in the southern extension. The rock between these showings is barren.

Mineralogy

The minerals of economic interest are molybdenite and beryl. Molybdenite occurs as flakes and crystals, disseminated through the granite, as well as along incipient joint planes and associated with stringers of bluish white quartz, which cut the granite. Beryl is sparsely disseminated through the granite, and thus far the quantities found are of scientific interest only. During the exploratory work of 1939, a sample was found at the southern end of the trench containing sheaves of green beryl crystals one quarter of an inch in diameter and up to three inches long. They were associated with quartz and large flakes of molybdenite.

In 1933, 700 pounds of ore from the prospect was shipped to Ottawa for testing at the Mines Branch laboratories. The shipment assayed 5.82 per cent MoS_2.

Wright concluded his report by recommending further prospecting of the property and of the surrounding area.

> ...molybdenite has been found in boulders and in bed rock in six neighbouring localities, and intensive prospecting may locate a property which has better possibilities than the one at Pabineau Lake.

Gloucester County, Little River

(as described by W. J. Wright, 1940b, p. 3)

This deposit was discovered by Hector Bourque, a member of a Provincial prospecting party in 1939, and our present knowledge of the deposit is confined to his field notes. The deposit is located in Gloucester County about six miles southwest of Bathurst, on the north side of the river about one mile from the bridge at the end of the Little River road. It is reached by rough portage road which joins the highway at the bridge. The data is subject to revision.

It is a boulder deposit, similar to the one at Pabineau Lake. The boulders are of aplitic granite, and are believed to have weathered in situ. Bed rock is exposed in the vicinity by a pit on a small body of hematite which is associated with white quartz.

Bourque mapped groups of molybdenite-bearing boulders in a distance of 2,000 feet, and reports a topaz-bearing boulder in the adjacent territory.

Gloucester County, Middle River

(as described by W. J. Wright, 1940b, p. 3)

The Middle river deposit is located on the east side of the river about eight miles southwest of Bathurst, Gloucester County, and about one quarter of a mile below the highway which runs from Bathurst to Little river. It was discovered in 1938 by a Provincial prospecting party led by T. H. Donaldson. The actual discovery is confined to quartz veins in an immense boulder of granite, but the inference is that the boulder has weathered in situ, and that the mineral would be found in the underlying bed rock. The mineral occurs in flaky crystals up to half an inch in diameter.

Gloucester County, Sugary Brook

(as described by W. J. Wright, 1940b, p. 4)

This deposit was discovered by Hector Bourque, a member of a Provincial prospecting party in 1939, and our present knowledge is confined to his field notes. The deposit is located on Sugary brook about nine miles southwest of Bathurst, and about two miles southeast of the deposit at Pabineau lake. Bourque found eight groups of molybdenite-bearing granite boulders in a distance of about 5,000 feet. The occurrence is similar to that at Pigeon Lake, and the impression gained is that it may be the largest area in the Bathurst district. This information is subject to revision.

Gloucester County, Pabineau River

(as described by W. J. Wright, 1940b, p. 4)

Molybdenite was first discovered in this locality by Addeley Hussey of Bathurst, and first brought to my attention in 1932. We examined the prospect in 1933, but it did not appear very promising and the work was abandoned. During the summer of 1939, the Provincial prospecting parties led by Robert Hossack, spent a couple of weeks in the vicinity without making other discoveries of interest.

The deposit is located on the Pabineau river at the mouth of Fred brook about 5½ miles above the crossing of the branch railway which runs from Bathurst to Austin brook, and is readily reached by a portage road. The mineral showings occur in aplitic biotite granite with accessory muscovite, close to the contact with older sedimentary rocks. The granite is cut by zones and dykes of pink aplite and small irregular veinlets of white quartz. Molybdenite is exposed in several outcrops and shallow pits along the south bank of the river. It is sparsely disseminated in aplite and in quartz stringers.

York County, Dumfries

(as described by W. J. Wright, 1940b, p. 5)

Dumfries is the name of a community in York County, on the south side of the Saint John river about 30 miles west of Fredericton. It is located on the main highway, route No. 2, and midway between stations Carson and Murray on the Canadian National railway.

The deposit was examined and abandoned several years ago under the supervision of the late Henry Bailey. He found molybdenite in the railway cut at two points about 200 feet apart, and wolframite in a large granite boulder about one quarter of a mile to the south. One of the exposures is associated with a quartz vein, and two trenches were dug on the strike of the vein south of the railway within a distance of about 900 feet from the outcrop.

The prospect was examined in 1939 by a Provincial party led by Francis Barr. The country rock is biotite granite which weathers to a reddish color and the region is strewn with angular granite boulders. Molybdenite was found in a 30-inch vein on the south side of the railway, and in waste on the side of an old trench north of the highway, but wolframite was not obtained.

York County, Stanley Parish

The occurrence of molybdenite in some of the quartz veins in the vicinity of the confluence of Burnt Hill Brook and the main Southwest Miramichi River has been known from about the beginning of the present century (T. L. Walker, 1911, pp. 21-22; Brock, 1912, pp. 13-15; and W. J. Wright, 1940c).

The quartz veins occur cutting dark slates of probably Cambro-Silurian age that have been invaded and metamorphosed by a granite batholith, outcrops of which are visible a short distance downstream from the mineral deposits. Walker stated that the deposits are rarely more than a mile from the granite contact as measured on the surface, and that, measured vertically, the igneous rock is still nearer.

Brock described the quartz veins as follows:

> Quartz is developed parallel to the strike of the schistosity of the sediments and parallel to the joint planes. Parallel to the strike, the quartz is irregular, forming lenses and sending irregular stringers into the country rock. Between the stringers the country rock is often silicified. Parallel to the joint planes the quartz occurs in well-defined, regular veins which can be traced in some cases for several hundred feet but some can be seen to pinch out . . . The majority of the veins are under 1 foot in width, but (at one point), I found the vein for about 50 feet to average at least 2 feet.

Brock considered that there was a gradation from dykes of greisen (containing cassiterite) to normal quartz veins, and that "the veins are clearly contact phenomena of the intruded granite." He observed the following minerals: quartz, muscovite, brown mica, feldspar, topaz, fluorite, wolframite, molybdenite, pyrrhotite, chalcopyrite, and cassiterite. In addition to the veins in the metamorphosed sedimentary rocks, Brock found molybdenite alone, in small quartz veins and pegmatites in the outcrops of granite exposed in the brook.

Eardley-Wilmot (1925, p. 60) stated that assays of 0.25 to 1.00 per cent MoS_2 were obtained at the Mines Branch, Ottawa, from samples of tungsten ore from this locality. The deposits were worked for some time for tungsten but no attempt was made to save the molybdenite.

York County, Burtts Corner

Molybdenite occurs with beryl and tourmaline in pegmatite and aplite at the contact between Devonian granite and hornfels, at a locality 1 mile west of Keswick River, 4½ miles west of Burtts Corner (Burtts Corner, west half, Geol. Surv., Canada, Map 7-1957).

Charlotte County, Pennfield

(as described by W. J. Wright, 1940b, p. 7)

> Pennfield is the name of a village and station on the Canadian Pacific railway about 12 miles east of St. George, Charlotte County. According to Bailey (1864) molybdenite occurs in granular quartz rock on Trout Brook about two miles north of the highway. It is in scattered grains and scales, some of which are half an inch in diameter. In 1927, Alcock reported that the deposit proved to be a boulder of quartzite about four feet long, two and one half feet wide and two feet thick with flakes of molybdenite distributed throughout, and concluded that if a deposit of this type should be found in bed rock, it would merit further investigation. The source of the boulder is not known, but one would infer that it came from near the granite contact about seven miles to the north.

Charlotte County, Clarendon Parish

On a hill south of Gaspereaux Station, in the northeast corner of the county, molybdenite occurs in quartz veins in granite (Matthew, 1877, pp. 328-29).

Charlotte County, St. George
(as described by W. J. Wright, 1940b, p. 10)

Molybdenite is one of the accessory minerals in the granite at St. George, Charlotte County. It occurs in small lenses of pegmatite but the discoveries are too small to be of commercial value. The best looking specimen from the St. George district was submitted by L. Leslie. It shows flakes of molybdenite an inch or more in diameter, and is said to have come from near Bonny River, a station on the Canadian Pacific railway, about eight miles north of St. George, but the exact locality is not known.

Queen's County, Wirral
(as described by W. J. Wright, 1940b, p. 11)

Wirral, Queens County, is a station on the Canadian Pacific railway about 35 miles northwest of Saint John. The station was formerly called Gaspereau. Johnston (1904, p. 8) states that molybdenite occurs in quartz veins cutting granite near Gaspereau station. This is the only known record on the subject, and at the present time residents of the community do not know the exact location. It is reported that samples of molybdenite and graphite were found in 1929 in the gorge of a small brook, but careful search in that place showed the country rock to be sedimentary, and failed to find molybdenite.

Queen's County, Petersville Township

The Square Lake occurrences, 3 miles southwest of Welsford, a station on the Canadian Pacific railway 19 miles northwest of Saint John, have been described by Poitevin (1933, pp. 56-57) and W. J. Wright (1940d).

According to Poitevin, prospecting began early in 1932 by the residents of the area, and specimens containing topaz, wolframite, fluorite, native bismuth, bismuthinite, molybdenite, arsenopyrite, chalcopyrite, pyrite, pyrrhotite, and specularite were submitted for examination.

The area lies towards the northeastern end of a body of Devonian granite some 50 miles long and about 8 miles wide. The granite varies in texture from medium grained to aplite porphyry and aplite, and muscovite is a common accessory mineral. Quartz veins and zones of greisen are common, but pegmatite is rare.

Wright (1940d, pp. 2-3) described the main features of the deposits:

Quartz Veins. The quartz veins usually strike about S70°E, and stand about vertical. They are composed chiefly of smoky colored and white quartz with occasional knots of pinkish feldspar, crystals of wolframite and molybdenite.

Most of the veins are less than two inches in width and lense out in distances of ten or more feet to be succeeded by another of the same type. Larger veins occur, most of which are in sharp contact with the granite, but one, composed chiefly of granular quartz, grades abruptly into the enclosing granite. The larger veins vary in width up to three feet and extend for distances of one or more hundred feet along the strike. The quartz veins carry wolframite, molybdenite, bismuthinite, native bismuth, specularite, and topaz.

Greisen. Frequently the walls of the joint planes and quartz veins are delineated on the surface by zones which are more resistant to weathering than the normal granite, and stand up as faint ridges one to three inches in width. The harder rock is greenish greisen, and where the quartz veins and joints are closely spaced, the greisen occurs in zones, some of which are ten feet or more in width. The greisen is made up of interlocking grains of quartz with flakes of mica and sheaves of topaz. Other common minerals are wolframite, molybdenite, arsenopyrite, pyrite, chalcopyrite, pyrrhotite, green fluorite, and galena. Weathering of the greisen commonly produces a pale yellow powder which appears to consist chiefly of sulphur; samples of it were tested for tungsten, molybdenite, and pitch blende with negative results.

Pegmatite. Pegmatite was observed only in a large boulder. It occurs in a small fine-grained patch and carries topaz, greenish fluorite, molybdenite, and white and amber-colored mica.

Regarding the grade of the deposit, Wright states: "The material exposed in most of the pits appears to be too low grade to be of commercial interest." No assays for molybdenite were given.

Nova Scotia

Cape Breton County, Glengarry Valley

Molybdenite occurs in pink granite in the bed of a small stream about 4 miles southeast of Big Pond post office (Hayes, 1918, p. 29F).

The granite is exposed about 100 yards upstream, to the north of the road, in the form of dykes which dip steeply northwards, having invaded fine-grained, green, somewhat schistose rock, apparently of volcanic origin. Three dykes, each less than 10 feet thick, lie in a zone of 100 feet along the Stream valley and above these granite about 60 feet thick occurs. The contacts with the green schist are well shown and indicate either a dyke of variable width or a small mass elongated in an east-west direction. The granite has the appearance of a fine-grained pegmatite and is probably genetically associated with a large mass of plutonic rock forming the highland to the north of Glengarry Valley. It is shattered and its brittle nature causes it to break into small fragments.

Scattered individual crystals of molybdenite frequently associated with iron pyrite, may be found by careful searching throughout the granite, but occur most abundantly in a zone about 2 feet wide paralleling the southern contact.

Although practically no development work has been done on the property, the stream has eroded a steep-sided valley about 50 feet deep and exposed the rock section to view. No ore-body of commercial value is exposed.

Cape Breton County, Gabarus Bay

The occurrence of molybdenite in the rocks in the vicinity of Gabarus Bay, a few miles to the west of Louisburg, has been known since the 1860's. The deposits have been described several times since then, chiefly by T. L. Walker (1911, p. 20), Hayes (1918, pp. 28-29F), Messervey (1933, pp. 206-207), and Douglas (1944, pp. 133-136). The mineral occurs in numerous thin quartz veins or pegmatite dykes, associated with granite, intruded into volcanic rocks that are exposed intermittently from Deep Cove to Seal Cove in the vicinity of Eagle Head. Messervey's report follows:

The molybdenite-bearing veins have cut both the granite and volcanic rocks and in one instance a section of a half inch dyke of pink feldspar, quartz, and molybdenite is exposed at the contact of a granite dyke, where it is clearly shown to have cut across granite and volcanics. It seems probable that the granite, quartz porphyry, and molybdenite-bearing rocks are genetically related, the latter resulting as a later phase of the plutonic intrusion.

Along the coast immediately east of Deep Cove the quartz veins lie in a number of intersecting planes, whereas farther east, towards Eagle Head, practically all the veins are roughly parallel and strike north and south and dip about 25 degrees to the west across the bedding of the volcanic rocks. About 600 yards north of the shore, on the brook which debouches immediately east of D. J. McKay's house, the molybdenite is found in similar pegmatite dykes, which have cut an acid granite porphyry. The granite is in the form of a dyke or small mass. It is probable that the mineralized zone extends from the shore northwards to this point at least.

Where the molybdenite-bearing dykes dip regularly to the westward, a rough approximate estimate may be made of the amount of molybdenite present, and the quantity of rock to be removed to recover it. At a point about half-way between Deep Cove and Eagle Head the dykes are about 3 feet apart, and might be considered to each contain enough molybdenite to equal a film one-sixteenth inch in thickness. That is, about 40 to 50 feet thickness of rock would have to be quarried to obtain an inch thickness of molybdenite. The average would not be as high as this, as in many places the molybdenite occurs in thinner films or smaller masses in the dykes, which, in turn, are separated by greater intervals of country rock. In the vicinity of Deep Cove where intersecting dykes occur, and at one point east of Eagle Head, the average may be higher; but the deposit does not appear to be of commercial value.

According to Eardley-Wilmot (1925, p. 58), 3,474 pounds of ore picked from the seashore was sent to the Mines Branch, Ottawa, in 1917. The average MoS_2 content was 2.49 per cent. Another small sample sent to Ottawa assayed 2.3 per cent MoS_2.

Inverness County

In the Mabou Highlands, near the headwaters of Northeast Mabou River, pegmatite float derived from an area of sheared schists was observed carrying sporadic specks of pyrite, galena, tetrahedrite, sphalerite, and molybdenite (Norman, 1935, p. 17).

Hants County

The Swinimer prospect at Leminster is situated near the junction of Lunenberg, Halifax, and Hants counties, 17 miles south of Windsor. Molybdenite occurs in a vein of quartz and calcite about 10 inches wide. In 1918, a quantity of 376 pounds of picked ore, assaying 1.08 per cent MoS_2, was sent to the Mines Branch, Ottawa (Eardley-Wilmot, 1925, p. 58). *See also* Douglas and Campbell (1942, p. 112).

Lunenberg County

The most important molybdenite area in Nova Scotia, so far discovered, lies in the neighbourhood of New Ross, some 45 miles west of Halifax. According to Eardley-Wilmot (1925, p. 59), 21.2 tons of ore was shipped from this area to the Mines Branch, Ottawa, in 1917-18. From this ore, 155 pounds of MoS_2 was recovered. The various shipments are given as follows:

	Pounds of Ore	MoS_2(%)
April 1917	675	1.66
August 1917	1,033	1.03
April 1918	40,684	0.49

The main reports on the New Ross area are those of T. L. Walker (1911, pp. 18-20), Eardley-Wilmot (1925, pp. 58-60), Cameron (1951), and Slipp (1951).

The New Ross area contains three known occurrences, the Leminster prospect in Hants county (*see above*), the Keddy prospect, and the New Russel or Walker prospect. The latter is apparently the most promising and has had the most work done on it.

According to Cameron (p. 101) rich molybdenite float was discovered on the Walker property in 1916. Trenching was carried out, and in 1917 a shaft was sunk to a depth of 35 feet, and 28 feet of drift was driven to the north. The shaft was subsequently deepened to 50 feet and drifts were started east and west for distances of 11 and 12 feet respectively. Approximately a ton of ore was shipped, averaging 1.2 per cent MoS_2. In 1949 the mobile mining plant of the Nova Scotia Department of Mines was moved to the property and it was rehabilitated. Drifts at the 50-foot level were commenced to follow the pegmatite body east and west, followed by a crosscut to the north and further drifts. Altogether about 200 feet of underground work was accomplished, together with thirteen diamond-drill holes underground and five from the surface—a total of eighteen holes and 2,046 feet of drilling.

According to Slipp three types of rock are exposed in the workings at the Walker prospect: granitized sediments, coarse-grained granite, and a molybdenite-bearing pegmatite which is the youngest rock.

The pegmatite has orthoclase and quartz as its chief mineral components; and molybdenite, tourmaline, and copper sulphides are also present. Slipp regarded the molybdenite as having crystallized in situ in the pegmatite, almost contemporaneously with the quartz. The pegmatite is extremely irregular in outline and of no great continuity. Slipp suggested that it was injected along lines of weakness in the granitized sediments, to which it is confined. Cameron described it as "a U-shaped pipe assuming a recumbent anticlinal form, the apex of which plunges to the northwest."

Shelburne County

Several small occurrences have been described from the area north of Jordan Falls (T. L. Walker, 1911, pp. 17-18; Faribault, 1918, p. 19F, and 1920, p. 6F; Messervey, 1933, pp. 208-209).

Faribault's (1920) description follows:

> The occurrence of molybdenite on Lead Mine Brook, a small eastern tributary of Jordan River, 3½ miles north of Jordan Falls, is comprised in the Lockeport map area, and the other occurrence, one mile to the northeast, is situated in the area under study. A more detailed examination, made in 1910, of the gold-bearing rocks of the locality shows that the deposits occur on a minor fold of schist and quartzite which terminates a short distance to the southwest but increases in amplitude toward the northeast. On the brook below the portage road the fold plunges westerly at an angle of 20 degrees, but one mile to the northeast the anticlinal part of the fold appears to plunge easterly at a low angle. Molybdenite in small flakes is found sparingly in a large pegmatitic quartz vein that follows the axis of the fold and cuts the stratification at a high angle, as well as in small quartz veins following the plane of stratification.... The deposits have been frequently examined from an economic point of view, but up to the present no attempt has been made to prove their commercial value. It is quite possible, however, that prospecting along the fold to the northeast may uncover quartz veins carrying economic values of molybdenite, and the locality deserves further investigation.

Island of Newfoundland

In all, about fifteen deposits containing molybdenite have been reported from the Island of Newfoundland. Several of the prospects have been developed to some extent. However, none has so far reached the production stage.

According to Baird (1953, p. 90), a close relationship to granites or acidic pegmatites is noticeable in all the Newfoundland molybdenite-bearing deposits. Pegmatitic deposits are present in Newfoundland, but they are less promising than the disseminated low-grade occurrences in microgranite. High-grade but apparently small deposits are found at Fleur de Lys, in serpentine and gneisses of unknown age that are intruded by granite pegmatite.

Rencontre East Area

The most important molybdenite area on the island is near Rencontre East, north of Belle Bay (part of Fortune Bay). There, altogether, six deposits of molybdenite have been located. They have been described and discussed in detail by White (1940); and Baird (1953, pp. 91-92) has given a general summary. The following account is from these two reports.

Molybdenite was discovered in the area before 1892, but at that time the demand for the metal was limited and no attempt was made to exploit the deposits. In 1915 a deposit on Rencontre Lake, some 3 miles from the coast (*see* Ackley City deposit below), was examined by a United States engineer who made a contract with the owners, but no work was done because the government prohibited the export of molybdenite to neutral countries. In 1935 and later, Dana & Co., Inc., of New York, carried out a program of exploration and drilling to determine the quantity of ore present, if any.

Nearly all the known molybdenite of the Rencontre East area is restricted to the southern border of a Palaeozoic batholith of granite and alaskite (Ackley batholith), at or near its contact with the Belle Bay (Ordovician ?) volcanic rocks. The mineralized part of the border zone is about 5 miles long, and extends from Wylie Hill on the east to Isle au Glu on the west. Molybdenite is concentrated at four localities: Wylie Hill at the eastern end; Crow Cliff and the Ackley mine, on the shores of Rencontre Lake, near the centre; and Motu, near the western end of the zone. The central mineralized areas adjacent to Rencontre Lake are separated from Wylie Hill and Crow Cliff by unmineralized or sparsely mineralized rock.

The distribution of molybdenite shows a close correlation with the distribution of the aplitic phase of the Ackley batholith; the richest mineralization is always in aplite, but alaskite also contains molybdenite where it is intimately associated with mineralized aplite.

Most of the aplite is concentrated in three broad embayments of the batholith into the volcanic rocks—namely the Wylie Hill, Rencontre Lake, and Motu areas—each of which contains a smaller mineralized zone adjacent to the contact with the Belle Bay volcanic rocks, which form the hanging-walls of each

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of the principal deposits. However, many aplite areas of various sizes contain no molybdenite, particularly where they are remote from the volcanic rocks.

The Ackley City deposit is the most promising, and most of the development has been done on it. The Wylie Hill deposit is much larger than the Ackley City deposit, but is of a considerably lower grade. The Crow Cliff and Motu deposits show erratic distribution of molybdenite, but small tonnages of commercial ore may be present. The Crow Cliff ore is of a pegmatitic type, whereas the Motu ore is like that of the Ackley City deposit.

At the *Ackley City deposit* the molybdenite occurs in the granite along a rather definite zone paralleling the contact, as disseminations and, to a minor extent, as small masses of nearly pure sulphide. The molybdenite is accompanied by silicification and the development of a greenish to green-black mica, but it may also occur in what is apparently unaltered microgranite. The known orebody is a lens-shaped body about 140 feet long that plunges eastward towards Rencontre Lake; the width is about 40 feet. Its southern boundary is the hanging-wall volcanic rocks, but the northern limit is an assay boundary.

To the end of 1938, exploration included 1,000 feet of surface trenching, a 60-foot shaft, and 650 feet of tunnelling. The ore zone consists of numerous patches of a greisen-like altered rock, with quartz, muscovite, molybdenite, fluorite, and chlorite distributed through the aplite. Orthoclase inversion to microcline is pronounced, particularly on the border of the ore zone. Biotite, magnetite, hematite, pyrite, chalcopyrite, pyrrhotite, and sphalerite, are minor associates.

At *Wylie Hill*, pyrite occurs abundantly with the molybdenite, which is present either as disseminations or as borders of quartz veinlets. The granite here is also fine grained, but has a light colour, possibly due to leaching.

The only mineralized area found in the Ackley batholith that is remote from the contact lies southeast of *Franks Pond*, more than 3 miles north of the contact. However, this deposit differs from that of the other areas because molybdenite is associated with quartz veins in granite. Two mining claims carry rather widely spaced veins. Each vein is several inches wide and is sparsely mineralized with molybdenite. Snelgrove and Baird (1953, p. 92) gave the following description:

> Another molybdenite occurrence is on Bell Island, near the mouth of Belle Bay, five miles west of Rencontre East Harbour. This deposit is in a small stock or sill of granite porphyry related to the main batholith. Chalcopyrite is a prominent associate of the molybdenite. Pyrite and fluorite are also present. Greenish mica is an accompanying alteration mineral. The molybdenite is generally in small quartz-chalcopyrite veinlets, but may occur disseminated in the granite. Molybdenite is also found in small quantities in other parts of the area, generally in definite quartz veinlets or in veins with a maximum thickness of several inches.
>
> Water power adequate for mining is available in one of the nearby streams flowing into Rencontre Lake.

White (1940) believed that the mineralization in the Rencontre East area was closely related genetically to the miarolitic aplite phase in which it occurs. He believed that it was due either to acid fluids, gases, or hydrothermal condensates, or to a combination of acid gases and alkaline liquids. The main period of mineralization is classed as high-temperature, with intermediate-temperature late phases. White classifies the Ackley City deposit as a "complex aplite".

Fleur de Lys Prospect

At this prospect, in White Bay county on the northeast coast of the Island, a 55-foot shaft was sunk on a high-grade deposit of molybdenite during World War I. A 12-foot drift was driven from the shaft at the 20-foot level, and 18 tons of picked ore, said to average 10 per cent MoS_2, and about 100 tons of 1.5 per cent ore, were taken out. This was sampled and assayed by the Mines Branch, Ottawa (Baird, 1953, p. 90).

The deposit lies at the contact between serpentine and gneiss. Fuller (1941, pp. 19-24) believed that this association was structural rather than genetic. The molybdenite is thought to be related in origin to a granitic magma which also was the source of the quartz-feldspar dykes containing molybdenite that are exposed in the immediate area. Molybdenite occurs in flakes and bunches associated with carbonate, pyrrhotite, actinolite and talc. Small quantities of molybdite are present as a result of weathering. In addition to the deposit explored by the shaft, two other mineralized patches have been found nearby. Although the material is high in grade, it is erratic in distribution. The richest masses appear to occur along minor faults.

Other Occurrences

The following summary is from Baird (1953, pp. 92-93).

Molybdenite occurs in small quantity on Burnt Island, Deer Lake in the west central part of the island. It does not appear to be of commercial importance.

At Berry Hill between Great Gull and Little Gull Rivers, near the headwaters of Gander River, south central Newfoundland, molybdenite is found in glacial drift. Granite boulders veined by quartz contain coarsely crystalline molybdenite. The bedrock source of this drift has not been located.

Flakes of molybdenite have been observed in granite gneiss of Indian Head Ridge, north of Bay St. George, west coast.

An occurrence of molybdenite is reported near *Woodfords,* Conception Bay, southeast coast.

In the vicinity of *Pomley, Van Dutten* and *Northwest Coves,* in Baie d'Espoir, south coast, in a region of Ordovician(?) schists intruded by granite, molybdenite is found in pegmatite sills and knots, in quarry veins and also in inclusions of schists within granite. This area was investigated for the Geological Survey by W. B. Jewell in 1937. The molybdenite deposits have been prospected to some extent but their commercial possibilities have not yet been determined.

Small quantities of molybdenite are reported in a granite intrusion near the hydroelectric plant at Lawn, Burin Peninsula, south coast. The mineral occurs as masses about an inch long in quartz and quartz-pegmatite veins several inches in width, and to a smaller extent as fine disseminations in granite adjacent to the veins. The textural features of the Lawn and nearby St. Lawrence granite masses with the association of fluorite and molybdenite, recall the similar granite in which the Rencontre East molybdenite is found at the head of Fortune Bay.

In Ferryland county on the Avalon Peninsula, at a locality 1.2 miles south of the Witless Bay railway line and 8 miles west of Bay Bulls, three narrow molybdenite-chalcopyrite-pyrite-quartz veins occur in the Holyrood granite, of Devonian age (Rose, 1952, p. 55). The veins are 2 to 6 inches wide and assayed up to 7.2 per cent MoS_2.

Quebec

Beauce County

The Beauceville occurrence, 600 feet north of Rivière des Plantes and 1,300 feet east of the Chaudière road, has been described by MacKay (1921, pp. 84-85).

The deposit consists of flakes, films, and small pockets of molybdenite scattered through a quartz vein developed at the contact of a muscovite granite and a serpentinized peridotite. The contact zone of this granitic intrusion has been changed into a fine-grained, compact, greenish white, massive rock, consisting principally of the calcium garnet grossularite, along with quartz and vesuvianite.

The width of the vein rarely exceeds 1 foot, but varies greatly when followed along the strike. The vein strikes north 18 degrees west magnetic, and dips northeast 58 degrees, the granite aplite intrusion forming the south and foot-wall of the vein.

The vein was mined for a distance of 50 feet along the strike, but the molybdenite was insufficient to be of economic importance.

Frontenac County

The Dostie-Doyon molybdenite property in Gayhurst tp., Frontenac county, has been described in some detail by Ingham (1942a).

Molybdenite deposits, the mining rights of which at present are owned by Patrick Dostie and Thomas Doyon of Thetford Mines, are located in Frontenac county, Quebec. The property is comprised of lots 16 to 23 of Range IX, Gayhurst township. It may be readily reached by motor road or by train. The molybdenite-bearing veins are exposed along the southeastern slope of the northern part of Mount St. Sebastien at an elevation of about 2,500 feet. Large timber is plentiful, but water is scarce.

Development work on the prospect consists of 12 small pits and trenches, a few stripped areas, and an adit driven for 20 feet into the side of the mountain. Most of them are in lot 18, with a few openings and one larger pit in lots 22 and 23. One car-load of ore (40 tons?) has been shipped to the mill of the Quyon Molybdenite Co., Ltd., Quyon, Quebec.

The molybdenite occurs in quartz veins, the majority of which occupy fractures in altered slate. Except for a few outcrops of granite which occur at the southwest end of the map-area the region is underlain entirely by slate or hornfels. The granite represents the northeastern extremity of a small batholith which extends for 6 miles to the southwest. The slate is believed to be a part of the St. Francis series which is regarded as of Ordovician age, and the granite is probably a Devonian intrusive. Structurally the area is a series of close anticlinal and synclinal folds the axes of which trend at 40° east of north.

Vein quartz is exposed intermittently in a zone along a distance of about 2,000 feet in lots 17, 18 and 19. In addition to this several veins occur in lots 22 and 23 in an area measuring about 300 to 400 feet. The molybdenite is found in the quartz as finely divided specks, as thin seams coating fracture planes, and as larger scattered pockets of coarse flakes. Most of the mineralized zones consist of a system of veinlets varying in width from 2 inches up to 2 feet and forming a stockwork from 10 to 15 feet wide made up of about two fifths quartz and three fifths slate. As a rule the molybdenite is concentrated along the outer edge of the veins across 2 or 3 inches on each side, and the central portion of the wider veins is not well mineralized. Enrichment occurs where the veinlets meet, and chalcopyrite and pyrite are commonly found in close association with the molybdenite.

In the lot 18 zone of veins an estimated 10,000 tons of ore are indicated, the grade of which, when the barren inter-vein slate is included, as would be necessary during mining, probably would not average over 0.20 % MoS_2.

A conservative estimate of ore in the pit No. 11 zone, on lot 23 is about 5,000 tons but it is quite possible that 5 or 10 times this amount could be indicated by 'proving up' the lateral and depth extension of the vein system. Here the quartz itself carries about 0.50 % MoS_2, but dilution by the slate between the veinlets would lower this value by more than half. Several hundred tons of 0.53% ore are calculated to be obtainable from the pit No. 9 vein, which is one foot wide. Although in most cases it would be necessary to extract as much barren slate as molybdenite-bearing quartz across the mineralized zone, the two could be readily separated by hand cobbing so that the grade of milled ore might be maintained at about 0.50 % MoS_2.

Gaspé-Nord County

Molybdenite has been reported as an accessory mineral in the Holland township deposits of Gaspé Copper Mines Limited. About 70 million tons of 1- to 2-per-cent-copper ore have been proved, and milling commenced in 1955. The ore mineral is chalcopyrite; secondary copper carbonate and silicate are present, as well as pyrite.

Megantic County

At the Caribou chromite mine in Coleraine township, molybdenite is said to occur disseminated in garnetiferous aplite (Poitevin and Graham, 1918, p. 14).

Also in Coleraine township, Eardley-Wilmot (1925, p. 159) reported molybdenite occurring "with asbestos in serpentine" at "Thetford". No details are given.

At Harvey Hill, range IV, lot 17, Leeds tp., semi-amorphous molybdenite is reported to occur in copper-bearing slates Eardley-Wilmot, 1925, p. 159).

CORDILLERAN REGION

Molybdenite-bearing deposits are very numerous in the Cordilleran region of Canada. The greater number, by far, lie within British Columbia. In all, about two hundred occurrences have been reported to date, but a great many of these must be regarded as only of mineralogical interest.

At the time of writing, no molybdenite was being produced from deposits within the Cordilleran province, but active exploration was proceeding on at least five. In the past, the mineral has been produced only in very small quantities, wholly from deposits situated in British Columbia.

In 1954 the British Columbia Department of Mines published the following figures for molybdenite production within the province:

Mine	Period	Production (Pounds MoS_2)	Other metals
Golconda, Osoyoos	1918–30	1,771	Au, Ag, Cu
Index, Lillooet	1916	2,448	none
Molly, Lost Creek, Nelson	1914–17	25,058	none
Tidewater, Skeena	1916	13,022	none
Victoria, Omineca	1926–40	1,600	Au, As, Co
		43,899	

The total value of this production is given as $36,698.

In addition to the properties listed above, another fourteen were actively explored during the period 1937-53 but did not reach the producing stage. At two of these, in addition to molybdenum, tungsten is present as a potentially valuable metal; and in a third deposit, in addition to molybdenum, there is silver, lead and zinc.

The writer visited fifteen molybdenite deposits in British Columbia in the latter half of the 1958 field season. In addition to the first-hand information gained from these visits, the following account incorporates much information from publications of the Geological Survey of Canada and the Annual Reports of the British Columbia Minister of Mines. In particular, liberal use has been made of the excellent report by Stevenson (1940) which is now out of print.

Yukon Territory

Molybdenite occurrences reported to date in the Yukon Territory are mainly of mineralogical interest.

The *Mount Filton occurrence* in the northern Richardson Mountains was reported briefly by Gabrielse (1957, p. 10). Molybdenite occurs with wolframite, pyrite, and arsenopyrite in an area of low-grade metamorphic rocks, probably underlain by granite.

At *Steele (Wolf) Creek* in northwest Shakwak Valley, molybdenite was observed in highly silicified and pyritized biotite granite, and in blocks of quartz monzonite in a moraine (Bostock, 1952, pp. 28, 42).

Quartz veins carrying galena and in places, molybdenite, occur on *Boswell River* in the Teslin district (Bostock, 1936, p. 12; Lees, 1936, p. 24).

The bornite-chalcopyrite ores of the *Whitehorse copper belt* carry small amounts of molybdenite, together with magnetite and some free gold. The host rock is a contact-metamorphic (skarn) gangue of calcite, garnet, augite, epidote, tremolite, and actinolite (McConnell, 1909, pp. 42-43, 46-49; Cockfield, 1928, p. 17).

British Columbia

Northwestern Cassiar District

Molybdenite has been reported from time to time in a few deposits and mineralized areas in the Coast Mountains, between the Yukon border and the Iskut River.

The *Adams occurrence,* on a tributary of the Klehini River in the Rainy Hollow district, is reported to carry molybdenite and galena in a body of pyrrhotite (Eardley-Wilmot, 1925, p. 49).

The *White Pass Tunnel* prospect is reported by Wells (1903, p. 114) to carry "considerable molybdenite with gold values."

Near *Pavey Station* on the Yukon and White Pass Railway, between Bennett and Tutshi Lakes, molybdenite occurs in quartz veins with free gold (Gwillim, 1920, p. 125).

T. L. Walker (1911, p. 52) examined specimens of "scaly molybdenite" reputed to have come from some of the claims of the *Engineer group,* on the west arm of Tagish Lake in the Atlin district.

In the *Iskut River area* two occurrences of molybdenite have been reported. On Johnny Mountain the mineral occurs in areas of disseminated sulphides with arsenopyrite, pyrrhotite, chalcopyrite, galena, sphalerite, and tetrahedrite (Kerr, 1930, p. 59). The same author (1948, p. 49) described quartz veins carrying pyrite, chalcopyrite, and molybdenite, that cut a small altered mass of orthoclase porphyry along the south side of Bronson Creek.

Stewart - Bear River Area

The mining area at the head of Portland Canal, according to figures given by Hanson (1929, p. 18), produced about $200,000 in gold, silver, lead, zinc and copper in the years 1909 to 1926. In addition "several hundred pounds of molybdenite" was extracted, though this does not appear in the production figures given by the British Columbia Minister of Mines (*see* p. 227).

Molly B Claim

(Hanson, 1935, p. 132)

> The Molly B claim is on the east side of Bear River 1 mile from Stewart..... The deposit is a silicified zone up to 10 feet wide, contains pyrite, pyrrhotite and molybdenite, and lies in sheared volcanic rocks near the contact with the Coast Range batholith.

Stevenson (1940, p. 91) also mentioned a claim "near Stewart", owned by a Mr. John Haahti, but gave no details.

Anyox - Alice Arm Area

Several small, and one notable, molybdenite prospects occur in this area. Hanson (1935, pp. 37-38) summarizes information regarding two of these deposits in the Alice Arm area as follows:

> ... Both are closely associated in places with small bodies of granite regarded as being part of the Coast Range intrusives. On the property developed by Tidewater Molybdenum Mines Limited, the molybdenite occurs in pegmatitic quartz veins that appear to be offshoots from a small stock of granite. The granite locally contains patches of disseminated molybdenite. The rocks intruded by the granite and in which the veins occur are hard, argillaceous quartzites. The second deposit is not well exposed but the molybdenite appears to be disseminated through dykes and a small body of granite intrusive into the sedimentary rocks.
>
> On the property of Tidewater Molybdenum Mines, as well shown on the surface and in underground workings, the molybdenite occurs in thin, flaky seams distributed throughout the quartz veins. The veins strike towards the body of granite mentioned and on reaching the granite cease, apparently, as a result of merging with the granite. This evidence and also the fact that locally the granite contains disseminated molybdenite suggests strongly that the veins and the molybdenite were derived from the body of granite during its consolidation. Dolmage examined the veins in 1922 and states that approaching the intrusive body they change gradually from quartz veins to aplite dykes ...

Black Bear Group

(*Hanson, 1935, p. 88*)

The Black Bear group is 3 miles from Anyox . . . A quartz vein about 12 feet wide containing a little molybdenite has been traced for 500 feet . . . .

Caribou Group

(*Stevenson, 1940, p. 91*)

On Lime Creek on the south shore of Alice Arm, molybdenite occurs in a stockwork of interlacing quartz stringers in granite.

Other references: Gwillim (1920, p. 124), B.C. Min. Mines, Ann. Rept. 1930, p. 86.

Mammoth Mine

(*Eardley-Wilmot, 1925, p. 51; Stevenson, 1940, p. 91*)

On Observatory Inlet, fine-grained molybdenite occurs in quartz veins.

Mohawk Group

This group is situated on the north side of Roundy Creek, which flows into Alice Arm on its east side about 2 miles from its head. The property is reached by a trail from Silver City. A vein carrying molybdenite is "reported to occur" on this property (B.C. Min. Mines, Ann. Rept. 1930, p. A86).

Tidewater Molybdenum Property

This property is by far the most significant one in the area. It has been inspected and reported on by several authorities since the early years of this century, chiefly McConnell (1913, p. 93), Dolmage (1923, p. 30-A), Eardley-Wilmot (1925, pp. 44-46), and Stevenson (1940, pp. 61-67). Accounts of the property were also given by the British Columbia Minister of Mines (Ann. Repts. 1916, p. 66; 1930, pp. A83-86). The following is mainly from Stevenson's report.

The property is on the north side, and at the head of the Alice Arm Inlet, about 4 miles from the town of Alice Arm. The camp and the main workings are at about 1,000 feet elevation and about 1 mile from the beach.

The area is reached by coastal steamer to Alice Arm and thence by launch to the property, camp and workings. A good pack horse trail extends from the beach.

The deposits consist of numerous disconnected lenses of quartz mineralized with varying amounts of molybdenite.

The rocks in the area include sediments and some greenish andesitic rocks of the lower Hazelton group of Mesozoic age, intruded by granitic rocks of the Coast Range batholith. The main eastern contact of the batholith lies 1 mile to the west of the property.

The sedimentary rocks consist of interbedded slates, argillites, argillaceous sandstones, sandstone and quartzite and possibly some beds of water-lain tuff. The rocks have a general northeasterly to easterly trend and although folded with varying degrees of intensity, they have a comparatively steep southward dip. These rocks are intruded by numerous hard and fine-grained greenish andesitic dykes of pre-batholith age.

All the above rocks are intruded by spurs and dykes related to the batholith. In the vicinity of the showings, these spurs consist of bodies of aplite and rhyolite, some granite dykes and numerous lamprophyre dykes which strike in a general northeasterly direction and dip steeply westwards. These rocks and their structural relations are especially well-exposed along the beach and in the creek-canyon.

Aplite and rhyolite occur to the north and west of the molybdenite-bearing quartz veins and appear to limit the continuity of the veins. On the surface, the veins strike northeasterly towards a body of pink aplite which trends easterly. As the aplite is approached the feldspar content of the veins increases and the veins merge with the aplite. In the underground workings an appreciable feldspar content is evident in places in the veins in their most northerly exposures.

A body of rhyolitic rock converges towards the veins from the west and disrupts their continuity .... Locally the aplite at the northern end of the showings contains patches and streaks of disseminated molybdenite. The evidence suggests that the veins and the molybdenite mineralization originated from the batholith at a late stage in its consolidation. The veins could be classified as pegmatitic quartz veins.

Shearing is prevalent along lines striking between north and northeasterly and dipping steeply westward, generally following the contacts of the dykes with the sedimentary rocks. Locally, the shearing cuts the veins and the lamprophyre dykes. Some faulting has occurred, but no appreciable displacement of the formation or the veins is evident. Lamprophyre dykes cut the veins, and interrupt their continuity so that projection of the veins along their strike and dip is difficult.

The veins ... comprise quartz stringers, veins and lenses, ranging from a fraction of an inch to several feet wide, mineralized with fine-grained molybdenite. The molybdenite is erratically distributed within the veins as thin ribbons and to a small extent as disseminated material within the vein quartz. As the quartz generally breaks along the ribbon-banding, freshly broken vein-matter can give a most deceiving appearance of solid molybdenite mineralization, whereas this mineral occurs only as a thin coating on the walls of the fractured quartz. Locally, a mere shadowy banding of the quartz is the only evidence of mineralization, and, when such material is broken, finely divided molybdenite is visible under a magnifying glass. The only sulphide accompanying the molybdenite ... is a small amount of pyrite. The molybdenite mineralization is confined to the quartz veins and does not penetrate the wall-rocks.

As the veins approach and merge with the aplite to the north, the tendency to disperse increases, the stringers become smaller and tighter, the pyrite content increases and galena, sphalerite, augen pyrite and some chalcopyrite begin to occur. In the aplite, some shearing similar in strike to that of the quartz veins is locally well-mineralized with galena, sphalerite, arsenopyrite, some chalcopyrite and tetrahedrite ... The aplite, into which the molybdenite-bearing quartz veins appear to merge, locally contains some streaks or patches of molybdenite.

The quartz veins, stringers and lenses strike in a general northeasterly direction and dip steeply northwestward. Local variations in strike and dip are frequent. The vein walls commonly vary in dip. These features tend to produce variations in width within short distances and great irregularity in horizontal and vertical continuity. Additional descriptions of continuity are caused by lamprophyre dykes cutting the veins. These dykes constitute a large proportion of the rock in the locality of the veins and frequently form both walls or completely enclose the quartz masses. Where the veins enter large areas of argillaceous rocks, they tend to form small stringers and to disperse ...

Horizontal continuity of the veins is also disrupted as they approach aplite and rhyolite areas, the main masses of which lie to the west and north. Small tongues of these rocks, however, also project into the central section of the showings. The intrusion of these tongues is probably responsible for some of the blind, or isolated, masses of quartz occurring in the workings.

On the surface, the quartz becomes more glassy and the occurrence of feldspar more frequent as the veins approach the rhyolite and aplite. Underground, the same characteristics prevail to the north along (both the) adits, with a marked decrease in the molybdenite content of the quartz veins, especially evident in (the lower one). In this section of the workings, quartzites become more abundant and are very common in the most northerly exposures of both adits. The evidence indicates the close approach of the most northerly underground workings of both ... adits to intrusive rocks and the consequent disruption of the veins in this direction at this general elevation.

A summary of the geological sequence of events is construed to have been as follows:

1. Deposition of sedimentary rocks
2. Intrusion of green dykes
3. Intrusion of granitic rocks
4. Fracturing
5. Formation of quartz
6. Crushing and formation of ribbon-structure within the veins
7. Deposition of molybdenite
8. Intrusion of lamprophyre dykes
9. Late shearing

Stevenson gave a brief history of the Tidewater property and an account of a detailed sampling program that he carried out in 1939.

> The best grade molybdenite mineralization noted on the property occurs in the old stope off No. 2 adit (upper). In this working, sampling indicates a grade of 2.65 per cent molybdenite for a length of 12 feet, and a width of 4.1 feet, but the tonnage of this material is small and limited.
>
> In No. 1 adit, the best grade indicated is 1.05 per cent molybdenite for a length of 78 feet and a width of 3.9 feet.

In conclusion, Stevenson remarks:

> The mode of occurrence, type of deposit and geological structure relative to the mineral occurrence, indicates the probable limitation of continuity of the mineralization to the north by mergence with intrusive aplite, and to the south by stringering of the quartz in the sedimentary rocks. In depth, approach to intrusive rock is also indicated and although good widths of quartz occur, there is definite indication of diminution in grade.

Terrace - Cedarvale District

The belt of country on both sides of the Skeena River between Terrace and Cedarvale, a distance of some 38 miles, contains a great variety of mineral deposits, and more than two hundred groups of mining claims have been staked. The metals in these deposits, in order of importance, are gold, silver, copper, lead, zinc, arsenic, tungsten, and molybdenum. According to Kindle (1937a, 1937b) the mineral deposits are in quartz veins that occur along faults, or in shear zones in the volcanic and sedimentary rocks of the Hazelton group, or in batholithic intrusions near these rocks.

Molybdenite deposits, associated with deposits of scheelite, occur on Thornhill Mountain about 6 miles southeast of Terrace; the molybdenite here occurs in a pegmatitic phase of granodiorite. On Molybdenum Creek, about 3 miles north of Usk, molybdenite occurs together with pyrite, in quartz veins in the granodiorite.

According to Kindle:

> The ore deposits are believed to have been derived from a common source, the Coast Range batholith. There is a gradual change in the type of deposit found in a direction at right angles to the main contact zone between the Hazelton group and the batholitic rocks. High-temperature minerals such as scheelite and molybdenite were deposited close to their point of origin in the igneous rocks. Gold-pyrite deposits came next in a slightly cooler zone, followed by the copper and arsenic zone minerals, and finally the silver, lead and zinc minerals were deposited in the zone of lowest temperature. The high-temperature minerals were deposited in the Coast Range batholith and the low-temperature minerals with few exceptions are as much as 15 miles from its edge. The gradation from gold through copper to silver-lead-zinc deposits shows no change

in relation to individual intrusive stocks. It is probable that the metals rose from a source directly below them and that the horizontal gradation from high- to low-temperature metals is due to the increasing depth from southwest to northeast of the source rock, the Coast Range batholith.

Bradle Bane Group

(Kindle, 1937b, p. 36)

The Bradle Bane group of eight claims . . . are about one mile east of Skeena River and 5 miles northeast of Usk. A fair pack-horse trail turns off from Skeena River a mile below the mouth of St. Croix Creek and leads to the Bradle Bane camp at 2,600 feet elevation.

The claims are underlain by very fine-grained, grey tuffs which strike east and dip 50 degrees south. Intrusive rocks, if present, are hidden by an abundant drift cover.

At elevation 2,850 feet the tuffs are cut by a fault that strikes south up the steep mountain slope in the bed of a small stream. A subsidiary fault which branches northwest encloses with the main fault a brecciated and altered zone of pinkish white tuff mineralized along minute fractures with fine veinlets of pyrite with a little galena and molybdenite . . . .

. . . . A typical sample of the mineralized tuff . . . . assayed: gold, none; silver, 0.46 ounce a ton; lead 0.72 per cent; molybdenum 0.11 per cent.

B. X. Group

(Stevenson, 1940, p. 93; Lay, 1928, p. C146)

This group is situated on Kleanza Creek, 6 miles from its mouth and 8 miles from Usk. Molybdenite occurs in a 4-foot quartz vein in greenstone.

Eureka Claim

(as described by Kindle, 1937a, p. 33; see also Kerr, 1936, pp. 23-24)

Molybdenite occurs on the Eureka claim, about 2 miles south of the Forest Lookout station, at an altitude of 4,800 feet on Thornhill Mountain. The owner, J. A. Michaud, has cut a rock trench 6 feet wide, 6 feet deep, and 25 feet long on the best showing and has removed some high-grade ore. The actual outcrop over which molybdenite may be seen to occur is less than 50 feet in diameter, but the granite is spotted with small rusty patches over an oval area of about 100 feet by 200 feet. The molybdenite occurs in rosette-shaped forms from 1 to 2 inches in diameter, the crystal groups commonly being in clusters. The molybdenite is associated with small, irregular, pegmatite dykes which are intrusive into a fine-grained, grey granite. In the trench the ore occurs in irregular-shaped pockets connected by very small, pegmatitic stringers. The pockets are outlined with a rust-coloured stain resulting from the oxidation of the pyrite that accompanies the molybdenite, and they contain abundant sericite and pseudomorphs of chlorite after hornblende. In places the molybdenite rosettes are coated by the straw-yellow oxidation product, molybdite.

Fifteen feet east of the rock trench, a 2-foot pegmatite lens striking north 60 degrees east and dipping 30 degrees to the southeast may be traced for 40 feet. Its surface exposures show very little molybdenite.

Kitsumgallum Lake

Gwillim, (1920, p. 125) reported an occurrence of molybdenite in reddish quartz about 5 miles north of Kitsumgallum Lake, some 22 miles northwest of Usk.

Morningstar Property

This property is 2 miles northeast of Woodcock, a station on the Canadian National railway, 6 miles northeast of Cedarvale. Veins carrying galena, sphalerite, pyrite, arsenopyrite, chalcopyrite, and molybdenite occur near the contact between the Hazelton sediments and intruding batholithic rocks (Kerr, 1936, pp. 53-54).

Nicholson Creek Mining Corporation

The mining claims are situated north of Usk, between Nicholson and Lowrie Creeks. In the mid-thirties, the Company did considerable work, including underground exploration, mainly on a prospect 3 miles from Skeena River on the south side of Nicholson Creek, at elevations of between 1,500 and 2,200 feet.

The main vein outcrops on Molybdenum and Calhoun Creeks, which are tributary to Nicholson Creek. A crosscut adit driven for 1,400 feet beneath these outcrops failed to intersect any ore-bearing veins.

Kindle's (1937a, p. 55) description follows:

> At the junction of Calhoun creek with Molybdenum creek a 2-foot quartz vein outcrops on the east bank of the latter stream. The vein strikes south 10 degrees east and dips from 50 to 60 degrees east. It occurs along a fault in granodiorite, is 250 feet long, and has an average width of about 15 inches. At its north end, the vein stops abruptly against a fault that strikes north 35 degrees east along the bed of Molybdenum creek. The quartz is well mineralized with coarse pyrite and is criss-crossed by narrow seams of fine, granular molybdenite. The granodiorite wall-rock is altered for 1 or 2 feet on either side of the vein. A 24-inch channel sample taken from a fresh surface across the vein a few feet from the creek assayed: gold, a trace; silver, a trace; molybdenum, 0.48 per cent. What may be the continuation of this vein outcrops on the west side of Molybdenum creek about 50 feet above the forks. A 24-inch quartz vein with from 1 to 2 feet of altered granite on both sides of it is exposed for about 15 feet in the steep banks of the ravine. Its upward continuation is drift covered. The vein strikes south 40 degrees east, dips 70 degrees northeast, and is mineralized with pyrite and molybdenite.
>
> Sixty feet below the forks of Calhoun and Molybdenum creeks, a 3-foot quartz vein mineralized with coarse pyrite cubes and seams of molybdenite outcrops on the steep east slope of the stream valley. This vein is exposed for less than 100 feet. Fifty feet above Molybdenum creek the vein narrows to 6 inches in width and 25 feet higher up it pinches out altogether. The fault line along which the vein occurs extends farther to the southeast up the steep side of the ravine, but contains no vein quartz. At the creek the westerly extension of the vein is cut off sharply by the fault in the bottom of the stream bed.
>
> A fourth vein is exposed in the bed of Calhoun creek, 300 feet above the forks. It strikes south 20 degrees east and dips 70 degrees northeast. At a waterfall about 10 feet high the vein has a width of 22 inches of quartz and contains considerable pyrite and molybdenite. Sixty feet northwest of the falls the vein pinches out and only the fault slip along which the vein occurs is seen. On the south side of the stream, about 100 feet higher than the waterfall, the vein is 10 inches wide where it is exposed near the top of a steep bluff. Beyond this point it is hidden by a heavy drift cover. About 300 feet farther upstream the granodiorite gives place to numerous roof pendants of andesitic rocks. A 22-inch channel sample taken across the vein at the 10-foot waterfall assayed: gold, a trace; silver, 0.26 ounce to the ton.

Phoenix Group

According to Kindle (1937b, p. 10) some work was carried out by the Nicholson Creek Mining Corporation on the Phoenix group, situated on Hardscrabble Creek. There, some molybdenite occurs in quartz veins, associated with pyrite.

Hazelton - Smithers Area

Mineral deposits carrying molybdenite occur chiefly in Rocher Déboulé and Hudson Bay Mountains. At present no molybdenite is being produced, but one mine produced a little as a by-product during the working of a gold-arsenic-cobalt ore.

The mineral deposits of this area have been described fairly recently by Kindle, who summarizes the general geology as follows (1954, p. 8):

> A thick series of Mesozoic sedimentary and volcanic rocks known as the Hazelton group form the bulk of the mountains and uplands in the Hazelton and Smithers areas. These rocks are invaded by numerous granodiorite stocks that may be related to the batholithic rocks of the Coast Mountains that lie some 25 to 35 miles westerly. Small areas of Upper Cretaceous or Paleocene beds occur along the Bulkley River Valley, and at Moricetown these are overlain by thin andesite and dacite flows. Lode deposits occur in both the granitic intrusions and older rocks.

In the mineral deposits of the Hazelton area, according to Kindle (1954, p. 15), the following metals have been found: gold, silver, lead, zinc, cadmium, copper, molybdenum, tungsten, antimony, bismuth, cobalt, nickel, uranium, and tin.

> The deposits occur along faults and shear-zones in volcanic and sedimentary rocks of the Hazelton group and in intrusive diorite and granodiorite stocks or in related dyke rocks. The veins are equally distributed in the rocks of these types but in the volcanic and sedimentary rocks they commonly occur near intrusions.

Kindle classed the vein deposits of the area into five principal types, the last two of which carry molybdenite as well as other minerals.

> (4) Gold-cobalt-uranium Veins. Hornblende veins on the Victoria property contain arsenopyrite, molybdenite, cobalt-nickel minerals, sulpharsenides, a little uraninite and appreciable gold. . . .
>
> (5) Tungsten Veins. A quartz vein-lode containing scheelite is mined for its tungsten content at the Red Rose Mine. Scheelite-bearing veins on the Blue Lake and Black Prince properties are very similar but they also contain some molybdenite.

Kindle considered (p. 18) that there is . . . .

> . . . . a direct genetic relationship between the mineral deposits and the granodiorite stocks within or near which the deposits occur . . . . The mineral-laden solutions probably rose from deep within the stocks along . . . . fissures and, as cooling progressed, the mineral content of the super-saturated solutions was precipitated to form the vein deposits.
>
> Fifty known vein deposits on Hudson Bay Mountains contain one or more of the following metals: gold, silver, lead, zinc, copper, bismuth, and molybdenum.
>
> The veins are largely confined to the volcanic flows of the Hazelton group . . . .

Of the six principal types of deposits recognized by Kindle (pp. 19-20), one contains molybdenite, namely:

> (6) Molybdenite veinlets in a trap dyke; an occurrence is below the ice-front on the south side of Glacier Gulch.

Hazelton Area

Black Prince Property

(Kindle, 1954, pp. 30-32)

The Black Prince property is on Rocher Déboulé Mountain 6 miles south of New Hazelton. A branch road 1 mile in length leaves the highway about 6 miles southeast of New Hazelton and extends southwest to the foot of the mountain, from where a pack-horse trail 5 miles long follows up the north side of Mudflat Creek Valley to the prospect. The cabin is on a flat bench at an elevation of 4,150 feet between two small cirque-lakes, and the workings lie a short distance to the south on a steep shoulder of the mountain.

A shear zone containing tungsten and molybdenum minerals occurs in the granodiorite about 1,500 feet southwest of the contact of the Rocher Déboulé granodiorite stock with sedimentary rocks of the Hazelton group. The shear zone strikes north 30 degrees west and dips from 50 to 70 degrees southwest. It ranges in width from 1 foot to 8 feet and contains from one to four parallel quartz veins from 2 to 18 inches wide. The quartz veins and the sheared and altered granodiorite are mineralized with various amounts of scheelite, pyrite, chalcopyrite, molybdenite, wolframite and ferberite.

At an elevation of 4,900 feet an adit has been driven for 35 feet along the sheared zone. A 12-inch sample collected by Kindle across the vein at the face of the adit assayed: WO_3, 0.38 per cent; Mo, 0.14 per cent; and Au, 0.02 ounce per ton. In a 12-foot-long open-cut at an elevation of 5,000 feet, a sugary, leached quartz vein, 12 to 18 inches wide, contains a little molybdenite, chalcopyrite, pyrite, scheelite, and ferberite. A 12-inch channel sample across the vein at the south end of the cut gave the following values: WO_3, 0.38 per cent; Mo, 0.11 per cent; and Au, 0.005 ounce per ton.

Some 500 feet farther south, two parallel quartz veins, about 6 feet apart, occur along the shear zone. They both contain scheelite, some pyrite, and a little molybdenite. A 14-inch channel sample taken by Kindle across the wider of the two veins gave: WO_3, 0.34 per cent; Mo, 0.21 per cent; and Au, 0.035 ounce per ton.

Blue Lake Group

(Kindle, 1954, pp. 32-34)

The Blue Lake group of ten claims is on the east slope of Rocher Déboulé Mountain, about 7 miles south of New Hazelton station. Access to the property is by way of the Black Prince camp (see above).

Two veins about 100 feet apart are exposed in steep granodiorite bluffs about a mile southwest of the Black Prince workings at the head of Mudflat Creek. The more westerly of these (No. 2 vein) strikes between N15 and N35°W and dips about 70°SW. Along the steep face of the bluff this vein is from 1 foot to 3 feet wide and consists largely of sheared granodiorite and vein quartz that carries small amounts of molybdenite. In a trench at the top of the bluff the vein is 5 feet wide and carries a little scheelite, molybdenite, and chalcopyrite. Farther south again the vein is well exposed for about 100 feet and ranges in width from 6 to 14 inches. It is composed largely of quartz carrying from 0.25 to 2.0 per cent scheelite, roughly equal amounts of molybdenite, and a little chalcopyrite.

A "typical specimen" collected by Kindle from the vein near the south end of this 100-foot exposure assayed 0.85 per cent Mo, 1.00 per cent WO_3, and trace Au. "A radioactive test disclosed a U_3O_8 equivalent of 0.004 per cent."

No. 3 vein lies about 2,000 feet northwest of No. 2. Where exposed in a trench, this vein consists of about 1 foot of vein quartz and 1 foot of sheared granodiorite. The quartz is honeycombed and carries an abundance of scheelite, and a little molybdenite and chalcopyrite. A typical hand specimen collected by Kindle from the vein quartz near the hanging-wall assayed 0.08 oz/ton Au, 11.31 per cent WO_3, and 0.06 per cent Mo.

Small pockets of dark-coloured altered hornblende and chlorite occur in this vein, and in some places a little scheelite is associated with these dark minerals. A little ferberite may be present. A hand specimen of this dark material assayed: tungsten trioxide, 0.41 per cent; molybdenum, 0.21 per cent; manganese, none; iron 19.48 per cent. A radioactive test of the specimen gave only 0.002 per cent U_3O_8 equivalent.

Rocher Déboulé Mine

(Kindle, 1954, pp. 57-63)

The Rocher Déboulé mine is on Rocher Déboulé Mountain near the head of Juniper Creek about 8 miles northeast of Skeena Crossing station.

The property was originally staked in 1911 and was worked intermittently up to about 1930.

From April 1915 until October 1918, the mine produced 39,833 tons of ore containing 4,214 ounces of gold, 62,865 ounces of silver and 5,746,306 pounds of copper . . .

In 1929 Aurimont Mines Limited took an option on the property and shipped 72 tons of hand-sorted ore, which assayed: gold 0.14 ounce a ton; silver, 40 ounces a ton; and copper 4 per cent.

The property was acquired by Western Tungsten Copper Mines in 1950, and the work of reopening the mine commenced.

The claims are on the west contact of the granodiorite stock that forms the core of Rocher Déboulé Mountain. The contact of this intrusion with sandstone, argillite and tuffaceous sediments of the Hazelton group runs northerly across the west boundary of the property. The granodiorite is traversed by four well-defined veins that are intersected by the mine workings through a vertical range of 1,250 feet.

The veins are fissure fillings that formed along strong fissured or fault zones. The gangue is predominantly quartz, hornblende, actinolite and altered granodiorite . . . Other gangue minerals include calcite, siderite, chlorite, titanite, tourmaline and rutile. Chalcopyrite is the most widely distributed ore mineral in the mine . . . In addition to chalcopyrite, the copper ore contains variable amounts of magnetite, pyrrhotite, pyrite, scheelite, cobaltite, arsenopyrite, molybdenite, tetrahedrite, smaltite-chloanthite, glaucodot, some complex cobalt-nickel sulpharsenides, and a little uraninite. This association of minerals suggests high temperature conditions of deposition; and the presence of scheelite and cobaltite in increasing amounts westerly along No. 2 vein, as the contact of the granodiorite and sedimentary rocks is approached, indicates zoning, and is accompanied by a decrease in the amount of hornblende gangue and an increase in the proportion of vein quartz.

Banded milky quartz veins containing small amounts of galena, sphalerite, tetrahedrite, pyrite, and chalcopyrite traverse the chalcopyrite-hornblende ore, or lie along the hanging-or foot-wall sides of the main veins in some places . . . These veins were formed following renewed movement along the vein fissure, and the lack in them of hornblende, pyrrhotite and molybdenite suggests that the temperature of deposition of these second-generation veins was much lower than that of the first.

A sample taken by Kindle across 36 inches of No. 2 vein, 20 feet west of the crosscut, assayed 0.23 per cent Mo, in addition to 1.20 per cent Cu, 2.02 per cent Pb, 2.36 per cent Zn and 0.02 ounce gold per ton.

Victoria Group

(Kindle, 1954, pp. 84-89)

The Victoria group includes the Victoria, Belle, View Fraction, Mammoth, Red Cross, Monoplane and Bowl Fraction claims. These were once under the same ownership as the nearby Hazelton View group and are described in most earlier reports under Hazelton View group, but are now owned by Western Tungsten Copper Mines Limited . . . The property is on the northwest slope of Rocher Déboulé Mountain about 5 miles south of South Hazelton Station. A pack-horse trail leads from Comeau's Ranch at the foot of the mountain to the mine camp at elevation 4,100 feet. The workings are on a steep rocky mountainside between an elevation of 5,500 feet and the crest of the mountain at 6,120 feet.

The claims were acquired by New Hazelton Gold Cobalt Mines, Limited, in 1916 and were developed continuously until 1919. Two adits were driven and a tramline constructed from the workings to the camp. During 1918, a carload of ore was shipped to the Ore Testing Laboratories, Mines Branch, Ottawa. The car contained 53,288 pounds dry weight of ore, which carried: gold, 1.24 ounces a ton; molybdenite (MoS_2) 1.40 per cent; molybdite (MoO_3) 0.18 per cent; cobalt 1.12 per cent; nickel, 0.60 per cent; and arsenic 8.98 per cent. Further work was done in 1925, and the following year 22 tons of ore were shipped, which assayed: gold, 4.65 ounces per ton; arsenic 42.3 per cent; and cobalt, 4.6 per cent. The property was operated by Aurimont Gold Mines, Limited, during 1928, and an additional 23 tons of the gold-cobalt-arsenic ore were shipped.

The property was acquired by Western Uranium Cobalt Mines Limited (now called Western Tungsten Copper Mines Limited) in 1949, and further development work was done both in 1949 and 1950 to evaluate the gold, cobalt and uranium resources of the property.

No. 1 vein. Most of the surface and underground exploratory work has been done on a fissured zone in the grey, coarsely crystalline granodiorite boss that forms the core of Rocher Déboulé Mountain. The fissured zone and ore shoots that occur along it are known as the No. 1 vein. It strikes east and dips from 40 to 65 degrees north. On the west side the vein extends nearly to the metamorphosed sedimentary rocks of the Hazelton group, but has not been traced into them . . . The fissured zone has been traced by open-cuts and adits for more than 1,500 feet up a steep slope between elevations of 5,168 and 6,025 feet and for several hundred feet farther east along the mountain top overlooking Juniper Creek. It ranges from 1 inch to several feet in width, and consists in large part of sheared, altered and brecciated granodiorite. Ore shoots occur where the wall-rocks are replaced and where the fissures are filled with veins of quartz, feldspar, hornblende and metallic minerals. The ore minerals include arsenopyrite, cobaltite, cobalt bloom, cobalt-nickel sulpharsenides, molybdenite, chalcopyrite, sphalerite, uraninite and gold. Most of the gold occurs as small grains scattered through the arsenopyrite and cobalt-nickel sulpharsenide minerals. The arsenopyrite and cobalt-nickel sulpharsenides generally occur as short streaks or veinlets of solid sulpharsenides from ½ inch to several inches wide and from 1 foot to 10 feet or more long. They also occur disseminated as fine crystals or as aggregates of crystals in the hornblende, feldspar and quartz gangue. The molybdenite occurs in thin films and as small nodules, and the uraninite as small black octahedral crystals that range from microscopic size to ⅛ inch diameter.

The No. 1 vein has been explored by five adits and an open-cut 30 feet long, 3 feet wide and 10 feet deep on the crest of the ridge at elevation 6,121 feet.

A hand specimen of cobalt-nickel sulpharsenides and hornblende vein gangue from the open-cut, collected by Kindle, assayed: gold, 7.88 ounces per ton; cobalt, 5.9 per cent; uranium-oxide equivalent, 0.75 per cent; nickel, 2.8 per cent, and molybdenum, 0.81 per cent. Kindle also reported that a specimen collected by Stevenson in 1949, from a continuation of No. 1 vein 325 feet east of the open-cut, assayed: gold, 5.66 ounces per ton; silver, 2.9 ounces per ton; cobalt, 2.4 per cent; molybdenum, 0.9 per cent; and nickel, 4 per cent.

Smithers Area

Hardy Prospect (American Metal Climax Inc.)

The presence of molybdenite in volcanic rocks of the Hazelton group in the upper part of Glacier Gulch on Hudson Bay Mountain has been known for some time. Kindle (1954, p. 102) mentioned the occurrence of molybdenite in a 'trap dyke' on the south side of the gulch a short distance below the ice-front. More recently, retreat of the glacier has exposed an extensive area of low-grade molybdenite-bearing rock extending across the steep valley at elevations between 4,000 and 5,000 feet.

The writer visited the occurrence in July 1958, when American Metal Climax, Inc. were carrying out a program of mapping, pitting, and sampling. The writer is grateful to officials of the company for facilities extended during the visit, and to W. W. Moorhouse, consulting geologist, for discussing the geological problems.

The occurrence lies some 5 miles northwest of Smithers, in the upper part of a steep glacial valley known as Glacier Gulch, on the eastern slopes of Hudson Bay Mountain. It is reached from Smithers by way of a road that follows Glacier Gulch up to an elevation of about 2,600 feet. From the end of this road a trail leads up the south side of the valley to the tent campsite at an elevation of about 4,900 feet. The camp buildings and equipment were flown in by helicopter. Food and other supplies are brought in by pack-horse.

The valley is narrow, U-shaped and steep-walled, and prospecting is hindered by the precipitous nature of the terrain. The main area of interest at the time of the visit lay immediately in front of, and below, the glacier, on a steeply sloping part of the valley floor about 2,000 feet long (measured across the valley), and 1,000 feet wide.

The difference in elevation across the area is about 1,000 feet. A grid of sample points had been laid out across the area, and sampling of these in late 1957 revealed areas of molybdenite mineralization ranging from 0.10 to 0.30 per cent average MoS_2 content. The 1958 program consisted in part of blasting and bulk-sampling pits along the grid system.

Molybdenite has also been found at the foot of the great 'step' in the valley, at an elevation of about 3,000 feet, and also in outcrops on the north side of the Lake Kathlyn glacier about 3,000 feet west of the present campsite. Mineralization was, therefore, widespread, but information is not yet sufficient to say if it is continuous or not, between the three areas.

The rocks in which the molybdenite occurs are part of the thick series of Mesozoic sedimentary and volcanic rocks (Hazelton group) which form the bulk of the mountains and uplands in Smithers area. A preliminary map of the area by Armstrong (1944) shows the distribution of these rocks.

On the Hardy prospect the rocks are exclusively of volcanic origin. Mainly fragmental types—volcanic breccias, agglomerates, and tuffs—occupy roughly the southern two thirds of the outcrop, below the glacier. To the north of these, the rocks are mainly light-coloured felsitic and rhyolitic types. In the zone between, bands and less-regular bodies of dark basaltic and diabasic rock occur.

Contacts are difficult to detect and even more difficult to decipher, and the actual relationships of the different types have not yet been worked out.

Banding in the rocks shows a strike of about N70 to 80°E with a steep dip to the north. The more basic bands and bodies also conform roughly to this direction. The steep-to-vertical rock walls surrounding the glacier to the west of the camp area appear to be mainly fragmental volcanic rocks with some bands of flows, probably andesites (W. W. Moorhouse, verbal communication).

Dykes of quartz-feldspar porphyry occur cutting the volcanic rocks in places, especially around the walls of the glacial cirque. The volcanic rocks are well-jointed and fractured. The most prominent set of joints—and the only one with any regularity—strikes between N70°E and N70°W and dips flatly to the south. The joints show a regular spacing of about 1 foot to 3 feet and give a 'stepped' effect to the steep exposures below the ice-front. Other joints are mainly vertical or steeply dipping but show little regularity in strike.

Small amounts of sulphide are widespread in the volcanic rocks of the Hazelton group below and around the Lake Kathlyn glacier. They are generally confined to the many joints and fractures cutting the rocks and little is disseminated away from these openings. The most abundant sulphides are molybdenite and pyrite, with chalcopyrite, pyrrhotite, and sphalerite present in lesser amounts. Molybdenite occurs as follows:

(a) *In veins and veinlets of sugary quartz occupying joints and fractures in the volcanic rocks.* These veins vary in thickness between a few mm and perhaps 2 inches; an average thickness appears to be between ¼ and ½ inch. The molybdenite is medium grained and shows a marked tendency to occur at intervals along both sides of the veins. In places the sulphide is abundant enough to fill nearly the whole vein, leaving only a thin rib of quartz down the centre. Other quartz veinlets show molybdenite as irregular 'splashes' up to 5 mm across. Pyrite occurs occasionally in these quartz veins with the molybdenite, but most commonly the latter is the only sulphide present. Other minerals occurring in places are carbonate, green hornblende and dark green chlorite—the latter in radiating, rosette-like forms about 1 mm in diameter. Moorhouse informed the writer that powellite had been found in one specimen from the area. Most of the samples so far assayed show a small but constant content of tungsten but the mineral carrying it has not yet been determined. The molybdenite along the walls of the veins and veinlets commonly shows a weak slickensiding, indicating slight post-ore movements. The veins show all attitudes and there are no preferred directions. Most however, dip steeply; and few, if any, occupy the prominent flat-lying joints.

(b) *As very thin coatings of fine-grained molybdenite on joint faces, without other accompanying minerals.* Many of these coatings are the merest 'films' on the rock surfaces. The above remarks regarding the attitudes of the vein-filled joints also apply to this type.

(c) *In distinct carbonate veins that may be shear-zone fillings or replacements.* Several of these veins cross the prospected area below the glacier, striking at about N40 to 50°W and dipping at about 45°SW. The main veins can be traced for several hundred feet—one for at least 1,000 feet. The distribution of molybdenite in these veins is erratic and patchy. In places they also carry pyrite and some sphalerite. The carbonate, which can commonly be seen cementing brecciated country rock, as well as in distinct veins, is iron-bearing, weathering to a buff or brown colour.

In addition to the above-mentioned veins and joint fillings, chalcopyrite and sometimes sphalerite are common along the flat-lying joints, as thin, vuggy veinlets or coatings nowhere more than about ¼ inch wide. Pyrrhotite occurs as a cementing medium in a breccia in the southeastern part of the area, according to Moorhouse.

The sulphide minerals on the Hardy prospect are widespread and the tonnage of mineralized rock is large. The 1958 sampling program was designed to determine the average grade of rock, with a view to large-scale mining. The visual inspection of the property indicated that the grade will be low but that, with the tonnages present and the low-cost mining methods that could be used, it may be possible to mine the material profitably.

According to Kindle (1954, p. 19) there are fifty known vein deposits on Hudson Bay Mountain, containing one or more of the following metals: gold, silver, lead, zinc, copper, and bismuth. The veins are largely confined to the flows and tuffs of the Hazelton group, but in places they extend into the overlying sedimentary rocks. There are a few veins in stocks of granodiorite. Most of the larger veins and vein lodes occupy fault fissures and sheeted, brecciated, or sheared zones. They range in width from a few inches to 10 feet and are remarkably persistent—the largest have been traced for 3,500 feet through a vertical depth of 900 feet (Kindle, 1954, p. 20). In this respect, the molybdenite-bearing deposit on the Hardy prospect is exceptional, as there are no distinct veins or lodes but rather a multitude of minor veins and veinlets occurring at random in the jointed and fractured volcanic rocks.

According to Kindle the molybdenite occurrences illustrate the highest-temperature type of deposit on the mountain, and deposits of successively-lower-temperature types occur outwards from the core of the massif. According to Kindle, this zoning is a prominent feature; he considered all the mineral deposits to be "genetically related to the granitic stock that is known to form the core of the mountain." The only deep-seated igneous rocks outcropping around the Lake Kathlyn glacier are the dykes of quartz-feldspar porphyry already mentioned, but the extensive ice of the glacier may conceal a larger body of such rock.

Fort St. James Area

Several small occurrences and one larger deposit have been reported from Fort St. James map-area (J. E. Armstrong, 1949). Most are concentrated in the southern part of the area and are represented by the Stella and adjacent properties southwest of Endako, and a deposit south of Ling Lake, northwest of Burns Lake. All these deposits occur in the Topley granite, which is probably post-Middle Permian, pre-Jurassic in age. The molybdenite occurs mainly in quartz veins or in pegmatites.

According to Kerr (1936, p. 164) the molybdenite-bearing quartz veins at the Stella property were clearly derived from the granite in which they occur, and were formed during a late stage in the cooling, in a manner similar to pegmatites. Armstrong supports this view. One or two scattered molybdenite deposits farther north in the map-area also seem to show a definite spatial relationship to the Topley granite bodies. An exception is the deposit near Chuchi Lake where scheelite, powellite, molybdenite, and chalcopyrite occur in a fracture zone at the contact between a granite stock, probably belonging to the Omineca intrusions, and an andesite of the Takla group. The Stella property appears to be the most significant molybdenite deposit so far discovered in the area.

Stella Mine

This property lies some 5 miles south of Endako—a divisional point on the Canadian National railway about 110 miles west of Prince George. The claims were first staked by C. H. Foote of Fraser Lake in 1927, following the finding of a large float-boulder during a hunting trip. The geology and mineral deposits on the Stella property have been described by several authorities, chiefly J. E. Armstrong (1937, pp. 27-28; 1949, pp. 192-193), Kerr (1936, pp. 163-165), and Stevenson (1940, pp. 13-16).

The writer visited the property in July 1938 with C. W. Foote, son of the original staker. Mr. Foote's cooperation and assistance is gratefully acknowledged.

The property was reached from Endako by a rough motor road which leaves the main Endako - Prince George highway at a point about ¾ mile east of Endako station. Three miles southwards along this road, a logging road branches off to the west, and this can be followed by trucks or 'jeep'-type vehicles for about 3½ miles, to the well-wooded northern slopes of a prominent ridge. From there a trail leads southwestward to the workings about a mile away. The trail is not obvious now and would be difficult to follow by a person not familiar with it.

The main workings are on top and on the southern slopes of an east-trending ridge, at an elevation of about 3,450 feet. They consist of an inclined shaft, an adit, and several surface trenches and open-cuts. Of the latter, two across the ridge-top have been excavated by bulldozer since the most recent previous report on the property was published.

The area in the vicinity of the Stella property is almost entirely covered by a mantle of glacial drift and soil. The only exposures are in trenches etc., excavated after the discovery of the large molybdenite-bearing quartz boulder in the drift.

J. E. Armstrong's (1949) map shows that the area is entirely underlain by Topley granite, the age of which is tentatively set as being post-Middle Permian and pre-Upper Jurassic. This granite is pink and ranges from very coarse and pegmatitic to very fine grained. Normally it is coarse grained and may be either porphyritic or non-porphyritic. The minerals present are pink and white feldspar, quartz, biotite, and hornblende. Armstrong (1949, p. 93) gave the following mode for a specimen of Topley granite from the Stella property: quartz, 40.3 per cent; orthoclase and microcline, 46.9 per cent; oligoclase, 4.6 per cent; biotite, 6.5 per cent; accessories, 1.3 per cent.

The molybdenite-bearing deposits consist of a series of discontinuous quartz veins and silicified zones following fractures or joints in the granite. The veins range in width from an inch or so up to perhaps 2 feet, and in length from a few feet up to perhaps 10 feet; lack of exposures prevents more accurate measurements.

The veins strike between N70 and 80°W, and most are flat or dip at 50 to 60°S. Vertical veins may be observed rarely. Nearly all the veins seen on the property show a similar character. They consist of fine-grained, white, sugary quartz in which very fine grained molybdenite occurs in a 'ribbon structure'. This is caused by closely alternating bands or films of molybdenite and quartz parallel with the walls of the veins. In a few places the 'ribbon structure' is absent and the molybdenite occurs in the quartz in regular aggregates, some with a grain size of about ½ to 1 mm. Yellow molybdic ochre is a prominent weathering product on most of the exposed veins and on the spoil heaps. No other minerals were observed by the writer, though Armstrong (1949, p. 192) reported that "pyrite and hematite occur very sparsely in the deposit."

The widest molybdenite-bearing vein seen was that on which the incline shaft has been sunk. This shaft is on the top of the above-mentioned ridge at an altitude of about 3,500 feet. It was sunk, according to Stevenson's report, in a direction S15°E for 24 feet on a slope angle of 53 degrees. At the time of the writer's visit it was largely caved and the only solid outcrop visible was on the west side of the collar where there is a 2-foot quartz vein striking east and dipping at 55°S. The quartz carries much fine-grained molybdenite in the typical banded structure. According to Stevenson—who was able to examine the vein down to 17 feet below the collar of the shaft—it ranges in width from 32 to 24 inches on the west wall of the shaft and from 2 to 4 inches in width on the east wall. Stevenson sampled the vein across 32 inches on the west wall at a point 5 feet below the collar; this sample assayed 1.6 per cent MoS_2.

Above the hanging-wall of the vein the granite country rock is partly silicified and mineralized for about 2 feet. A 2-foot sample taken by Stevenson across this zone assayed 0.7 per cent MoS_2.

Also on top of the ridge are two north-trending trenches—one on either side of the shaft—which were excavated by bulldozers in 1952. The more westerly of these lies about 50 feet to the west of the shaft. It is about 15 feet wide, about 150 feet long, and has been excavated through overburden up to

6 feet deep. It exposes at intervals coarse-grained granite and some quartz-porphyritic aplite. At a point in the northern part of the trench, along the strike of the vein in the shaft, is exposed a 1-foot quartz vein with considerable molybdenite. The vein appears to be dipping vertically.

The second of the bulldozed trenches lies about 200 feet to the east of the shaft. This trench is of about the same dimensions as that to the west and reveals mainly scattered outcrops of granite beneath about 10 feet of overburden. Near its southern end is a molybdenite-bearing quartz vein less than a foot wide.

On the southern slope of the ridge, below the incline shaft, an adit has been driven into the hillside in a northerly direction. This adit is now completely caved and no solid exposures can be seen. In the spoil heap beneath it, are blocks of coarse-grained granite with occasional thin quartz veinlets carrying fine-grained molybdenite. According to Stevenson, the adit was driven for 35 feet in pink granite that, at the face, was cut by numerous closely spaced fractures striking east and dipping 65°S. At a point 5 feet back from the face the rock was irregularly fractured and carried a little molybdenite.

Along the hillside to the west of the adit, and along a small valley between the main ridge and a smaller one to the south, is a series of shallow trenches and pits which have uncovered several molybdenite-bearing quartz veins of various widths.

At a point about 50 feet west of the adit, and some distance above it, is a trench revealing a 1-inch veinlet of molybdenite-bearing quartz, striking N80°E and dipping 55°S, apparently parallel with a joint direction in the granite.

Another 50 feet to the west, and at the same elevation as the granite, a more or less circular pit in very shallow overburden reveals outcrops of badly broken and fractured granite with irregular masses and zones of fine-grained quartz. These zones do not appear to be regular fracture-fillings but rather to be due to replacement and silicification of the granite. They all carry notable molybdenite.

About 200 feet still farther to the west, another series of shallow excavations in the floor of the above-mentioned valley shows a series of almost horizontal quartz veins in the granite. They are each about a foot thick and contain much fine-grained molybdenite showing the typical ribbon structure. A random chip sample over one of these veins assayed 1.80 per cent MoS_2. No Bi was present. Also in this area, trenches expose a silicified zone at least 6 feet wide carrying fine-grained molybdenite.

Across the valley, on its steep north-facing slope, is a small open-cut whose face reveals a sheeted silicified zone up to 2 or 3 feet thick with plentiful molybdenite. The zone strikes N75°E and dips 55°S. Most of the molybdenite is of the typical fine-grained type, but some of the richer parts show a grain size up to $\frac{1}{2}$ mm.

To judge from available exposures, this area—at the foot of the southern slope of the main ridge and in the valley between this and the smaller ridge to the south—is where most of the molybdenite-bearing veins on the Stella property are concentrated. The fact that there are veins present with dips that are both flat and steeply inclined seems to suggest that the granite in this area may be intersected by a 'stock-work' of molybdenite-bearing quartz. So far, exploration has been confined almost entirely to surface trenching and, so far as is known, no diamond-drilling has taken place. Thus very little is known about the behaviour of the quartz veins in depth or for any distance along strike.

The high molybdenite content of the veins so far seen suggests that if any appreciable concentration of them can be found in the area the overall grade might be sufficient to enable the ground to be mined by large-scale methods. Future exploration should perhaps be directed towards solving this problem by diamond-drilling. A great drawback to diamond-drilling and subsequent milling on the site is the scarcity of water. The nearest permanent surface water is about 1½ miles to the east of the property. But perhaps in the spring sufficient water could be obtained from low-lying ground to the south to enable a drilling program to be completed.

Other Properties

Savory Prospect (Armstrong, 1949, p. 193)

A little work has been done 3½ miles southwest of Savory on occurrences similar to those on the Stella group, but much less extensive.

Ling Lake Prospect (Armstrong, 1949, p. 193)

A. Ostrem has uncovered a pegmatite vein carrying flakes of molybdenite, 3 miles south of Ling Lake. The vein, which has an 8-inch centre of quartz and 2-inch borders of orthoclase, cuts coarse-grained, pink Topley granite.

Chuchi Showing (Armstrong, 1949, p. 193)

The Chuchi tungsten showing lies 9 miles south of the east end of Chuchi Lake, at the contact of a small granitic stock with andesite of the Takla group. The deposit consists of scheelite, powellite, molybdenite and chalcopyrite, disseminated throughout a fracture zone at least 12 feet wide in silicified andesite at the granitic contact. Two grab samples assayed 0.075 per cent WO_3; 0.015 per cent MoS_2; a trace of gold and 0.70 ounce silver per ton.

Radio Gold Mines (Kerr, 1936, pp. 158-161; Armstrong 1937, pp. 22-23; 1949, pp. 135, 182)

This property lies on the south shore of Babine Lake, about 26 miles by road from Burns Lake. Work commenced in 1934 resulted in much surface trenching and in two shafts being sunk. Armstrong (1949, p. 182) gave the following description:

The mineral showings occur at the contact of metamorphosed Cache Creek rocks (gneisses, schists, and banded foliated sediments) and a body of Topley diorite, which is intimately intruded by granodiorite. The contacts are indefinite and irregular, and throughout the area the Cache Creek rocks are cut by dykes and larger bodies of diorite, which in turn are cut by offshoots from the granodiorite body lying to the south.

Several types of showings are represented on the property. In the west, are irregular lenses of glassy quartz, up to 30 feet thick and 100 to 200 feet long, carrying a little pyrite, chalcopyrite, and molybdenite. Adjoining these quartz lenses are areas of rocks composed mainly of epidote, and up to 50 feet in diameter, which carry disseminated pyrite, magnetite, and glassy quartz, and a little intermixed chlorite, hornblende, pyrite, magnetite, specularite, and chalcopyrite. Elsewhere the metallic minerals are more scattered through the rocks.

South of the above showings a shaft is sunk on a quartz vein, which occurs in a hornblende-rich phase of the diorite. The shaft was flooded and could not be examined, but specimens on the dump showed diorite containing disseminations of bronze-coloured pyrite, epidote, magnetite, and quartz, and vein matter carrying minor amounts of pyrite, chalcopyrite, and molybdenite.

Shass (Grizzly) Mountain (Gray, 1938, p. 11)

An occurrence of molybdenite and pyrite in granitic pegmatite is situated on the southern slopes of Shass Mountain, north of the Sutherland River and some 25 miles due north of Fraser Lake.

Cariboo Area

Boss Mountain Property (American Metal Climax Inc.)

The Boss Mountain property lies on the east side of Takomkane (Big Timothy, or Boss) Mountain, about 50 miles east of Williams Lake. Access at the time of the writer's visit was afforded by float plane from Williams Lake to a small lake (Buster Lake) to the north of Takomkane Mountain. From Buster Lake a newly cut pack-trail led to the campsite at an elevation of about 5,500 feet. At the time of writing the property was being actively explored by American Metal Climax Inc.; two diamond-drills were in operation during the summer of 1958. The writer is grateful to officials of the company for their cooperation, especially P. A. Peach and D. Campbell, in local charge of the operation, for their hospitality and willing discussion.

The showings are on both sides of a small creek flowing easterly into Molybdenite Creek (*see* Fig. 20, in pocket). The south side of the valley rises steeply from the bank of the creek and is covered by drift and a dense growth of timber. The workings on this side of the creek extend from an elevation of 5,500 feet near the bank to an elevation of 6,000 feet. The north side of the valley slopes gently back for about ¼ mile before it begins to steepen. In this area, trenching, and more recently diamond-drilling, have been carried out on a breccia zone; it is this zone that holds the most promise of workable tonnages of ore.

History

The property was first located in 1917. In the next year, about 1,000 pounds of selected ore was taken from vein deposits on the south slopes of the valley and shipped to the Mines Branch, Ottawa (Eardley-Wilmot, 1925, p. 32). The property was acquired in 1918 by The Consolidated Mining and Smelting Company of Canada Limited, who sold it for taxes in 1955. The present claims were recorded in 1956 by H. H. Huestis and associates of Vancouver. Later they were optioned by the Climax Molybdenum Company, prior to their amalgamation with American Metals, Inc., early in 1958. Exploration was begun by the Climax company in 1956 and was continued by American Metal Climax Inc., during the summer of 1958.

Previous Publications

The geology of the Boss Mountain molybdenite deposit and the surrounding area has been described in several reports. The chief ones are by Reinecke (1919, 1920), Stevenson (1940, pp. 34-47), and Sutherland-Brown (1958, pp. 18-21). The present writer has drawn on this information to supplement field observations.

General Geology

Sutherland-Brown gave a detailed account of the geology of the area surrounding the deposits; his main points are summarized below.

The Takomkane Mountain area is underlain mainly by plutonic rocks of Mesozoic age. On the top of the mountain itself are basaltic lavas and fragmental volcanic rocks, probably of Pleistocene age. The oldest rocks are from the southwestern part of the mountain and consist chiefly of monzonite and syenodiorite. These rocks have the appearance of fine-grained diorites, but are very heterogeneous in grain size and rock type. They appear to be of hybrid origin. Intruding the hybrid rocks are uniform, medium-grained, hornblende-rich quartz diorites. The contacts may be gradational over a few hundred feet, but more commonly over a few tens of feet; they may also be sharply intrusive.

These plutonic rocks form part of a large, little-known, batholithic body having a diameter of about 30 miles, with its nearest contact some 7 to 8 miles east of the property (P.A. Peach, verbal communication). Sutherland-Brown mapped and described a foliation in these plutonic rocks, forming an arc from N20°E in the north and east to N50°E in the south and west. This foliation could not be distinguished by either the writer or Peach.

The rocks are markedly jointed; the chief joint directions are N65°E, dipping 65°SE; N45°W, dipping vertically; and N30°W, dipping 40°SW.

Quartz porphyry and lamprophyre dykes up to 1 foot or 2 feet wide, in places cut the plutonic rocks. The lack of outcrops probably masks their time frequency. Where their strike can be determined, it is nearly parallel with the ore-bearing breccia zones.

Takomkane Mountain is an upraised plateau-like massif formed of the batholithic rocks, with steep scarp-like slopes to the northeast and much gentler slopes elsewhere. The highest parts, in the northwest of the massif and including the twin peaks themselves—7,057 and 7,069 feet high—are composed of volcanic rocks, mainly fragmental types but also including some lavas. The fragmental rocks are made up of vesicular bombs and cinders of olivine basalt up to 1 foot or 2 feet in diameter. Lava flows occur in places, especially along the cliffs on the north side of the mountain. There they are made up of dark basalt with crowds of large and small, rounded and subrounded inclusions of olivine rock (dunite). These inclusions are highly fractured and commonly altered, but occasionally small fragments of gem-quality peridot can be seen in them.

Sutherland-Brown believed that the volcanic rocks were erupted into an ice-filled cirque on the top of the mountain. The writer saw little evidence of this, as the pre-volcanic top of the mountain is an almost-plane surface onto which the volcanics have been erupted. The writer agrees with Sutherland-Brown that the cone is very recent in origin; the almost-unconsolidated material forming it would have been eroded completely away if it were not very young, geologically.

P. A. Peach, from ground observations and aerial-photo interpretation, has delineated a system of faults across the area, some of which can be traced for a mile or two, a few for even longer distances. The faults show two main trends: (1) striking N40°W, sensibly parallel with the ore-bearing breccia zones; and (2) striking approximately N70°E. One or two other linear features are present that do not fit into these main trends. Little is known of any displacements on these structures as few have actually been investigated on the surface. Molybdenite Creek seems to follow one of the N70°E faults, though little evidence of it can be seen on the ground. Some of the faults are probably post-mineralization in age.

Mineral Deposits

The mineralized rock consists of two main types, only one of which appears to be of commercial interest.

On the southern slopes of the valley, extending for some 2,000 feet in a southeasterly direction from a point opposite the campsite, is a zone of quartz veins carrying molybdenite. This seems to be of little economic interest. To the north and west of this zone of veins, at least three parallel zones of mineralized breccia have been delineated and at least one of these gives promise of economic quantities.

During 1957, diamond-drilling on the principal zone (*see* Fig. 20, zone A) outlined approximately 1.2 million tons averaging 0.76 per cent MoS_2 over a strike length of about 700 feet and a width of about 100 feet, down to a maximum depth of 450 feet. The drilling during 1958 was designed to extend this zone along the strike and also to investigate two parallel zones (B and C) which were found to the west of the zone A. All the zones—both those of breccia and those of quartz veins—strike at about N35°W.

The quartz-vein zone consists of a series of *en échelon* quartz veins and lenses, some of which carry spectacular quantities of molybdenite. The zone has been explored by cross-trenching at intervals along its strike and by diamond-drilling. The results were economically disappointing. The trenches expose veins of massive quartz up to 2 or 3 feet wide in a coarse-grained diorite. Molybdenite occurs along both walls of the veins in bladed aggregates up to $\frac{1}{4}$-$\frac{1}{2}$ inch in diameter. The blades stand at right angles to the vein walls, intersecting each other in a triangular pattern. The quartz away from these wall zones is mostly barren. Many of the veins carry large isolated fragments of country rock set in the quartz, and comb-like molybdenite occurs in places as a border around these fragments.

Another type of quartz vein was noticed in trenches at an altitude of about 5,900 feet. There a 2-foot-wide quartz vein was exposed for about 20 feet along strike. Fine-grained molybdenite is irregularly disseminated in the massive quartz, commonly in a ribbon-like form along the centre of the vein. The vein carried no breccia fragments.

The bladed type of molybdenite along the vein walls and around fragments of country rock would seem to have crystallized earlier than the quartz, which is 'moulded' around the blades. This suggests that the walls and the fragments hastened the precipitation of the sulphide, probably by their cooling effect, or perhaps by some chemical action. No other minerals were observed in these veins, but slightly rusty spots in the quartz suggest the weathering of pyrite.

Stevenson (1940, pp. 41-45) described in detail the various trenches in this vein-quartz zone.

Breccia Zones

The original discovery of breccia ore was made in the banks of the creek about 800 feet downstream from the camp cabin. The showings there have been described in detail by Stevenson (1940, pp. 45-47) and in lesser detail by Sutherland-Brown (1958, p. 21). Prior to the drilling in 1957 and 1958, the outcrops were considered to represent parts of a 'breccia-pipe' in the quartz diorite. Sutherland-Brown, for instance, described this 'pipe' as forming "a lens about 100 feet wide by more than 400 feet long . . . . The orebody forms the centre of the pipe, about 20 feet wide by 360 feet long." Stevenson (1940, p. 39) considered that "the area of intense brecciation presumably forms the central part of an ore-chimney or breccia-pipe."

The past two seasons' investigations, however, have shown that the structure is in reality an elongated zone of breccia (zone A), averaging about 100 feet wide and extending for at least 1,200 feet along strike. So far the ends of the zone have not been determined. Recently two further parallel zones—zone B and zone C—have been outlined. Relatively little was known of these two zones at the time of writing. They were first recognized by Peach in very small outcrops in the creek bed and their presence was later confirmed by diamond-drilling.

Most of the information regarding the breccia type of ore has been gained from zone A, and the following remarks are mainly concerned with this zone.

Zone A—The original outcrops of mineralized breccia in the banks of the creek below the campsite have been described in some detail by both Stevenson and Sutherland-Brown. The former gave a sketch map of the outcrops, together with assays (1940, p. 38). His description of the "Creek showing" (pp. 45-46) is as follows:

> In an area approximately 20 feet in diameter on the east bank of the creek, the quartz diorite has been intensely brecciated and the fragments sealed by quartz, orthoclase and molybdenite. This mineralized breccia has been cut by post-mineral faults, the fault zones being marked by crushed rock and mineral matter; much of the molybdenite in the crush zones has altered to the canary yellow, hydrated ferric molybdate, molybdite. The quartz diorite here and to the north across the creek bed contains numerous feldspathized greenstone inclusions; these are in various stages of absorptions or feldspathization by the quartz diorite and as a result, range in colour from dark-grey to a light-grey, which is only slightly different from the general colour of the main rock mass.
>
> The molybdenite occurs mainly as rims surrounding rock fragments. Less frequently it occurs in the quartz forming the matrix for the breccia or in quartz-molybdenite veinlets cutting the rock mass. In the ground exposed, the best development of molybdenite is confined to the 20-foot area of intense brecciation .... Only small amounts of molybdenite occur to the north across the creek or in trenches that lie northwesterly and southeasterly from the Creek Showing . . . .
>
> The faults and accompanying fault-zones are post-mineral in age and as such have no casual relation to the emplacement of the molybdenite. The quartz-molybdenite solutions probably rose through the brecciated quartz diorite, the brecciated fragments inducing precipitation of the molybdenite and orthoclase as is indicated by the frequent occurrence of molybdenite and orthoclase as rims around the rock fragments.

In addition to the quartz-diorite fragments, the breccia contains rare dark inclusions of biotite or chlorite schists which may represent shattered lamprophyre dykes or altered inclusions of other rocks.

Besides the molybdenite, pyrite, magnetite, and chalcopyrite occur in minor quantities. Pyrite commonly occurs as subhedral to euhedral crystals in the quartz cementing the breccia, but also as a fine impregnation in the fragments. A random grab sample of the mineralized breccia assayed 7.28 per cent MoS_2, but no bismuth was detected.

The recent diamond-drilling has given many good sections through zone A, and the writer was able to study the core from drill-hole 10C, which is probably one of the best intersections. In this hole the breccia was entered at a depth of about 300 feet and the hanging-wall of the ore at about 325 feet. In the quartz diorite above 300 feet the core shows appreciable amounts of quartz as irregular veins and veinlets with a maximum thickness of about an inch. Fine- to medium-grained molybdenite occurs, mostly concentrated along the walls of the veins. The quartz diorite itself is normally unaltered in appearance, with fresh grey-white feldspars. A certain amount of silicification has occurred near the borders of some veins and there has been an introduction of new pinkish cream feldspar (orthoclase ?) with the quartz. This becomes apparent, though not too common at about 280 feet. Some patches of the quartz diorite are almost wholly replaced by the quartz and new feldspar—an introduction of Si and K into the rock.

Another type of alteration is especially noticeable in the quartz diorite between 288 and 293 feet. This has produced a rock consisting of grains of quartz about 1 mm in size in an indistinguishable dirty-yellow-brown matrix. The ferromagnesian minerals and original feldspar have disappeared during this alteration which may have involved the formation of epidote.

Below 290 feet the amount of vein quartz increases and is accompanied by more molybdenite and by notable amounts of pyrite as bright, shining cubes and other grains, 0.2 to 2 mm in diameter.

Above the hanging-wall of the breccia at 300 feet the main features are the quartz veins with or without molybdenite, increasing silicification and feldspathization of the quartz diorite, and increasing pyrite. Molybdenite is present occasionnally in very finely divided form with quartz in blue-grey veinlets cutting the country rock.

The true breccia appears to be marked by the appearance of angular fragments of the dark, biotitic schists, and by the originally fresh greyish feldspar of the quartz diorite becoming chalky and altered-looking. The new, introduced feldspar in the quartz veins does not appear to have been affected by this alteration, which may be kaolinization.

Within the breccia the fragments are overwhelmingly of quartz diorite; the dark, schistose fragments are less abundant and even less so are fragments of a basic, porphyritic dyke rock. Recovered from the breccia were stretches of core up to several feet long, of quartz diorite that is neither brecciated nor fractured and shows no quartz or molybdenite. The rock also appears fresh, without the chalky alteration of the feldspars. These parts represent either extra large fragments or suggest that in places the breccia is 'sheeted'.

Pyrite is notable in places in euhedral crystals 2 to 3 mm across; in one veinlet a little chalcopyrite was noticed. Molybdenite is mostly very fine to fine grained, generally as rims around the breccia fragments, but also commonly impregnated in patches of vein quartz or silicified country rock. Light brown translucent barite is present in parts, commonly in minute tabular crystals in geodes. Magnetite occurs sparingly as grains and in small veinlets.

The foot-wall of the breccia occurs at 445 feet in the hole and coincides with the foot-wall of the ore zone at this point. Below this the quartz diorite shows much the same features as it does above the hanging-wall—quartz veins with some molybdenite, fair amounts of pyrite, silicification, and the introduction of the new, pinkish cream feldspar.

From the Creek showing, zone A by 1958 had been traced by diamond-drilling for a distance of about 500 feet north of the creek and for 400 feet south of it, on an almost constant strike. The horizontal thickness varies between 50 and 100 feet. At about 200 feet north of the creek there seems to be a left-hand offset, possibly along a fault zone, for a horizontal distance of about 40 feet. About 400 feet south of the creek the breccia zone seems to swing to an almost easterly direction. The breccia has been traced by surface outcrops for another 400 feet or so to the east along this new strike.

Breccia-zone A has a generally steep dip (80-85 degrees) to the east. Its walls are not, on the whole, parallel, and especially to the south it seems to be widening in depth. This, however, may be due to the way in which the diamond-drill holes intersect the zone in the area where it swings to the easterly strike.

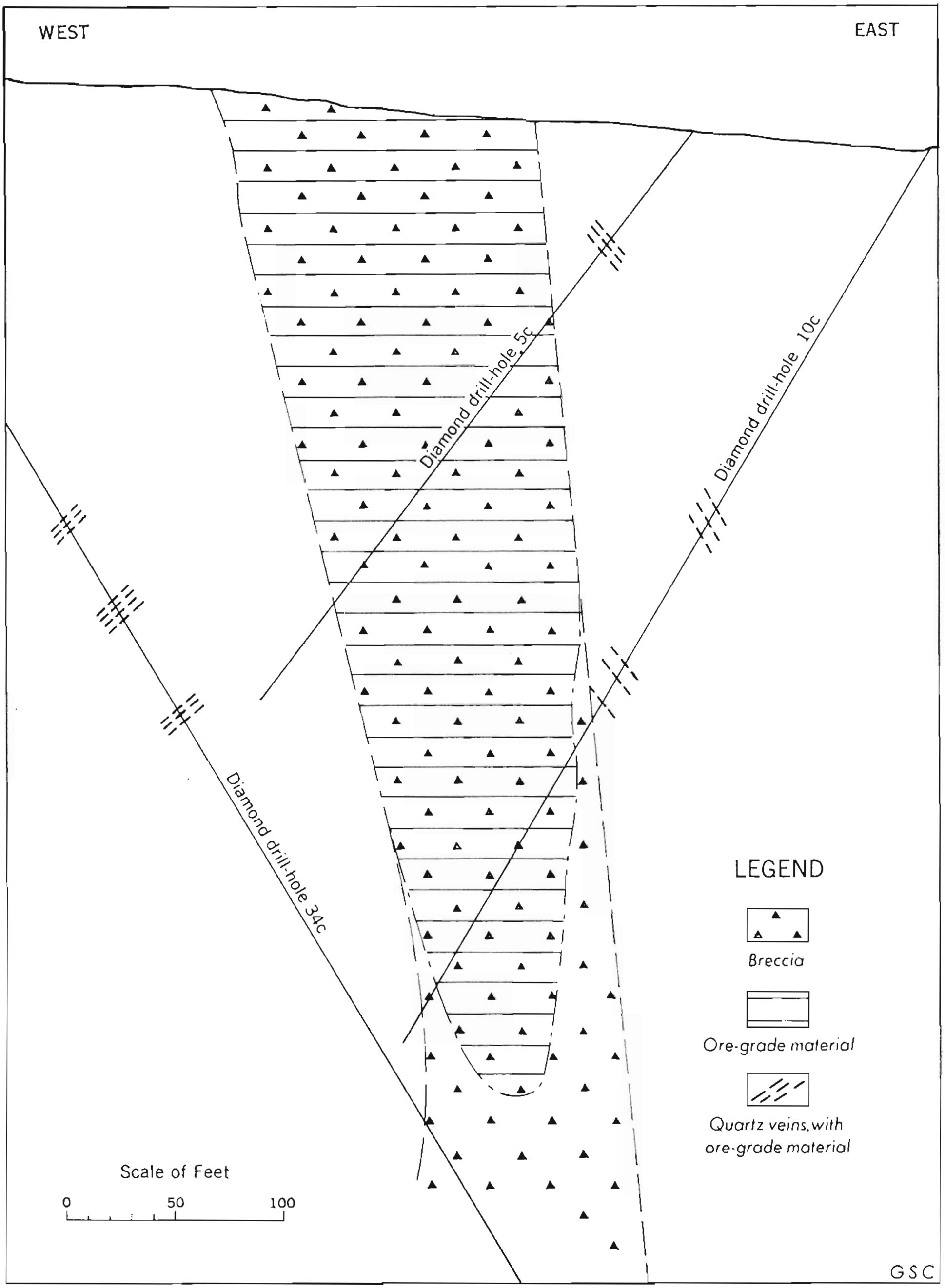

Figure 21. *Vertical section through zone A, 200 feet north of creek, Boss Mountain property, British Columbia.*

To the north, zone A was not cut in the shallower holes, but was found by the deeper (60-degree) holes drilled later. This seems to suggest that the breccia zone plunges to the north.

Ore-grade mineralized rock (+ 0.3 % MoS_2) does not everywhere occupy the full width of the breccia zone. The best section of ore so far found lies about 200 feet north of the Creek showing; it is about 120 feet wide under the overburden, gradually tapering to about 20 feet at a depth of 450 feet (*see* Fig. 21). At this depth the width of the breccia zone is about 90 feet, and it continues downwards to an undetermined depth.

Figure 22 is another section across the breccia zone at about the position of the creek exposures. This shows a lens of ore about 300 feet long down the dip and 80 feet wide at its widest point. The actual breccia zone continues downwards for some distance below the ore without diminution in width, although it may be starting to finger out in depth.

Other sections north and south of these two show that the ore-grade part of the zone may occupy either the whole width or only a central strip. It does not occupy any definite 'shoot' within the breccia zone. The vertical depth of the mineralized part of the zone decreases north and south of the positions of the two sections discussed.

Zone B lies about 400 feet southwest of zone A and so far is much less well known. It was discovered in 1958 in small outcrops in the creek bed upstream from the original 'Creek showing'. At the time of the writer's visit it had been intersected by three diamond-drill holes, but little information was available regarding these. The apparent horizontal width is of the order of 90 to 100 feet.

In the lower outcrop of zone B in the creek, the brecciated nature is not obvious, and there is little molybdenite to be seen. The fragments include a large piece of fine-grained felsitic rock (or fine-grained quartz porphyry), probably derived from a dyke in the quartz diorite.

The second outcrop, 50 feet or so upstream from the first, shows a more 'normal' breccia and one small patch containing molybdenite. The breccia fragments are all quartz diorite.

Zone C is the smallest of the three, lying some 250 feet southwest of zone B. Its apparent width is less than 50 feet. It has been intersected by one diamond-drill hole and is visible in a small outcrop on the south bank of the creek, just below the trail crossing from the campsite. Fragments in the breccia there include quartz diorite, dark micaceous schist, and some lighter dyke rocks. Molybdenite is very scarce. At the trail-crossing itself, there is a massive, barren quartz vein, 9 inches to 1 foot thick, striking N40°W and dipping 30°SW.

Between these zones the massive quartz diorite is commonly cut by thin quartz veins carrying molybdenite, which in places reach ore grade over narrow widths, nowhere of mineable size.

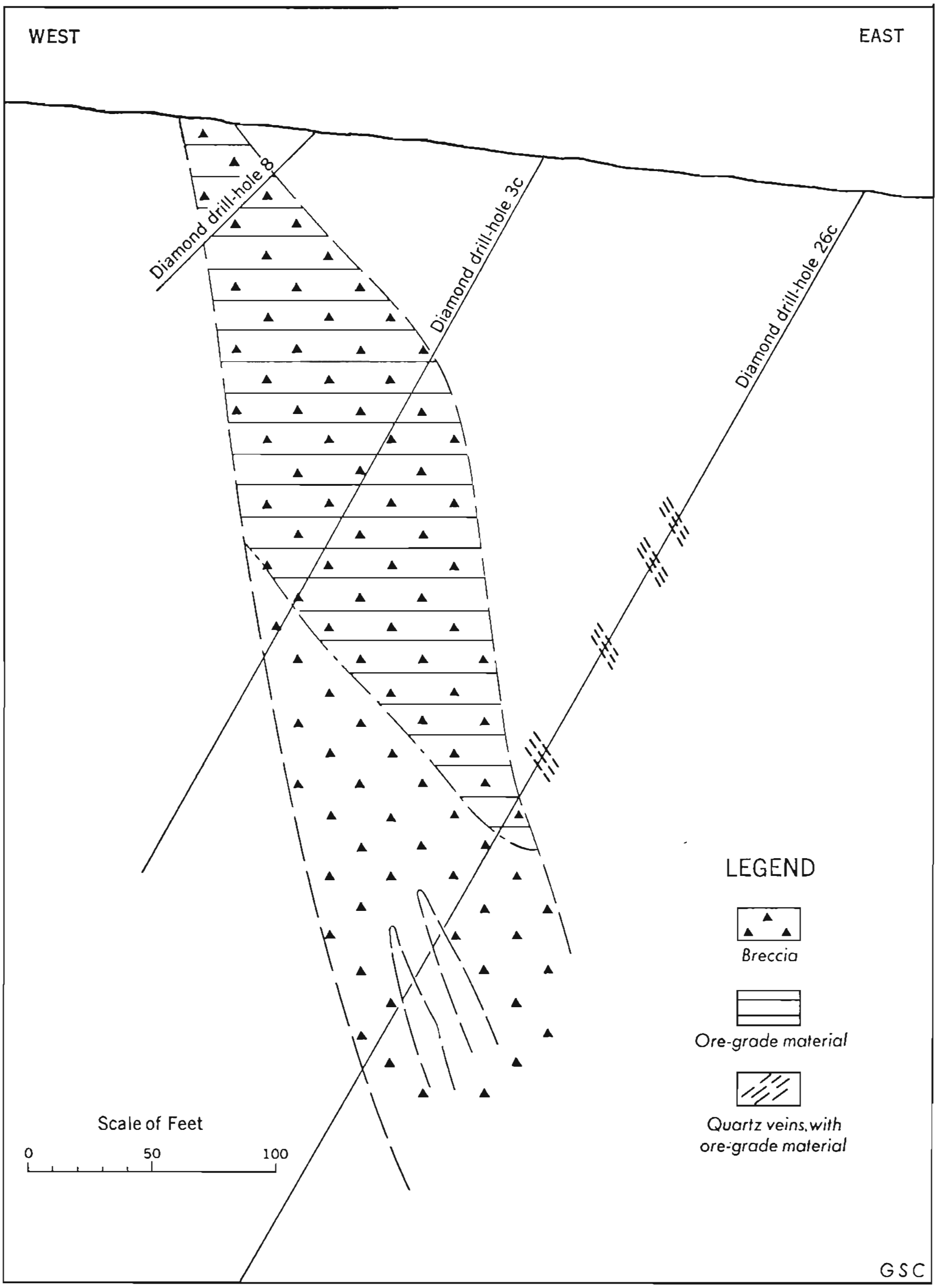

Figure 22. *Vertical section through zone A at north bank of creek, Boss Mountain property, British Columbia.*

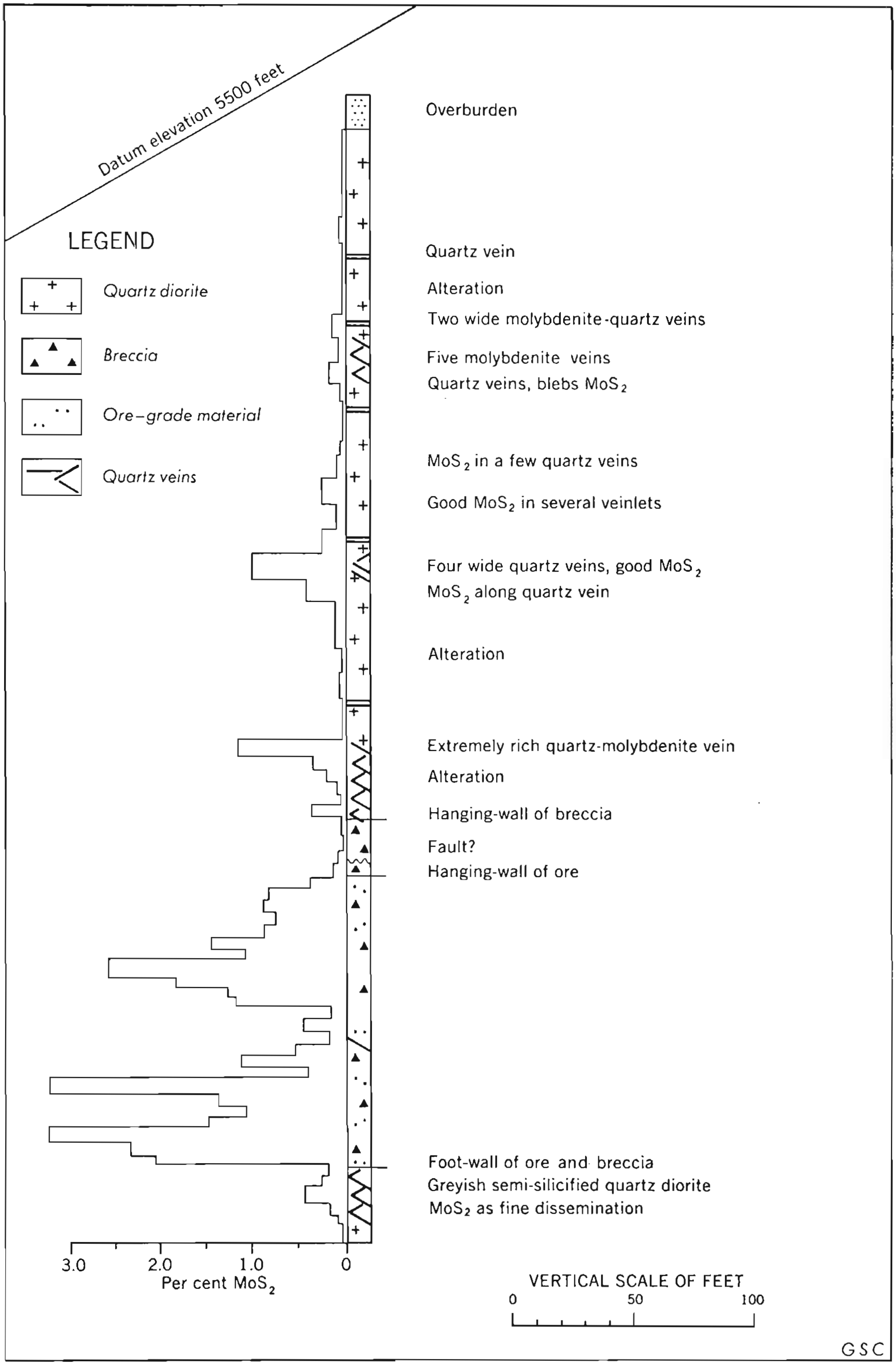

Figure 23. ***Vertical section through DDH 10c showing geology and MoS_2 content, Boss Mountain property, British Columbia.***

Grade

The samples taken by Stevenson from the original Creek showing ranged between 2.0 and 3.5 per cent MoS_2 over widths between 30 and 70 inches. Samples taken from diamond-drill cores ranged between 0.01 and 3.0 per cent MoS_2. There appears to be no regularity in the distribution of molybdenite within the ore zone. Figure 23 is a graphical representation of the variation in MoS_2 content along diamond-drill hole 10C.

For the purpose of estimating tonnages, the cut-off grade was taken as 0.3 per cent MoS_2.

Origin of the Breccia Zones

P. A. Peach (verbal communication) regarded the zones as being due to explosive activity occurring near the roof of the batholith during the later stages of its cooling history. The dark schist fragments may thus represent pieces of the roof rocks that fell back into the zones after the explosions, as no rocks of this type have been seen in situ anywhere in the area. The presence of feldspar in the quartz cementing the breccia also suggests that the filling is a form of quartz pegmatite formed late in the cooling history of the batholith.

Lower Mainland and Coastal Islands

Knight Inlet

At the *Grayson-Otto prospect* flake molybdenite occurs in narrow quartz veins (Gwillim, 1920, p. 125; Stevenson, 1940, p. 85).

Quadra Island - Cortes Island Area

The *Ottawa Central* property is on Quadra Island, ½ mile west of Bold Point. A little molybdenite occurs in limestone (B.C. Min. Mines, Ann. Rept. 1922, p. 241).

An occurrence on *Cortes Island,* east of Barrington Bay, is reported by Stevenson (1940, p. 85). Small quantities of molybdenite occur in quartz veins in granite.

Texada Island

Molybdenite occurs in small quantities in the contact-metamorphic copper ores of various properties at the north end of Texada Island. The mineral association is generally bornite, chalcopyrite, and magnetite, with minor iron sulphides and molybdenite. These minerals occur in a pyroxene-garnet gangue. (*See* T. L. Walker, 1911, pp. 50-51; Stevenson, 1945, pp. 162-174).

Powell River Area

Bentham Molybdenite Prospect

(Stevenson, 1940, pp. 47-49)

This prospect consists of the Molly Nos. 1 to 8 mineral claims staked in 1937 by T. Bentham, and owned by Bentham and associates of Powell River, B.C. The writer examined this prospect in September 1939.

The showings are on the north-west side of Haslam Lake, a small lake lying about 6 miles east of Powell Lake. Haslam Lake may be reached from the town of Powell River by following the Cranberry Lake road south-easterly for 2.6 miles and thence by a branch road to the east for 1.5 miles to a boat-landing at the south end of Haslam Lake. From here a boat may be taken for 2 miles to the camp-cabin on the north-west shore of the lake.

The showings are scattered along the hillside between elevations of 430 feet and 1,150 feet above Haslam Lake.

The mineralization consists of small amounts of molybdenite in scattered occurrences of (1) aplite or fine-grained granite dykes, (2) quartz-filled joints ranging from $\frac{1}{16}$ of an inch to $1\frac{1}{2}$ inches wide, and (3) quartz veins ranging from 4 to 18 inches wide. Assays of the samples taken ranged from: Molybdenite, nil to 0.2 per cent. The rock is quartz-diorite.

The main working is an adit 430 feet above the lake and approximately 1,600 feet westerly from the cabin. The working has been driven northerly as an open-cut 15 feet wide for 9 feet, then as an adit 10 feet high for 12 feet. This development cuts three aplite or fine-grained granite dykes in quartz-diorite. The dykes strike north 40 degrees east, dip 60 degrees north-westward and range from 4 to 18 inches wide. A small amount of molybdenite occurs as $\frac{1}{8}$ to $\frac{1}{4}$ of an inch flakes associated with pegmatitic quartz and feldspar on the footwall side of the largest aplite dyke. Two selected samples of the best material assayed: Molybdenite, nil.

At a point 520 feet above the lake and about 900 feet south-easterly along the hillside from the adit, a stripping 15 feet wide extends in a direction north 15 degrees west for 45 feet. The bottom or southern part of the cut was covered by sloughed overburden at the time of the writer's examination (September 1939). No mineralization was seen in the exposed part, but the dump showed a considerable amount of material consisting of quartz stringers from $\frac{1}{2}$ an inch to 2 inches wide that contained molybdenite and chalcopyrite. Several of these stringers are reported to occur in the lower part of the stripping.

At a point 80 feet south-westerly along the hillside from the last stripping and approximately 500 feet above the lake, a second stripping extends in a direction north 15 degrees west for 35 feet. This stripping ranged in width from 10 to 15 feet. The mineralization consists of numerous quartz veinlets occupying joints in the quartz-diorite. These veinlets generally range from $\frac{1}{16}$ of an inch to $1\frac{1}{2}$ inches in width; one 4-inch vein was seen. In the 35-foot length of stripping 65 veinlets were seen, spaced from 4 inches to 2 feet apart. They contain quartz and small amounts of molybdenite and chalcopyrite. Seven chip-samples taken over consecutive 5-foot sections along the stripping assayed from: Molybdenite, nil to 0.2 per cent.

At a point 100 feet south-westerly from the last stripping, a quartz vein has been exposed for 25 feet. This vein is vertical, strikes north 50 degrees east, ranges in width from 2 to 6 inches, and contains a small amount of molybdenite and chalcopyrite.

Thirty feet above and due west from the adit, a little open-cutting has been done on a vertical shear that strikes north 45 degrees east. The shear is 1 foot wide and consists of sheared, chloritic quartz-diorite that contains a small amount of disseminated chalcopyrite and green carbonate. It contains neither quartz nor molybdenite.

At a point northerly from and 160 feet above the adit, a small cut 2 by 5 feet with a 10-foot face, has been made on an 8-inch wide aplite dyke that strikes north 50 degrees east and dips 75 degrees north-westward. The dyke contains only a very little molybdenite.

At a point northerly from and 350 feet above the adit, a cut 10 feet long by 2 feet wide by 2 feet deep has been made on a quartz vein from 6 to 12 inches wide that strikes north 50 degrees east and dips 75 degrees north-westward. The mineralization consists of a small amount of magnetite, molybdenite and yellow molybdic ochre.

Aplite, or fine-grained granite dykes cut the quartz-diorite at various places on the hillside between the adit and a bench approximately 700 feet above. These dykes, strike north-easterly, dip steeply north-westward, range in width from 12 to 18 inches, and in places contain a small amount of molybdenite in paper-thin seams.

Other Occurrences

At a prospect on the shores of *Powell Lake,* Eardley-Wilmot (1925, p. 50) reported the presence of fine-grained molybdenite in quartz.

Jervis Inlet Area

Mount Wellington Prospect

Stevenson (1940, pp. 49-50) reported as follows:

> In 1937, the writer examined an occurrence of molybdenite on the south-easterly slopes of Mount Wellington, a mountain opposite or south-westerly from the mouth of Princess Louisa Inlet, near the head of Jervis Inlet. The occurrence is half a mile south-west from the south-west end of a lake, about 2 miles long, that is approximately 3 miles from and 2,800 feet above tidewater. The writer examined this prospect in September 1937.
>
> Access is by Union Steamship up Jervis Inlet to Gustafson's Logging Camp, where a launch may be obtained; thence by launch for 10 miles to the mouth of a small creek that flows into Queen's Reach of Jervis Inlet from the south-west, at a point opposite the mouth of Princess Louisa Inlet. From the beach, access is by an old logging incline or skid-way that extends up a very steep slope westerly to a point 2,400 feet above the lake; thence by a poorly defined foot-trail south-westerly for approximately 2 miles to the north-east end of a small lake 2,800 feet above tidewater. From this end of the lake a log raft is used to travel, for approximately 2 miles, to the other end of the lake. From here, a foot-trail leads south-westerly for half a mile to the bottom of a large talus slope that extends upwards to the base of unscalable rock bluffs.
>
> There are no workings on the property. The molybdenite occurs in talus fragments as ⅛-inch flakes in clusters that range from 2 inches to 4 inches in diameter scattered in quartz-diorite, and as similar flakes associated with 2-inch clots of pegmatitic quartz feldspar and mica, widely scattered in the quartz-diorite. The occurrence of the molybdenite is not controlled by any recognizable structure. Many of the talus boulders contain numerous rust spots that are the result of oxidation of grains of pyrrhotite and pyrite.
>
> Although two samples, taken across two individual clusters, assayed molybdenite, 2.6 per cent and 2.7 per cent, respectively, these clusters are too widely spaced to permit mining in the aggregate; the distances between clusters range from 1 foot to several feet.

Other Occurrences

From the *Blackwood prospect* near Pleasant Lake, 5½ miles south of Jervis Inlet, Gwillim (1920, p. 125) reported flake molybdenite plentifully scattered through quartz and granite.

On the *Sechelt Peninsula,* molybdenite has been observed in the granite of the Coast Range intrusions southeast of Sakinaw Lake (Bacon, 1957, p. 40).

At *Salmon Arm,* molybdenite is a minor mineral in chalcopyrite-bornite ores (T. L. Walker, 1911, p. 52).

Vancouver Island

Several molybdenite-bearing mineral deposits have been reported from Vancouver Island, but they all appear to be of minor importance. No production has been recorded.

Cowichan Lake Area

Allies Property

This deposit, in the southeastern part of the island, appears to be the most important. Stevenson (1940, pp. 73-76) describes it as follows:

> The Allies molybdenite property comprises the following claims: *Britain, France, Victoria, Belgium, Sunset* and *Panorama.* The owners are Archie Cowie, 355 Nicol Street, Nanaimo, and associates of the same city. The writer examined this property in July, 1939.
>
> The property is reached by (1) motor road for 15 miles from Nanaimo up the main south fork of the Nanaimo River to the Nanaimo city waterworks dam, at an elevation of 820 feet, thence by (2) approximately 16 miles of trail up Jump Creek to the Jump Creek-Green River divide, and finally by trail up a steep hillside to the camp-cabin at an elevation of approximately 3,200 feet. With the exception of the last mile the trail is good, and with only a little cutting, quite suitable for pack-horses; this trail is in the E. and N. Railway Belt and is kept open as a fire trail by the Canadian Pacific Railway. The last mile to the cabin, although not in a burnt-over area, is covered by numerous windfalls of large timber, and because of the frequency of these falls it would be unwise to attempt to keep this part of the trail open.
>
> The showings are on the steep northerly slopes of Mt. Buttle. For the most part this hillside is heavily wooded with large hemlock, but towards the top and in the vicinity of the showings, steep rock canyons, in part inaccessible, prevail. The upper parts of Mt. Buttle, between elevations of 4,100 and 4,900 feet are relatively open and the cover is alpine.
>
> The deposit consists of single quartz veins that carry small amounts of molybdenite. The veins range in width from 1 inch to 54 inches, and in exposed length, from a few feet to an observed maximum of 37 feet. They occur over an area that measures 6,500 feet in a north-south direction, by 1,800 feet in an east-west direction . . . Samples taken by the writer from mineralized quartz veins assayed . . . Molybdenite, trace to 0.4 per cent.
>
> The quartz veins cut granitic rocks that range from quartz-diorite through granodiorite to granite in composition. Showings Nos. 1 to 16, inclusive, are in quartz-diorite; Nos. 17 and 18 in granodiorite, and Nos. 22 and 23 in granite; Nos. 19 to 21 are in pyritized greenstone.
>
> Quartz-diorite is the most abundant rock type, and extends southerly from the cabin for approximately 3,500 feet, and easterly for a minimum distance of 1,000 feet. Outcrops were seen on the trail for approximately one mile northerly from the camp-cabin; traverses were not made to the east. The quartz-diorite, as exposed on the *Allies,* probably represents the south-westerly part of a large mass that extends north-easterly.
>
> A section of granodiorite, approximately 500 feet wide, was observed in a canyon at a point towards the southern margin of the area of quartz-diorite; the actual contact with the quartz-diorite was not seen.
>
> Andesitic greenstone occurs on the east and west peaks of Buttle Mountain, and extends northerly down to a bench 500 feet below; this bench is 800 feet above and 2,500 feet southerly from the camp-cabin.
>
> Granite dykes cut the greenstone in many places, and extend from the bench south-easterly over the pass between the east and west peaks of Buttle Mountain. These dykes strike north-westerly and range in width from 25 feet to 750 feet.

Other Occurrences

Eardley-Wilmot (1925, pp. 47-8) reported the occurrence of molybdenite on the *Marguerite, Evangeline,* and *Josephine* claims on the north side of Buttle Mountain.

Fyles (1955, pp. 57-59) described occurrences of molybdenite in quartz veins and replacements, and as disseminations in skarn at the *Comego Mine*. This lies on the east side of the divide between Widow Creek and the Chemainus River, 4 miles north of a point 1 mile east of Youbou.

On the Kinman property of the *Nimpkish Copper Group,* on the east side of Nimpkish Lake, pyrite, chalcopyrite, and molybdenite occur in a shear in granodiorite (Gunning, 1930a, pp. 127-128.)

Zeballos Area

Molybdenite has been reported from two localities in this area. From the *Scorpio property*, 4 miles from Zeballos along the Zeballos River, M. F. Bancroft (1940, pp. 20-21) reported the occurrence of masses of pyrrhotite carrying chalcopyrite and molybdenite. At the *Bird occurrence,* 4 miles up the southeast fork above the main forks of the Zeballos River, pyrite, molybdenite, pyrrhotite, and chalcopyrite occur in veins in sheared and crushed sedimentary and volcanic rocks (Gunning, 1933).

Buttle Lake Area

On the *Brown claims,* west of Courtenay, molybdenite occurs as a minor constituent in seams and lenses of pyrite and chalcopyrite, together with magnetite. These claims lie in a valley tributary to Oyster River on the north side of Albert Edward peak (Gunning, 1930b).

Other Areas

From Dry Gulch, on the west side of *Bedwell River,* M. F. Bancroft (1937, p. 25) reported a stock-work of quartz stringers in granodiorite carrying gold and molybdenite.

On the north passage of *Fanny Bay* on the east side of Vancouver Island, molybdenite occurs in narrow quartz veins in granite (J. A. Bancroft, 1913a, p. 141; Stevenson, 1940, p. 95).

On the *Thistle claim,* a mile north of Mount Hayes, west of Ladysmith, chalcopyrite, bornite, and molybdenite occur in a quartz vein in granodiorite (Clapp, 1914, pp. 125-26).

On *Sooke Peninsula* at the extreme south end of the island, molybdenite has been found in copper ores on the Willow Grouse, Blue Bird, and neighbouring claims (B.C. Min. Mines, Ann. Rept. 1948, pp. 162-170).

Vancouver Area

In the area immediately north of Vancouver, between Howe Sound and Pitt River, there are about a dozen reported occurrences of molybdenite. Many of these are of mineralogical interest only, and the most promising appears to be the Margaret property on Boise Creek.

Margaret Property

This occurrence was described in detail by Stevenson (1940, pp. 58-61); the following account is taken from his report:

The Margaret group consists of six mineral claims—the *Margaret, Emily, William, David, Fred,* and *Jean*—staked in 1936 and owned by O. A. Woolsey of 4329 Kinney Street, Vancouver. The writer examined this property in September, 1937.

The property is 12 miles northwesterly from the head of Pitt Lake. It is reached from Pitt Lake by following Pitt River upstream for 3 miles along an old motor road, then crossing the Pitt River to the west side in a rowboat; thence by good pack-horse trail for 9 miles to the camp and workings at an elevation of 1,800 feet.

The showings are between elevations of 1,650 feet and 1,850 feet, on Boise Creek that flows southeasterly into Pitt River, joining it approximately 4 miles above the head of Pitt Lake. The most important showings are along the banks of Boise Creek near its junction with a small southwesterly flowing creek that joins Boise Creek from the east at an elevation of 1,670 feet. Several less important showings occur along the bed of this branch creek and isolated showings in other more remote branch creeks.

In the immediate vicinity of the showings, Boise Creek flows in a V-shaped valley, the hillsides of which are heavily timbered. In many places sloughing along the creek banks exposes bedrock and the molybdenite showings. The main branch creek flows through a rocky canyon and over a rocky floor to Boise Creek.

The rock formation of the immediate area is quartz-diorite that includes many large and small inclusions of fine diorite, andesitic greenstone and remnants of feldspar-porphyry dykes.

In the vicinity of the main molybdenite showings, the hybrid mixture of quartz-diorite and diorite is conspicuously sheeted by closely-spaced joints; however, these do not appear to have influenced the localization of the molybdenite. On the other hand, it is to be noted that the most abundant molybdenite occurs in an area where the amount of diorite conspicuously exceeds the quartz-diorite, whereas quartz-diorite with very little diorite, common at distances of 500 feet or more from the main molybdenite occurrences, contains only widely scattered flakes of molybdenite.

The molybdenite occurrences on the property are of two types. First and most important, are stringers and clusters of molybdenite flakes in silicified crush-zones that are up to 3 feet wide; and second, scattered segregations in clean-cut quartz-pyrite veins that range from ½ inch to 12 inches wide. Of these two types, the first is the more important.

The main occurrence of molybdenite is at the portal of the only adit which has been driven on the southwest side of Boise Creek, opposite the junction of this creek, at 1,670 feet elevation, with the branch creek as above described.

This adit has been driven in a direction south 25 degrees east for 25 feet. Most of the molybdenite occurs in an indefinite zone that ranges from 2 to 3 feet wide, and strikes northeasterly. This zone consists of leached and silicified wall-rock that contains scattered clusters of flake-molybenite and quartz-pyrite molybdenite veinlets which range from 1 inch to 3 inches wide.

Three samples taken across this zone assayed as follows: across 12 inches at a place 6 feet in from the portal; molybdenite 0.72 per cent, iron 8.5 per cent; across 28 inches at the portal; molybdenite 0.36 per cent, iron 4.6 per cent; across 14 inches at a point 3 feet out from the portal; molybdenite 1.26 per cent, iron 5.7 per cent.

Immediately to the north and northeast across Boise Creek from the adit, two small cuts have been dug on two lean molybdenite showings. One cut is located 75 feet in a direction north 45 degrees east from the adit, and has been driven 3 feet northeasterly; the other cut, 8 feet above, is 30 feet northwesterly upstream from the lower, and has been driven 8 feet in a direction north 20 degrees east.

The lower cut exposes three irregular, gash veins of quartz and pyrite, averaging 2 inches wide, that occur in a 5-foot-wide leached zone in the quartz-diorite; this zone contains a small amount of disseminated molybdenite. The upper cut exposes a flat vein, 4 inches wide, containing quartz, pyrite and a small amount of molybdenite.

A small cut has been driven 3 feet northwesterly into the bank of a small branch creek, at a place 150 feet in a direction north 70 degrees west upstream from the last upper cut. This cut has been driven on a lenticular crush-zone that ranges from 4 to 8 feet wide and contains four 4-inch veins of quartz, pyrite and a little molybdenite.

Several widely spaced quartz-molybdenite veins occur in the bed of the branch creek that joins Boise Creek directly across from the adit.

Four hundred feet down Boise Creek from the adit, an 8-foot cut has been driven northeasterly into the east bank of the creek on a 10-inch-wide fracture zone that contains pyrite, quartz, broken diorite and a little scattered molybdenite.

At an elevation of 1,840 feet on both banks of a creek that flows northeasterly into Boise Creek and joins it approximately 1,000 feet downstream from the adit, there is a wide crushed and leached zone in the quartz-diorite that carries scattered and varying amounts of molybdenite. Here, a combination of open-cutting and sloughing of the stream-banks has exposed two main crush-zones, one downstream, 12 inches wide, and one upstream, 12 feet wide; the strike of both zones is indefinite, but is apparently southeasterly across the creek. A sample taken across the 12-inch-wide zone assayed: molybdenite, 0.72 per cent; iron, 5.4 per cent. A 6-foot sample taken across the best mineralization in the 12-foot zone assayed: molybdenite, nil; iron, 2.9 per cent. The rock in these crush-zones is both silicified and sericitized to such an extent that the original nature of the rock is destroyed; however, it is considered to be quartz-diorite and similar to that upstream and downstream. For a short distance downstream from these crush-zones there are numerous tight, widely-spaced stringers of quartz and pyrite and a little molybdenite, from 1 inch to 2 inches wide.

At an elevation of 3,400 feet in a small creek that flows northeasterly into Boise Creek and disappears in a rock and snow-slide 300 feet up-stream from the adit, occasional stringers of quartz and molybdenite are exposed in the quartz-diorite bedrock of the stream.

Other Occurrences

At *Britannia Mines* on Howe Sound, molybdenite occurs in a few places with chalcopyrite in shear zones (Eardley-Wilmot, 1925, p. 52).

The *Bank of Vancouver property,* near the headwaters of Seymour Lake, contains a breccia in granite cemented by hematite, magnetite, chalcopyrite, chlorite, carbonate, quartz, molybdenite, and sphalerite (James, 1929, p. 117).

On the *London group* of claims, on the east side of Indian River, a mineralized granodiorite dyke carries pyrite and chalcopyrite, with molybdenite on fracture planes (James, 1929).

From the *Soule claims* near the head of the north arm of Burrard Inlet, T. L. Walker (1911, p. 52) reported the occurrence of molybdenite in a 14-inch quartz vein in granite.

On the *Gideon Bower prospect,* 1½ miles from the shore of the north arm and opposite Croker Island, quartz veins carry molybdenite and copper (T. L. Walker, 1911, p. 52).

At *Lynn Creek,* irregular mineralized bodies occur along fracture zones in altered sedimentary rocks. The associated minerals are sphalerite, chalcopyrite, pyrite, pyrrhotite, molybdenite, and magnetite (LeRoy, 1908, p. 29; Alcock, 1930, p. 355).

On the *St. Paul group* on the west side of Pitt Lake, a "4-foot vein of molybdenite" is reported to have been uncovered for 400 feet. (B.C. Min. Mines Ann. Rept. 1901, p. 1121).

The *Cox claims,* 5 miles up Canyon Creek from its confluence with Pitt River, cover small quartz veins carrying pyrite and molybdenite, with, in places, gold.

In the *Stave River area,* 6 miles northwest of the head of Stave Lake, molybdenite is reported to occur in silicified shear zones in granitic rocks (B.C. Min. Mines, Ann. Rept. 1918, pp. K288-289).

Lower Fraser Valley Area

Molybdenite-bearing deposits of minor importance are reported from various localities in and near the lower Fraser Valley. The main concentration appears to be on both sides of Fraser River just east of Agassiz, and between Spuzzum and the north end of Harrison Lake. Other occurrences are reported from the valleys of Coquihalla and Tulameen Rivers.

Agassiz Area

Several small deposits are reported from the high mountains bordering the Fraser Valley to the east.

At the *Dupres-Knight prospect,* near Cheam View, molybdenite occurs in lenses of quartz in granite (Gwillim, 1920, p. 126).

Quartz-filled gash veins with molybdenite occur on the *Mary Jane and Annie Lou group*, situated on Jones Mountain 2½ miles southeast from Cheam View station on the Canadian Pacific Railway (B.C. Min. Mines, Ann. Rept. 1918, pp. K286-287).

The *Last Chance group,* on the south side of Hurling's Mountain, 7 miles east of Agassiz, is reported to carry molybdenite with other sulphides in limestone (B.C. Min. Mines, Ann. Rept. 1918, p. K289).

Molybdenite is reported from the *Lindeman prospect* on a mountain west of the north end of Chilliwack Lake (Gwillim, 1920, p. 126).

Empress Property

At this property, on the southern slopes of Bear Mountain overlooking the lower Fraser Valley, 4 to 5 miles north of Agassiz, marble and impure meta-limestone of the Carboniferous Chilliwack series are intruded by quartz diorite and diorite of post-lower Cretaceous age (*see* Cairnes, 1924). Along the contact between the sediments and the igneous rock, contact metamorphism has produced irregular bands and bodies of garnet-diopside-wollastonite 'skarn', with associated small bodies of copper ore, in the form of chalcopyrite. Some of these bodies have been worked on a small scale at the now-disused Empress Copper Mine. The reports tell of molybdenite associated with the copper ore. The writer visited the old workings in August 1958.

The mine is easily reached from Agassiz Station on the Canadian Pacific Railway, by driving for 5 miles over paved and good gravel roads to the beginning of the old mine trail at the foot of the southern slopes of Bear Mountain, west of Seabird Island. The mine trail is somewhat overgrown but is easily negotiated by a four-wheel-drive vehicle up to the workings; these are about 800 to 1,000 feet above sea-level. On foot it takes ¾ hour.

The workings examined by the writer consisted of a series of shallow open-cuts and pits on the steep hillside at the end of the mine track. These showed evidence of recent blasting and excavation. In addition, the writer examined an old open-cut and two adits situated about 150 to 200 feet higher up the hillside. In all the workings, little sulphide-bearing rock was seen.

The workings at the Empress Copper Mine are referred to in two Annual Reports of the British Columbia Minister of Mines: 1917 (p. 286) and 1931 (p. 176). In 1915-1916 five carloads of ore were shipped (totalling 200 tons) from an open-cut on the steep hillside. The ore-minerals are chalcopyrite and iron sulphides occurring in masses in the contact or "skarn" zone, which varies in width from 10 to 30 feet. The sulphide masses apparently were restricted to the surface, as none of the underground workings showed any ore. Altogether the production from this mine was negligible.

The writer found molybdenite at only one place. Small patches and areas of disseminated chalcopyrite occurred sparingly in the workings, but any large bodies of sulphides that may have been present had been completely removed. The molybdenite-bearing zone is exposed in the lowermost and most easterly of the workings. This is an irregular face blasted out along the northerly side of the mine trail. It is about 60 feet long and from 4 to 20 feet high. The face strikes at N65°W. The rocks exposed are impure, banded, garnetiferous marble, a hard, greyish white siliceous meta-limestone, and a band of garnet skarn from 6 to 10 feet thick. The banding in the impure meta-limestone strikes about N80°W and the skarn body is concordant with this. Dips are vertical or nearly so, being modified by shallow, open folds along almost horizontal axes.

The skarn body is composed mainly of light brown garnet, with minor green diopside and variable amounts of interstitial, coarsely granular calcite. Occasional patches of radiating wollastonite crystals are present. The main body of skarn is massive, but in parts the garnets have developed as euhedral crystals of various dimensions. Particularly noticeable are zoned garnets up to an inch in diameter. On either wall of the skarn body, masses and individual crystals of garnet occur in the siliceous meta-limestone and marble, diminishing in abundance outwards.

Along the face, and especially in the greyish white siliceous meta-limestone, very fine flakes of molybdenite occur scattered indiscriminately. They vary from the finest individual specks to patches a few inches across in which the grain size reaches perhaps ⅕ mm. On the whole the concentration of molybdenite is low. A systematic chip sample along the zone assayed 0.33 per cent MoS_2.

The molybdenite is confined mainly to the siliceous rock. It occurs scattered in small isolated patches of skarn, but appears to be completely lacking in the main body. No other sulphide mineral was seen accompanying the molybdenite. In the loose rock away from the face small patches of granular chalcopyrite were present, but these had no associated molybdenite. According to the old reports molybdenite was associated with chalcopyrite and magnetite in the ore extracted at the mine, but unfortunately this ore is no longer available for inspection.

The molybdenite-bearing zone examined by the writer is probably of mineralogical interest only. Replacement deposits are erratic in their behaviour and there is no reason to suppose this one is an exception. However, the molybdenite-bearing rock doubtless extends in both directions beyond the 60-foot face that was available for inspection. Its true width is of the order of 10-20 feet and it seems reasonable that it may conform in attitude to the vertical banding in the metasediments. In view of the low grade revealed in the one sample assayed, this showing does not seem to be of commercial interest.

The other workings on the Empress property revealed no molybdenite, indeed very little sulphide of any sort. The rocks exposed are banded calcite marbles, impure siliceous meta-limestones, and irregular bands and bodies of garnet-diopside-wollastonite skarn.

Other Occurrences

Eardley-Wilmot (1925, p. 48) reported that molybdenite occurs with free gold on the north fork of *Spuzzum Creek,* on the divide between it and Harrison Lake, about 10 miles northwest of Yale Station.

At the *H.L.M. group,* on Silver Creek, on the northeast side of Harrison Lake, molybdenite occurs in narrow quartz veins in granitic rocks (B.C. Min. Mines, Ann. Rept. 1939, p. 100).

According to Cairnes (1924, p. 163) molybdenite is a common accessory mineral in some of the batholithic rocks in the Coquihalla valley. Along the railway at *Portia,* he observed the mineral as—

> Small, lustrous bluish-grey scales scattered throughout the coarse granite within a few hundred feet of the contact of this intrusive with the Ladner slate belt. . . . it is intimately associated with the rock minerals, and was probably introduced during the consolidation of this intrusive. Its occurrence here is of no economic importance.

Cairnes (1924, pp. 163-164) also described the occurrence of molybdenite at the *Dominion Mineral group,* located at an elevation of about 5,500 feet on the summit west of Iago, the next station along the railway northeast of Portia.

> The only showing of importance seen by the writer was located in the face of a steep granite bluff where a quartz lens 1½ feet wide was heavily impregnated with molybdenite. This mineral occurs in flakes or lumps filling small cavities in the quartz or more finely distributed in the adjoining granite. Small masses of molybdenite equivalent in volume to a cubic inch were observed, but as a rule the lumps were smaller and were confined to the quartz. In the granite the sulphide occurs in finer particles.
>
> The granite composing the wall and country rock is typical of the coarse pink granite member of the Cretaceous batholithic rock in this section of the district, except that near the quartz lens it is slightly miarolitic and the small cavities are commonly occupied by flakes of the molybdenite. The quartz lens is so intimately and irregularly intergrown with the granite as to suggest its origin as a pegmatitic phase of the intrusive. It has a very vitreous lustre, is greatly fractured, and contains small cavities occupied by the ore mineral.

> The molybdenite was probably introduced together with the quartz gangue during the later periods of the intrusion of the batholithic country rock. Subsequently, it has been partly oxidized near the surface to yellowish molybdite (MoO_3). No other molybdenum minerals were observed.
>
> The percentage of molybdenite in this deposit seems to be well above that necessary for economic extraction, but no estimate could be made as to the actual amount of ore present.

At the *Independent camp,* at the head of the Coldwater River, molybdenite occurs in fine scales in the granite porphyry (Camsell, 1907, p. 38).

At *Champion Creek* in the Tulameen Valley, molybdenite is present in little quartz stringers cutting the schists at and near the contact with the granite (Camsell, 1907, p. 38). Rice (1947, p. 112) described the latter locality under the name "Nickel Plate group"; he includes the following quotation from Camsell (1913, pp. 170-171):

> Much contact metamorphism has been effected by the granodiorite intrusion and with an abundant development of the usual contact metamorphic minerals in the intruded rocks. Some quartz veins, generally of small size, also traverse the schists and limestones.
>
> The molybdenite occurs in small flakes and scales, having a bright metallic lustre and a lead-grey or slightly bluish colour. It is scattered plentifully in small particles throughout a gangue consisting of quartz, garnet, epidote, hornblende, and pyroxene. It is seen, in this section, to be intergrown with these minerals in such a way as to indicate a contemporaneous origin.
>
> The deposits are clearly of contact metamorphic origin, and were formed by and at the time of the intrusion of the Eagle granodiorite. The associated minerals indicate that the rock in which the molybdenite occurs was originally a limestone which, on the intrusion of the granodiorite, had its constituents altered from carbonates to silicates by a process of metasomatic replacement, the molybdenite being introduced into the limestone along with the silica which went to form the lime silicates.

Small amounts of molybdenite and chalcopyrite were seen in the granodiorite of the Osprey Lake body on the ridge between Summers and Hayes Creeks, some 6 miles north of Jura, a station on the Kettle Valley line, and some 12 miles north-northeast of Princeton (Rice, 1947, p. 114).

Gwillim (1920, p. 127) mentioned the *Gaynor prospect,* ½ mile up Granite Creek from the Tulameen River and 6 miles southeast of Tulameen, but gave no details.

Ashcroft-Kamloops Area

A considerable number of molybdenite deposits, of several different types, have been reported and described from this area. None has produced any molybdenite. Most of the occurrences fall within the Nicola and Ashcroft map-areas (*see* Cockfield, 1948; Duffell and McTaggart, 1952). These other properties are included here for convenience: the Index property on Texas Creek, southwest of Lillooet; the Kenallan property, 3 miles south of Westwold, southeast of Kamloops; and the Anticlimax and Sands Creek properties, both north of Kamloops.

Index Group

These claims are located on a high divide (about 8,500 feet above sea-level), between the headwaters of the north fork of Texas Creek and Cottonwood

Creek, a tributary of Cayuse Creek. The property is about 15 miles southwest of Lillooet and 11 miles from Seaton Lake Station on the Pacific Great Eastern Railway.

According to Eardley-Wilmot (1925, pp. 34-35) the claims were staked in July 1915, and later that year some work was done and shipments were made. During 1916 some high-grade ore was quarried and 8½ tons of 15.01 per cent ore was shipped to the International Molybdenum Company's concentrator at Renfrew, Ontario.

In 1918 the property was taken over by the Index Mining and Milling Company. A crosscut tunnel was driven for 30 feet and reportedly cut several stringers of molybdenite. About 50 feet from the tunnel a 4-foot quartz ledge containing molybdenite was exposed by means of a trench 35 by 5 by 6 feet. A number of pits and open-cuts were said to have been made at different points on the property. Eardley-Wilmot mentioned that about 8 tons of high-grade ore was extracted and stored on the property.

The property was examined by Drysdale, who reported (1917, p. 54):

The molybdenite ore is very clean and free from copper, tungsten, tin, bismuth, arsenic and other deleterious elements. The highest-grade ore is 76 per cent molybdenite and occurs sparingly in bunches up to 1 foot in width, along certain closed-spaced joint planes in the fine-grained quartzose members of the granite stock, as well as impregnations in the intervening granite. The low-grade ore could be readily concentrated, as the molybdenite occurs in rosettes and flakes that are uniformly distributed throughout the disintegrating granitic gangue. The latter consists of quartz, feldspar, and, in places, sericite flakes. Biotite mica occurs as an essential constituent in the blocky granite away from the ore zones. Molybdenite occurs less sparingly in rusty, vitreous, quartz veinlets cutting the granite. In the vicinity of the ore, the granite is much stained by the straw-yellow trioxide of molybdenum, molybdite, and this, along with a certain amount of kaolinization of the orthoclase feldspar serves as a good indicator of the ore zone.

Duffell and McTaggart (1952, p. 106) reported that specimens from the Index property have been found to contain uraninite, but not in quantities of economic interest.

Martel Mine

This mine was reported on by Stevenson (1940, pp. 9-11), and by Duffell and McTaggart (1952, pp. 106-107) whose description follows:

This property, operated by Martel Gold Mines, Limited, during the mid-thirties, included the Hat Nos. 1 to 11; Bug Nos. 12, 13, and 14; Axe, Boe, Boe No. 1, Dave, Matt, and Vernon mineral claims. It is situated on the eastern slope of Martel Mountain at an elevation of 2,400 feet and about 200 feet above the floor of Venables Valley. Two roads lead to the valley and the mine; one, an abandoned narrow wagon road climbs the slope behind Martel, and the other branches from the Cariboo Highway about 8 miles above Venables Valley. The latter is a good gravel road, suitable for truck haulage, and in 1945, when the property was visited, was in good repair.

The buildings at the mine camp were in good repair, but all equipment had been removed. Mining operations were conducted at the property from 1934 to 1938, but in 1939 the entire operation was abandoned and the equipment sold. Nothing has been done since. In 1945, the property was restaked by Lester Starnes of Ashcroft.

The deposit consists of a group of small lenticular quartz veins in argillites, cherts, and minor tuffs of the Cache Creek group. The veins range in thickness from a fraction of an inch to 12 inches and from 2 to 60 feet in length. They strike north 35 to 40 degrees east, dip 70 to 75 degrees northwest, and are displaced a few feet by northwest-striking faults.

The gangue is mainly quartz, with some calcite, and carries small amounts of molybdenite, pyrite, chalcopyrite, pyrrhotite, sphalerite, and arsenopyrite. The quartz has been fractured, allowing passage of mineralizing solutions. In 1937, a small shipment was sent to the Mines Branch at Ottawa for testing. This assayed 0.015 ounce gold and 0.04 ounce silver a ton, 1.48 per cent molybdenite, and 0.11 per cent copper. The molybdenite occurs in very thin seams that parallel the vein walls.

Underground work comprised 1,035 feet of drifting, crosscutting, and sinking in an effort to follow the veins. Most of the work was done on the main adit level, but two winzes were sunk, to depths of 88 and 55 feet respectively. Some short lateral workings were driven from these in an effort to find the veins on their downward extension from the main level, but with little success.

Highland Valley Area

The geology and mineral deposits of this area have been described in some detail by Cockfield (1948, pp. 116-123), by Duffell and McTaggart (1952, pp. 92, 99), and by White, Thompson and McTaggart (1957). The following account is taken from these reports, supplemented by field observations by the writer during a visit in August 1958. The writer is grateful for facilities extended by Mr. H. H. Huestis, president of Bethlehem Copper Corporation.

The Highland Valley area is underlain by rocks of the Guichon Creek batholith, one of several that fringe the eastern margin of the main Coast Intrusions. Its age has been well established as Lower Jurassic, as it intrudes volcanic rocks of Upper Triassic age near Ashcroft and is overlain by Middle and Upper Jurassic fossiliferous marine sediments. The Guichon Creek batholith is thus somewhat exceptional among the Coast Intrusions, many of which intrude Upper Jurassic or Lower Cretaceous strata (White, Thompson, and McTaggart, 1957, p. 2).

The Guichon Creek batholith is about 40 miles long and 16 miles wide and is elongated in a direction a little west of north, parallel with the general trend of the surrounding older rocks. The batholithic rocks are generally massive and structureless and comprise a complexity of types, mainly quartz diorites, granodiorites, and various types of porphyry.

Copper and minor amounts of molybdenum, gold, silver, and tungsten occur both in veins and disseminated in the Highland Valley area. So far no molybdenite has been produced. Some of the veins contained high-grade shoots (e.g. the Tamarack) but proved to be too small to be of economic importance. On the other hand it may be possible to recover considerable quantities of molybdenite as a by-product from the huge, low-grade disseminated copper deposits now being investigated (e.g. the Bethlehem).

Bethsaida Property

In the Tamarack workings on the Bethsaida property, molybdenite is abundant as coarse-grained foliated masses in quartz veins, some of which, in addition, contain chalcopyrite and/or bornite. The property, originally staked for molybdenite, was later worked as a copper mine (Eardley-Wilmot, 1925, p. 32). In 1904 a shaft was sunk to a depth of 20 feet, and 1 ton of the best molybdenite was shipped for experimental purposes to a firm in Pennsylvania. "However owing to the hardness of the quartz gangue, the amorphous structure of the molybdenite and the presence of considerable copper, the results obtained were far from satisfactory" (loc. cit.). The mine closed down in 1918.

In recent years exploration on the Bethsaida property has exposed several molybdenite-bearing copper-quartz veins in addition to the one originally worked at the Tamarack shaft. The writer examined some of these in bulldozer cuts on the hillside southwest of Highland Valley.

The widest vein seen was about 3½ feet of massive, white quartz which, on the surface was rusty and copper-stained. The quartz carried occasional blebs and patches of chalcopyrite, and rarely, insignificant amounts of very finely divided molybdenite.

About 50 feet west of the old shaft a deep bulldozed trench has cut through the main vein which there strikes about due east. It is 3 to 4 feet wide as exposed in the trench, with up to 6 feet of sericitic alteration in the granite on either side. The vein matter is white massive quartz carrying appreciable fine-grained and amorphous molybdenite, both in the quartz and along slip-planes or other fractures. Considerable amounts of yellow molybdic ochre occur on weathered surfaces. Chalcopyrite is also present. Molybdenite also appears in the altered granite on either side of the quartz vein.

O.K. Mine

In 1916 and 1917, the old O.K. mine, to the west of the Bethsaida group, was the principal producer in the Ashcroft area. In those years it produced 10,000 tons of ore averaging 3.6 per cent Cu. Since 1917 the mine has been idle, the buildings have collapsed, and the workings have become inaccessible.

The ore lies along a fracture in the Guichon Creek batholith; it consists of copper sulphides in a gangue of sericitized wall-rock, quartz, and fault gouge. Ore minerals are chalcopyrite, chalcocite, bornite, and secondary copper minerals. Molybdenite is present in minor amounts, both in patches and veinlets of quartz and in the heavily sericitic wall-rock.

Duffell and McTaggart (1952, pp. 99-100), described the workings.

Disseminated Deposits

White, Thompson and McTaggart (1957, p. 9) stated:

> Molybdenite is a minor but constant constituent of nearly all mineral deposits in the Highland Valley area. Exceptionally, it is found in large radiating crystal aggregates, in part intimately associated with chalcopyrite, but more commonly molybdenite grains are so small as to escape detection.

Other molybdenum minerals recognized by these workers are:

> *Powellite*—Powellite though fairly common in bulldozer cuts on the Bethlehem property is most abundant in the southern part of the Iona zone. It probably accounts for persistent molybdenum values in rocks in which molybdenite could not be identified.

Ferrimolybdite . . . has been identified in the southern part of the Jersey zone of the Bethlehem property. It occurs as a canary-yellow earthy coating or as tufted or radical aggregates.

Westerly striking joints are abundant in the Bethsaida granodiorite and many of them contain quartz with bornite, chalcopyrite, and more rarely, molybdenite. At one place on the Bethsaida ground these joints are sufficiently closely spaced to constitute a zone of disseminated mineralization about 500 feet wide.

Bethlehem Copper Property

The Iona and Jersey zones on the Bethlehem property constitute two of the best known breccia deposits in the Highland Valley area. Molybdenite generally occurs in very finely divided form with the copper sulphides, commonly as thin films along fracture planes and joints but also in the body of the rock. A local concentration of fine-grained molybdenite can be seen at an old shaft—known as the 'Molybdenite Shaft'—which lies in a fault zone forming the southern 'tail' of the Jersey zone.

In the large adit which the Bethlehem Copper Corporation was driving to intersect the Jersey zone at depth at the time of the writer's visit, molybdenite occurred occasionally in finely divided form in altered quartz diorite together with chalcopyrite, bornite, and pyrite. Figures were not available for the molybdenite content of the Jersey zone but its average value was estimated at about 15 cents per ton of ore. In the event of the Bethlehem orebodies being worked for copper, the molybdenum could be recovered as a by-product in not inconsiderable quantities.

Black Buff

Cockfield (1948, p. 124) stated:

This property, which was not seen by the writer, is situated on Dupuis Creek, about 2 miles west of the north end of Mamit Lake. On it a sheared zone in granite carries copper minerals and molybdenite.

Diamond S Group

The Diamond S group is situated on Criss Creek, about 3 miles northwest of Red Lake post office, and about 15 miles due north of the west end of Kamloops Lake. The deposits have been described in some detail by Cockfield (1948, pp. 79-80):

Several pits on part of the Diamond S claim expose quartz veins carrying pyrite and molybdenite. These lie along a small gulch draining to Criss Creek . . .

The rocks in the vicinity consist of sandstone, shale, and conglomerate intruded by a nearby body of granitic rock, for some distance from which the sedimentary beds have been highly sheared and converted into schistose conglomerate, gneiss and schist.

The cuts on the quartz veins that show molybdenite are in the sedimentary rocks close to the intrusive contact. Many of them are sloughed in, so that the attitudes of the different veins cannot be obtained, and it is, consequently, difficult to relate the different showings.

The most southerly and highest of the cuts along the small gulch draining to Criss Creek was observed on the east bank of the gulch. Here a quartz vein 3 feet wide in altered sediments strikes southeast and dips 60 degrees southwest. The quartz carries a little pyrite and small grains and masses of molybdenite. A second cut driven 20 feet northwesterly along the strike partly exposes a quartz vein distinct from that in the last two cuts. It is 5 feet wide, strikes east, dips 65 degrees south, and is sparsely mineralized with pyrite and molybdenite. A sample across this cut is reported to have shown 0.3 per cent molybdenite.

Some 250 feet downstream on the opposite side of the gulch are several small stringers of quartz carrying pyrite, but no molybdenite was seen. About 300 feet farther downstream, also on the west bank of the gulch and 50 feet above its bed, a cut exposes a quartz vein about a foot wide. This strikes east and dips 60 degrees south. The vein contains masses of pyrite and grains and small masses of molybdenite, and the wall-rocks carry bunches of quartz.

About 400 feet farther northwest, a quartz vein 2 feet wide, striking south 70 degrees east and dipping 62 degrees southwest, is partly exposed. It carries small masses of pyrite and molybdenite. A second cut about 20 feet away but somewhat off strike, now sloughed in, apparently encountered a quartz vein.

On the eastern side of the creek about 200 feet northerly from the last exposures a quartz stringer 4 inches wide appears in altered granite. This is heavily iron-stained, but no molybdenite was seen.

Veron Group

This group of four claims lies to the south of the Diamond S group, on the west side of Criss Creek and about 3 miles northwest of Red Lake post office. The following is from Cockfield (1948, pp. 80-81):

> The showings consist of quartz veins in rocks that have been badly sheared and altered close to the contact of a nearby granitic mass, but are believed to represent altered Cretaceous or Tertiary sedimentary rocks. Few outcrops occur in the vicinity. The veins are mineralized with pyrite, tetrahedrite, zinc blende and molybdenite. Many of the showings consist of quartz float and of broken material lying virtually in place.
>
> An open-cut and adit have been driven at the lowest showing. The adit is only a few feet beneath the surface and does not disclose the walls of the vein. Quartz occurs low down in the walls for about 10 feet in the adit, with broken rock above, and the face is also in quartz. The quartz is heavily impregnated with sulphides, chiefly pyrite and tetrahedrite, with some molybdenite. The attitude of the vein is not known. A sample cut in mineralized quartz across the face, a distance of 6.5 feet, assayed: gold, a trace; silver, 0.09 ounce a ton. Above the adit a stripping has been made and quartz shows in this and to the southeast, but it is doubtful if the vein matter is in place.
>
> A group of cuts 250 feet to the east discloses quartz float carrying pyrite and some molybdenite.
>
> About 200 feet westerly from the adit, an open-cut partly exposes a quartz vein about 3 feet wide. This appears to be striking northwest and dipping 75 degrees northeast. Higher up the hill several cuts have encountered quartz float, but the vein matter has not been found in place.
>
> About 1,000 feet northeast from the adit there is a group of cuts. The first two are each about 10 feet long and about 10 feet apart. They show granite on the foot-wall of the cut and an altered carbonate rock with considerable mariposite on the hanging-wall. Stringers of quartz intersect the granite. Thirty feet easterly a quartz vein is shown in a cut about 6 feet long. The vein is 3 feet wide, strikes east, and dips 40 degrees north. It is not exposed in the cuts previously mentioned, although these cross its strike. Two slips offset the vein in the cut. The vein carries pyrite, tetrahedrite, zinc blende, and molybdenite, the last mineral occurring in masses up to an inch in diameter. Mineralization on the whole is sparser than at the other workings. The wall-rock is sheared and carbonatized, and contains considerable mariposite.
>
> The indications are that veins of considerable size occur, but up to the time the property was last examined (September 1941) work had not progressed far enough to relate the various showings. One gold assay of $5 a ton is reported to have been obtained, but a sample by the writer of well-mineralized material failed to show appreciable gold values.

Kenallan

The molybdenite occurrence known as Kenallan lies some 4 miles southwest of the village of Westwold (formerly Grand Prairie), which is on provincial highway 97 some 34 miles east of Kamloops. The property is best reached from Westwold along the Douglas Lake road. From a point 4 miles south of Westwold, an old logging track leads northwest up a small valley for some 1¼ miles to the showings. The track is negotiable part of the way by car. The old workings lie on the top and eastern slopes of a low north-trending ridge, some distance to the west of the steep escarpment overlooking the valley of Salmon River.

The first published reference appears to be that of Hoffman (1897), who stated that molybdenite occurred "accompanying chalcopyrite in a gangue of a massive clove-brown to reddish-brown andradite with a light greenish fine-granular pyroxene."

When T. L. Walker (1911, pp. 53-54) visited the property there were already a number of pits, including an incline shaft more than 25 feet deep. Walker compared the occurrence with those on Texada Island—sedimentary rocks were altered by igneous intrusion and deposits formed along the contact carrying copper and molybdenite. According to Walker "the molybdenite is almost entirely confined to quartz stringers in the contact zone. It is scaly, but there does not appear to be evidence at present of any economic quantity." He quotes the following results of an assay of the ore: Mo, 3.61 per cent; Cu, trace; and Au, nil. These figures must apply to selected ore, as the Mo content is much higher than that found by later workers.

At the time of Brewer's report (1916, pp. 217-19) the property consisted of the Silver Wedding, Kenallan, and Bonaccord claims, owned by C. A. Mackay, C. A. Bodie, and K. W. Mitchell. The claims were originally staked for copper, then abandoned. Due to the increased demand for molybdenum in World War I the area was restaked for that metal. Brewer stated that four distinct zones of mineralized rock occur, and he gives a brief account of the geology and workings. Several assays are given for material from the various workings; these range from 0.5 to more than 3.0 per cent molybdenite.

The Kenallan property (under the name 'Grand Prairie') is briefly mentioned by Gwillim (1920, pp. 126-132) who regarded it as one of the "promising prospects". Of the geology he said:

> hornblendic granites intruding a patch of the Cache Creek quartzites and limestones (Carboniferous) have sent out spurs causing intense metamorphism. Dykes of a more basic character are also present. The ore-bearing material is a narrow band of hard greenish siliceous rock with much garnetite. This band, averaging 2 feet in width, strikes approximately north and south and dips to the west at an angle between 30 degrees and 45 degrees. Câche Creek quartzites form the foot-wall, while crystalline limestone is in contact on the hanging-wall side. The band has been followed nearly continuously by open-cuts for about 300 feet. There is one incline shaft 40 feet deep, said to be in barren rock at the bottom, and barren places also occur in the open-cut work. From these excavations, 50 to 75 tons of ore, carrying from 1 to 2 per cent of molybdenite have been taken out. Representative specimens show the large flakes characteristic of this ore.

There are many other excavations on this ridge showing some molybdenite, but the only promising concentration of values is in this 300 by 2½ feet of ore-bearing rock in contact with crystalline limestone.

Gwillim thought the property deserved further development.

Eardley-Wilmot (1925, p. 33) gave a short account of the occurrence, mainly reviewing previous publications. The latest and most thorough account is that by Stevenson (1940, pp. 28-33), who described the location, access, and geology in fair detail. He also gave a detailed description of the individual workings.

According to Stevenson the property was restaked in 1939 by R. and F. L. Fitzmaurice, Otto Sandberg, and F. W. Groves. Stevenson regarded the occurrence as a high-temperature replacement deposit in which the molybdenite occurs as a minor constituent in beds of lime-silicate rock. These rocks occur in two northerly striking zones. The westerly zone has a maximum length of 1,000 feet, and although the maximum width of the zone is 100 feet, the widths of the individual lime-silicate beds range from a few inches to 4 feet. The easterly zone, some 400 to 500 feet to the east, has a maximum exposed length of about 150 feet and a maximum width of 12 feet, which is also the width of the lime-silicate bed. According to Stevenson the molybdenite is widely scattered and nowhere seems to be sufficiently concentrated to constitute ore. He considered the best material to be that found in a dump from a small underhand stope in the central part of the westerly zone. A 250-pound sample of this assayed: MoS_2, 0.5 per cent; Fe, 19 per cent; and Cu, trace.

The writer agreed with Stevenson's opinion regarding the mineralization, though no samples were taken.

The writer investigated the property during August 1939 and mapped the workings on the two main zones (*see* Fig. 24). The workings seemed to agree fairly well with the description given by Stevenson, so that little if any work was done on the property since his visit.

The main rock types are interbedded crystalline meta-limestone, and fine-grained siliceous hornfels, and probably fine-grained whitish quartzite. The meta-limestones are typically white and pure, consisting almost entirely of calcite. They are fairly thickbedded and well-jointed on an east-trending joint system. The hornfels are very finely crystalline and hard, mostly dark brown or dark green in colour. The outcrops of many are rusty due to the weathering of iron sulphides. Stevenson stated that they typically consist of a mosaic of quartz, with small amounts of feldspar and biotite. The whitish quartzites seen in some exposures are probably purer representatives of these rocks.

The lime-silicate, or skarn bands seem almost invariably to occur between a bed of limestone and a bed of hornfels. Nearly all the old workings show a mineralized skarn band between a hanging-wall of crystalline meta-limestone and a foot-wall of rusty hornfels. The skarn bands in the western zone range in thickness from a few inches to a maximum of about 4 feet. In the eastern zone a pit exposes a true thickness of about 6 feet of mineralized lime-silicate. The main minerals in the lime-silicate bands are light red-brown lime-garnet (andradite) and green diopsidic pyroxene. The proportions of the various minerals vary considerably, from pure garnet rock to almost pure diopside rock. Commonly the garnet appears as stringers or veinlike forms cutting the diopside rock, suggesting that the garnet crystallized slightly later. Coarsely crystalline white calcite is fairly common in irregular patches in the skarn and fine green crystals of epidote commonly occur in these patches. Stevenson mentioned the presence of wollastonite and axinite, but these minerals were not seen by the writer.

Narrow quartz veins were observed in places cutting through the skarn bands, apparently on east-striking joint planes. These veins were particularly noticeable in the spoil from a large pit on the easterly zone and notable amounts of molybdenite occurred in them. Stevenson mentioned the presence of tongues and sills of diorite cutting the rocks towards the north end of the westerly zone and particularly in the easterly zone. The diorite is a medium-grained, feldspar-amphibole rock and may be seen especially well on the north side of an incline shaft on the easterly zone. Stevenson considered the diorite to have been emplaced prior to the period of skarn formation and mineralization. He also pointed out the presence of an area of granite outcrop northwest of the workings, surrounded by hornfels and crystalline limestone. This is doubtless one of the 'spurs' from the granite mass that has caused the metamorphism and must underlie the area at no great depth.

The only sulphides seen in the lime-silicate bands were molybdenite and chalcopyrite. Green copper carbonates were visible here and there on the dumps and outcrops.

The molybdenite is erratically distributed but is confined wholly to the skarn bands; none was seen in meta-limestone or hornfels. Most of the visible molybdenite was on dumps of material taken out of the workings, and hardly any was seen in situ. Where seen the mineral occurred in spectacular flakes and 'splashes' up to ½ to 1 inch across, but the overall content was probably nowhere very high. Stevenson's figure of 0.5 per cent MoS_2 for dump material from the main incline and stope seems to be representative for the best mineralized parts. However, these parts do not persist very far along strike and much of the zone appears to have been barren.

The molybdenite flakes in places appeared to be coating joint faces or fractures in the skarn; in others they are sparsely disseminated in the body of the rock. In the latter cases the grain size of the mineral was invariably much finer than normal. In material on the dump from a large pit on the easterly zone, the molybdenite tended to be concentrated almost exclusively in narrow veins of quartz cutting the skarn. This may indicate the introduction of at least part of the molybdenite together with siliceous solutions at a late stage in the formation of the skarn, or even after its formation. It thus raises the question of whether the molybdenite is genetically related to the formation of the skarn or whether it was introduced later.

The reader is referred to Stevenson's account for a description of the workings. Those on the westerly zone are shown in Figure 24. Although they cover a strike length of more than 1,000 feet, the main workings occur along the central 300 feet or so, on either side of the small stope and incline. These central workings seem to have been driven on the same band of calc-silicate rocks, which was obviously not equally rich in molybdenite along the whole length. Most of the workings are very shallow and it would appear that the mineralization does not extend to any depth. In the trench immediately north of the stope the lime-silicate band is double, with a band of crystalline limestone between the two parts. Elsewhere it seems to be a single band, varying in width from a few inches to several feet. The other workings north and south of the central part probably have exposed minor parallel bands of skarn—Stevenson distinguishes four separate ones in the westerly zone. These other bands do not appear to have yielded any significant amounts of molybdenite.

The easterly zone comprises a single band of skarn, varying in thickness from about 1 foot to 6 feet. It lies about 400 to 500 feet to the east of the westerly zone, on the slopes of the ridge overlooking the Salmon River valley. The workings on it consist of three inclined pits or shafts and a certain amount of stripping. The total exposed length is about 200 feet. The molybdenite content of this zone does not appear to be very significant.

Anticlimax

Stevenson (1940, pp. 20-28) reported as follows:

The property is approximately 17½ miles northwest of Littlefort (Mt. Olie), a village on the west side of the North Thompson River, 60 miles north of Kamloops. A good highway connects the village with Kamloops. From Littlefort the camp may be reached by following a good motor-road up Lemieux Creek for 9 miles to an abandoned farm known as Dunshek's; it is possible to take a car 2 miles farther, but the way is narrow and partly overgrown by bushes. From Dunshek's there is a good pack trail for 8½ miles to the camp at an elevation of approximately 4,375 feet . . .

The showings are on a low, rounded hill that rises to a height of approximately 590 feet above Loon Lake (which is a small body of water 2 miles southerly from the east end of Taweel Lake).

The mineral occurrences consist of a pegmatitic quartz lens heavily mineralized with molybdenite, and many narrow quartz veins only slightly mineralized with molybdenite.

The rock formations which contain the mineral occurrences consist of a small stock of granite and related rhyolite porphyry. The area of granite outcrops measures approximately 2,500 feet in a northwesterly direction, by 1,500 feet in a northeasterly direction. This granite stock is bounded on at least three sides, the northeast, southeast and southwest, by areas of greenstone. The absence of outcrops northwesterly from the stock prevented determination of the rocks on that side. Nearly continuous outcrops of greenstone occur on a ridge that lies approximately 1,000 feet northeasterly from the granite and extends for 1 mile in a northwesterly direction. Scattered outcrops of greenstone occur on the Fourteen-mile Creek slope at points approximately one-half a mile southeasterly from the stock. Continuous outcrops occur on the top of a low hill that lies 1½ miles southwesterly from the stock.

The outcrops of granite on the hill are as shown (Figure 25). The granite is medium-grained, and almost white in colour. Under the microscope this granite is seen to be composed essentially of quartz, microperthite and albite-oligoclase. The ratio of potash feldspar to soda-lime feldspar is a little greater than 5 to 3 which classifies the rock as granite. Because of the almost complete absence of dark minerals and the sodic nature of the plagioclase, this rock could be classed as an alaskite—an alkaline granite with no femics.

Rhyolite porphyry occurs in the areas indicated (Figure 25). It is a light-coloured rock in which the quartz phenocrysts, or eyes, are a very conspicuous feature. Under the

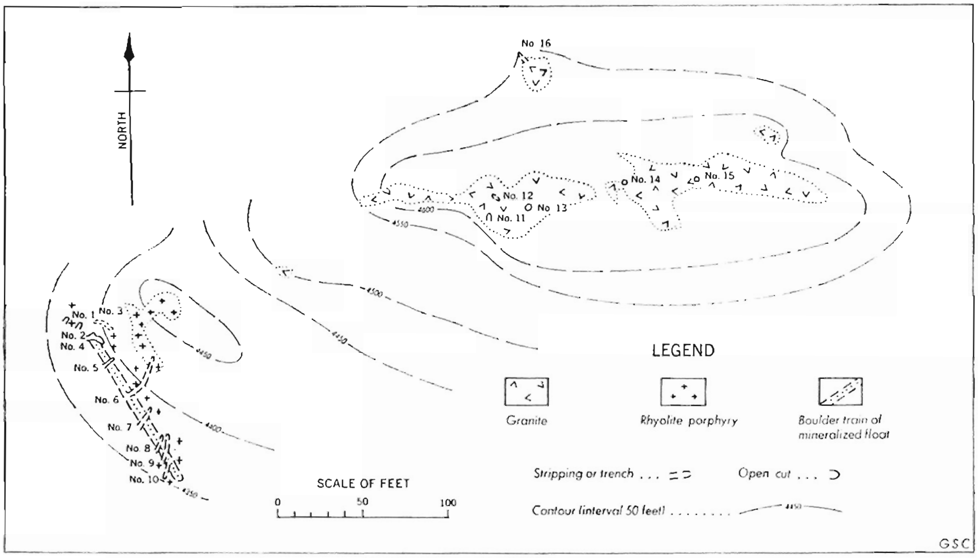

Figure 25. *Sketch map of surface features and workings, Anticlimax Molybdenum property, Lillooet, British Columbia.*

microscope the rhyolite porphyry is seen to be composed of phenocrysts of quartz, microperthite and albite-oligoclase from 1 mm. to 2.5 mm. in size set in a groundmass of the same minerals.

The relation of the rhyolite porphyry to the granite was not evident in the field. However, the writer interprets the rhyolite porphyry as a border phase of the gently-sloping but definitely upper surface of the granite stock. Definite dyke-like relations to the granite were not found; an irregular and indefinite contact with the granite is indicated by a variation in texture of the rhyolite porphyry that is not uniform in any one direction. This non-uniform variation may be the result of the intersection of the uneven surface of the ground with the irregular contact of the rhyolite porphyry and granite. This contact may tend to conform to the gently-sloping upper surface of the composite granite-rhyolite porphyry stock.

One large, and several small masses of aplite occur in the granite and rhyolite porphyry. A large mass in No. 4 pit appears to strike northerly and dip gently eastward. Within the boundaries of the pit the mass measures 50 feet along the exposed dip-length by 15 feet along the strike by 6 feet across the dip. Smaller bodies of aplite occur in the granite to the west of Nos. 11 and 12 workings. In the outcrop these are crescentic to triangular-shaped areas that range from 2 inches to 2 feet in maximum dimension. Although they have no continuity the aplite masses have sharp contacts against the granite. It is probable that the aplite fills gash-like openings in the granite.

Small irregular patches of pegmatite measuring from a few inches to 2 feet in diameter, occur in the rhyolite porphyry and aplite of No. 4 pit, and in the strippings immediately northeast of the pit. The pegmatite patches are very poorly defined and merge into the surrounding rock. The pegmatite is composed of abundant watery quartz and lesser amounts of potash feldspar; in places, as in No. 4 pit, molybdenite occurs in pegmatite.

The granite is massive and cut by only a few joints. The rhyolite porphyry, on the other hand, is cut by a great number of joints, spaced from 2 to 6 inches apart, which strike north 73 degrees west and dip 80 degrees northeastward. The only recognizable features are along the northeast side of No. 4 pit. One of these consists only of a paper-thin fracture that follows a joint-plane; the other is a fracture only ¼ of an inch in width, that strikes north 30 degrees west and dips 75 degrees southwestward; it definitely cuts the first, but there has been no measurable displacement. Apart from the main ore-lens in No. 4 pit, many narrow veins and stringers of quartz and molybdenite cut the granite to the east of No. 4 pit. These veins strike approximately north 25 degrees west and dip steeply northeastward. They are discontinuous in length, pinching out to a mere joint within distances ranging from 2 to 20 feet. They represent joints in the granite that have subsequently been filled mainly by quartz.

The mineral assemblage is definitely high-temperature and closely related to the formation of pegmatites. Medium-grained molybdenite is evenly disseminated in pegmatitic quartz and feldspar and in watery quartz that is adjacent to pegmatitic areas and undoubtedly pegmatitic itself in origin. Small amounts of molybdenite occur elsewhere in narrow quartz veins and stringers that range from ½ an inch to 8 inches in thickness. In addition to molybdenite, small amounts of pyrite, sphalerite and fluorite occur in these quartz veins and stringers. It may be noted that the alkaline nature of the enclosing granite and rhyolite porphyry would presuppose small amounts of fluorite present in the accompanying vein-matter. The molybdenite is most abundant where associated with the pegmatite and pegmatitic quartz of No. 4 pit, and is much less abundant in the narrow quartz veins and stringers elsewhere on the property.

The main occurrence of molybdenite is in No. 4 pit. The mineralized lens has been largely removed. However, it is reported to have comprised a gently-dipping lens approximately 8 feet in diameter by 2 feet thick. Remnants of this lens as seen on the northeast side of the pit consist of molybdenite replacing aplite along ill-defined planes that strike north 65 degrees west and dip 25 degrees northeastward. Remnants of the same lens as seen on the southwest side, consist of an exposure of molybdenite mineralization measuring 8 feet in length by 2 feet in depth by 1 foot in exposed width; in this part of the lens the molybdenite is associated with watery quartz and a small amount of feldspar.

Although the molybdenite of the mineralized lens has several mineral associations, it appears to be most commonly associated with pegmatitic quartz and feldspar. It is found replacing rhyolite porphyry in a few places, more commonly replacing aplite and most commonly associated with the watery quartz and feldspar of pegmatitic patches. In the pegmatite, quartz is much more abundant than the feldspar, and single hand-specimens of the mineralization wrongly suggest that the molybdenite is associated with only quartz. The pegmatitic material occurs as irregular patches, ranging from 6 inches to 2 feet in diameter, and occurs both in the rhyolite porphyry and the aplite.

There is a wide variation in the molybdenite content. A sample taken from a 10-inch specimen of high-grade material in the ore-bin assayed molybdenite 10.8 per cent; another sample from a 12-inch specimen of high-grade assayed molybdenite 5.8 per cent.

A sample taken across 2 feet of the remnant of the lens as exposed on the southwest side of the pit assayed molybdenite 1.4 per cent. A 10-pound sample approximately representative of the ore in the bin assayed molybdenite 1.1 per cent. A sample taken across 14 inches of aplite and banded molybdenite in the northeast side of the pit assayed molybdenite 0.4 per cent.

Stevenson mentioned (pp. 27-28) that the discovery of mineral in situ was a result of following to its origin molybdenite float found in the overburden. Most of the float was distributed by glacial action as evidenced by the parallelism between the alignment of the boulder train and of glacial striae on outcrops on top of the hill. This is probably the only recorded instance of a molybdenite deposit being found in Canada as a result of tracing a glacial boulder train.

Sands Creek Molybdenite

Stevenson's (1940, pp. 33-34) description follows:

The occurrence is a small showing of molybdenite that occurs in the south bank of Sands Creek, a small creek that flows westerly into the Clearwater River and crosses the Clearwater road at a point about 1½ miles back or to the north of the main North Thompson highway near Clearwater Station (C.N.R.) about 76 miles north of Kamloops. The showings are 700 feet downstream from the road-crossing. This property has been briefly described by Walker (J. F., 1931).

The workings consist of a little blasting on three quartz lenses in the bank of the creek. Two of these are close to the top of the 30-foot bank and the third is halfway down the bank at the base of a 15-foot rock bluff that extends down from the upper showings.

The uppermost showing is a lens of barren quartz, 6 feet long by 18 inches thick at its thickest part, that strikes north 70 degrees east and dips 7 degrees southward.

At about the same level in the bank and 20 feet easterly, a 4-foot zone of quartz stringers cuts aplitic granite. These stringers strike north 70 degress east and dip 60 degrees southward and carry a small amount of molybdenite. A sample taken across the zone assayed molybdenite 0.1 per cent.

A short distance below the quartz lens first described, a third showing containing a small amount of molybdenite extends diagonally northeasterly down the bank of the creek for approximately 20 feet. This quartz strikes north 50 degrees east and dips 80 degrees southwards, and ranges in width from 3 inches to 8 inches. A sample taken across 6 inches of vein-matter near the upper end assayed molybdenite 0.3 per cent; and one consisting of selected dump material assayed molybdenite 0.78 per cent. This occurrence is in coarse-grained granite similar to that of the second showing.

Barrière Molybdenite Prospect

The St. Eugene Mining Company Limited, 402 West Pender Street, Vancouver, has investigated (1957-58) a deposit of low-grade disseminated molybdenite in granite, occurring 6 miles north of North Barrière Lake, about 17 miles east-northeast of Chu Chua on the North Thompson River. Work was suspended in the summer of 1958 as the deposit proved to be below commercial grade.

Osoyoos Area

The area stretching from the vicinity of Hedley, over Keremeos, to the neighbourhood of Oliver in the Osoyoos Valley, contains a considerable number of mineral deposits. It includes the classic mining camps of Hedley, Olalla, and Fairview, as well as many individual deposits that have been worked in the past. The only activity in the area at the time of writing was in the neighbourhood of Hedley, where the ore at the Oregon mine was being worked by French Mines Limited and gold was being recovered.

Molybdenite has been reported from several of the deposits, mostly in small quantities as an accessory mineral. A small amount has however been produced from the Golconda mine at Olalla (*see* p. 280).

The geology and mineral deposits of the area have been covered by Camsell (1910), Cairnes (1940) and Rice (1947).

Hedley Area

Molybdenite is widespread in small quantities in the contact-metamorphic or skarn deposits of the area. Camsell (1910, p. 140) mentioned its occurrence at "Twentymile Creek" (now known as Hedley Creek). He gave the locality as "on the north slope of Twentymile Creek, about half a mile below the dam." According to Camsell the molybdenite occurs in fine, small scales, sparingly disseminated throughout quartz diorite near the contact of a rhyolite dyke. The writer unsuccessfully attempted to find Camsell's locality, with the aid of Mr. Hugh Glenn, a prospector, whose cabin is situated in the canyon of Hedley Creek 3 miles north of the bridge.

Mr. Glenn showed the writer large blocks of garnet-diopside skarn carrying sparse flakes of molybdenite and much scheelite, which had fallen from a band 150 to 200 feet above his cabin, on the steep western wall of Hedley Creek canyon.

The French mine (formerly the Oregon)—and the only producing mine in the Hedley camp at the time of writing—lies about 4 miles southwest of Hedley on the steep eastern slope of the Similkameen River valley at an elevation of 4,000 feet. Here, gold was being recovered from an irregular body of skarn (*see* Lamb, 1957).

The country rock consists of brown tuff, limestone, and cherty formations belonging to the Nicola group of Triassic age (Rice, 1947). The vicinity of the mine is underlain at no great depth by a large mass of granodiorite which has presumably contact-metamorphosed the sedimentary rocks.

The orebody is a relatively flat layer of brown skarn associated with strong brecciation, silicification, and shearing in a predominantly limy member of the Nicola group. It has been described by Billingsley (1936) as a 'manto' orebody. The ore is located in a complex structural area, where the sedimentary formations jut westwards into an embayment of the granodiorite mass.

According to Lamb, the following metallic minerals have been identified in the French mine ore: bornite, chalcopyrite, pyrrhotite, molybdenite, chalcocite, covellite, safflorite, cobaltite, gold, native bismuth, and two tellurides—hedleyite and joseite. "None of these minerals is abundant and, except for bornite and chalcopyrite, which occur locally in massive form, they are seldom visible to the naked eye."

The writer visited the underground workings of the French mine in August 1948 to examine some of the occasional local concentrations of molybdenite. The localities visited showed patchy but marked concentrations of rather coarse grained molybdenite in the garnet skarn. Accompanying metallic minerals were bornite, chalcopyrite, and joseite. There is no apparent system in the occurrence of these molybdenite-rich patches and no apparent statistical relationship between the molybdenite and any other mineral, except for joseite, which appears to vary sympathetically with the molybdenite. This mineral association thus shows once again the very general geochemical relationship between molybdenum and bismuth, joseite being a bismuth telluride.

Molybdenite also occurs in similar skarn-type rocks near the French mine, on the *Nighthawk claims* of Hedley Mascot Mines Limited on Cahill Creek.

The Hedley area is thus characterized by a widespread, but sparse and erratic distribution of molybdenite in its contact-metamorphic ore deposits. Like the other molybdenite deposits of this type in British Columbia, it appears likely that none of these can be mined profitably for molybdenite alone.

Ashnola Creek—Stevenson (1940, p. 92) mentioned the occurrence of molybdenite in quartz at a prospect 5 miles up Ashnola Creek—a west-bank tributary of Similkameen River about 10 miles south-southeast of Hedley.

Rice (1947, p. 114) gave a short description of a molybdenite occurrence on the *Forks claim*, situated on the southeast side of Ashnola Creek above the mouth of Ewart Creek, about 6 miles up from the Similkameen River.

> Here a quartz vein 2 to 6 feet wide follows the contact between a granite dyke and badly altered sediments, now quartz-mica schist and gneiss of the Bradshaw or Independence formations. Faulting and fracturing have occurred along this contact, so that both dyke and intruded rocks are traversed with veinlets of quartz. Finely disseminated pyrite, molybdenite, and some chalcopyrite occur in the main quartz vein and veinlets and in the adjacent wall-rocks. A little carbonate is also present.

Keremeos-Olalla Area

Golconda Mine

Chalcopyrite- and molybdenite-bearing veins occurring in shear zones in basic and ultrabasic rocks were opened up during World War I by D. and A. McEachern on the Golconda property. This property lies some 1,000 feet above and a mile to the west of the small settlement of Olalla in the Keremeos River valley, 4 miles north of Keremeos.

The workings are easily approached by a rough gravel road that leaves the Keremeos-Penticton Highway opposite the Olalla autocourt. This road is negotiable by most cars. Golconda mine has been described by Gwillim (1920, pp. 126, 133), Freeland (1923, pp. N162-163; 1928, p. C239; 1931, p. A218), Eardley-Wilmot (1925, p. 43) and Cairnes (1937, p. 36).

Between 1918 and 1925 about 280 feet of tunnels were driven and 10 tons of selected ore carrying 18.6 per cent copper was sent to the Trail smelter. In 1917, 3,390 pounds of 17.10 per cent MoS_2 ore was sent to the Mines Branch, Ottawa; from this 691 pounds of pure molybdenite was recovered. According to Freeland (1927) samples of ore sorted from the lower level of the mine assayed:

Au, trace; Ag, 1 ounce per ton; Mo, 1 per cent; Cu, 7 per cent;
Au, nil; Ag, 2 ounces per ton; Mo 0.4 per cent; Cu, 14.1 per cent.

In 1928 D. McEachern shipped a 100-pound sample to the Mines Branch, Ottawa for mineral-dressing tests. The sample assayed:

Mo, 2.84 per cent; Cu, 4.66 per cent.

The tests gave a recovery of 72 per cent of the molybdenite in a concentrate containing 50 per cent MoS_2 and 3 per cent Cu.

Operations at the property continued in 1930; sorted copper ore assayed from 7 to 18 per cent copper and sorted molybdenite ore assayed 17 per cent MoS_2 (Freeland, 1931, p. A218). More recently the property was taken over by Olalla Mines Limited (NPL) which in 1957 erected a small mill and did some drifting.

The writer visited the property in August 1958 and mapped the underground workings and the surrounding surface features. Samples taken at that time assayed as follows:

Grab sample from chute leading from ore-bin to primary crusher ....0.57% MoS_2

Grab sample of crushed and screened ore on floor of mill ....0.40% MoS_2

Grab sample of fine jigged ore on floor of mill ....0.32% MoS_2

Chip sample over 22 inches true width, vein zone in No. 1 level adit ....0.50% MoS_2

Chip sample over 4 feet true width, vein zone in No. 1 level adit ....1.52% MoS_2

No Bismuth was detected in the samples.

The geology of the Olalla area is shown on Cairnes' map (1937). The Keremeos Valley on each side of Olalla is occupied by a body of pyroxenite of post-Triassic age, belonging to the Okanagan intrusives. This body is about 2 miles across in an east-west direction and 1½ miles north and south. South of Olalla it appears to be intruded by a plug of alkaline rocks about ½ mile in diameter, and at its northwestern extremity it is in contact with a small body of diorite and quartz diorite. This composite intrusive body is surrounded on all sides by sedimentary and volcanic rocks ranging in age from Permian to Tertiary. The copper-molybdenum veins at the Golconda property occur in shear zones in the pyroxenite near its contact with the diorite—quartz-diorite body.

The chief rock type on the property is a coarse-grained, dark green pyroxenite which, in the hand specimen, appears to be composed solely of pyroxene and biotite. Much of the biotite occurs as irregular, lustrous flakes up to ½ inch in diameter; more rarely it is subordinate or absent from the pyroxenite. The ultrabasic rock is bordered to the northwest by a plagioclase-bearing massive igneous rock, probably of gabbroic composition. There appears to be a gradual transition between these two types of rock, suggesting they may be due to differentiation from the same igneous magma. The transition can clearly be seen along the side of a bulldozed road about 100 feet vertically above the bottom adit level of the mine. (*See* Fig. 26.) There the outcrops grade—by slowly increasing plagioclase content—from biotite pyroxenite to a medium-grained gabbro in a distance of about 50 feet. In small outcrops beside the gravel road on the northwest side of Golconda Creek, there is a biotite-plagioclase-pyroxene rock that seems to be a transition from the pyroxenite to the gabbro. To the northwest, up the road, the rocks grade into medium- to coarse-grained gabbro.

Due to scarcity of outcrops it is not easy to delineate accurately the boundary between the pyroxenite and the gabbro, but it appears to run roughly northeast along the southeastern side of Golconda Creek and to dip in a northwesterly direction.

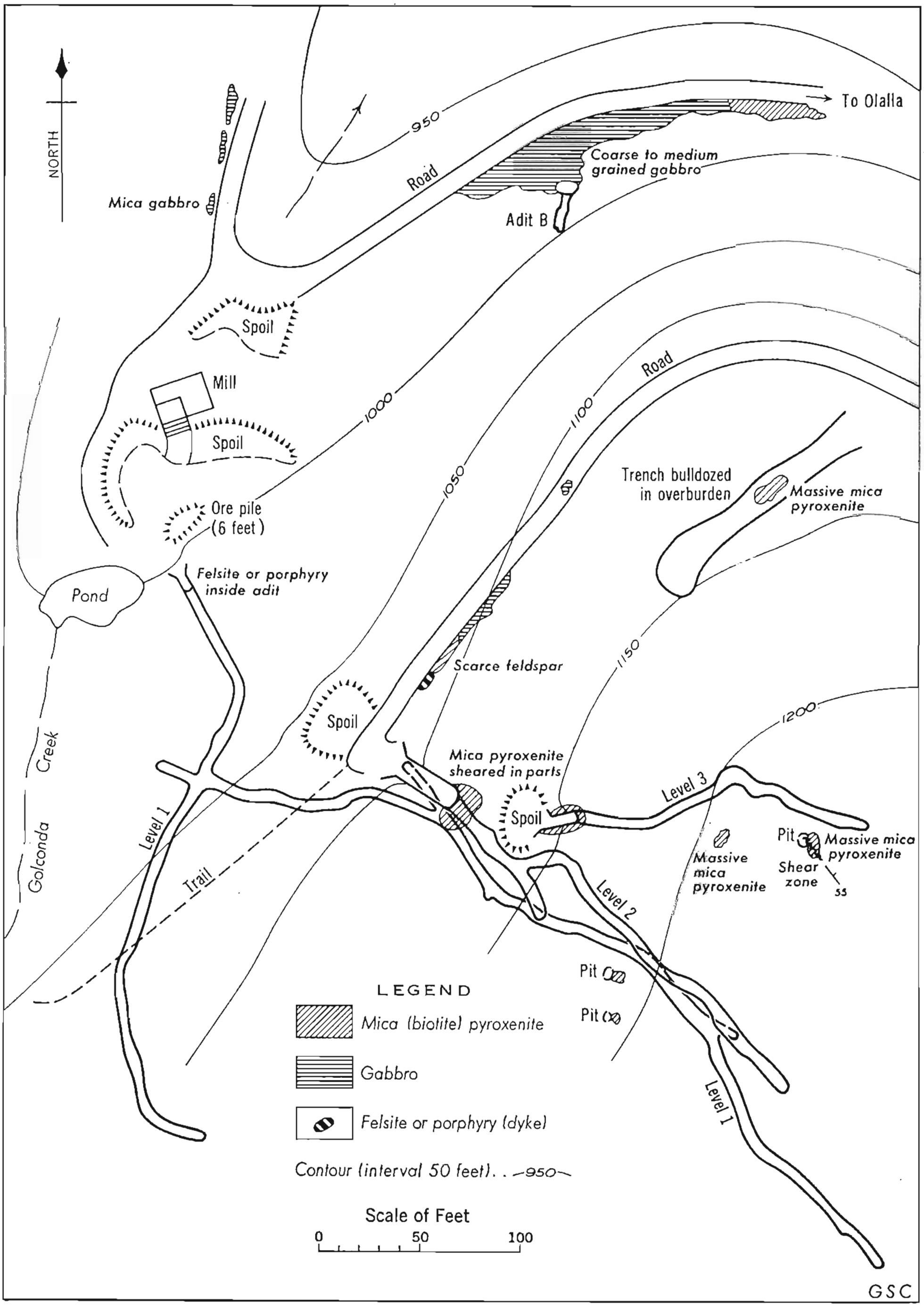

Figure 26. *Sketch map of surface features and workings, Golconda mine, Olalla, British Columbia (1958).*

A third type of rock occurs as an irregular dyke in a direction about N70°W, cutting through the mica pyroxenite. This is a light-coloured, generally very fine grained, granitic rock—perhaps best described as a hornblende-feldspar porphyry. It shows, typically, a pinkish white microcrystalline groundmass, with sparsely scattered light green fibrous hornblende crystals of the order of $\frac{1}{2}$ to 1 mm long, and less-abundant pink feldspar of the same order of magnitude. This dyke rock is very blocky and jointed and much of it is highly shattered, suggesting that it was emplaced prior to the movements that opened up the vein structures. The porphyry was mapped in the lowest adit level, on the hillside just north of the middle adit, and in the inner part of the upper level. The alignment of these exposures suggests they are all part of the same dyke and that it is vertical. The contact between the dyke rock and the enclosing pyroxenite is irregular in the extreme and is mostly 'sealed' or 'frozen'.

The main openings are three adits driven into the steep south-eastern slopes of Golconda Creek (*see* Fig. 26). In all, more than 1,200 feet of drifts and cross-cuts were available for inspection at the time of the writer's visit, of which the greater part was the bottom adit level. Taking this level as zero elevation, the elevations of the other two levels are roughly +100 feet and +145 feet respectively. They will be referred to as levels 1, 2, and 3 respectively, from the lowest upwards.

There is very little evidence of stoping in the underground workings; the backs along some of the drifts have been slashed, but most of the muck appears to be still in place. A few short raises have been driven from the lower level, but nowhere has a connection been made between levels.

In addition to the underground workings there are several open-cuts, mostly in overburden, on the hillside above the adits. These revealed little of the vein structures or mineralization.

To the north of and just below the portal of level 1, a small mill had been newly erected (winter 1957-58). Water for mining and milling purposes was obtained from a small pond formed by damming the Golconda Creek at a point south of the mill. (At the time of the writer's visit the flow in his creek was very small due to the prolonged summer drought.)

The molybdenum-bearing zone at the Golconda mine is a northwesterly trending shear and crush zone in the mica pyroxenite. All exposures of this zone (mostly underground) lie to the southeast of the pyroxenite-gabbro boundary and it is not known whether the structure extends across this boundary or not. The shear zone was mapped on levels 1 and 2 (*see* Fig. 27, in pocket). It is not present on level 3, which appears to have been driven too far to the northeast. On level 1 the structure is exposed over a length of approximately 450 feet, and on level 2, over about 250 feet. The actual orebodies consist of irregular and discontinuous sheets or lenticular veins of white quartz lying in the shear zone, and in some places the sheared and crushed pyroxenite is itself mineralized. In one or two places a more general silicification of the crush zone has taken place, resulting in a much greater width of vein quartz. Normally, however, the quartz 'ribs' exposed underground vary in width from an inch or so to about a foot. The width of the shear zone in which they lie varies from 6 inches up to about 5 feet.

In plan, the shear zone shows several 'splits' or branches along its length. These are well illustrated on the plan of level 1 (*see* Fig. 27). Lack of exposures makes it difficult to assess the importance of these 'splits' and to decide whether the more promising branch has in each case been followed. On level 1 three main splits occur in the vein structure; two leave the structure at 20 or 30 degrees in a clockwise direction, and the third, that nearest the portal, is in the opposite direction. On level 2 the vein structure, as followed in from the portal, makes a marked curve to the east and connects with a new branch having the same strike as the original one. It was not possible to deduce any overall pattern to the branching veins but in any future development it might be advisable to follow both branches after a 'split'.

The dip of the vein structures, as seen on the two levels, is everywhere to the northeast at angles of about 60 to 75 degrees, though dips as low as 45 degrees were measured locally. However, if the shears on the two levels connect (*see* Fig. 26) an overall dip must be to the southwest. The possibilities are: (a) a roll or marked change in dip between the two levels; (b) splitting or branching of the structure down dip as well as along strike; or (c) two separate, parallel vein structures. Considerable movements appear to have taken place along the shear zones since the emplacement of the quartz veins and the sulphide mineralization. These movements have resulted in crushing and fracturing of the vein quartz, in the formation of gouge zones within the shear zone, and in the general reactivation of the shear itself. It is indeed difficult to assess the relative amounts of 'pre-mineral' and 'post-mineral' movement. The most striking result is the formation of the gouge zones, generally only an inch or two thick and lying on the hanging-wall or the foot-wall, or in some intermediate position in the vein zone. The walls of these gouge zones are normally very strong and smooth and form a good wall to break to in drifting. However, they do not everywhere coincide with the vein walls and mineralized material may lie behind them. In the re-sheared parts of the vein structure, molybdenite is notable as an extremely fine coating on the planes of movement; it has no doubt acted as a lubricant along these planes.

The main introduced minerals in the quartz veins and shear zones are pyrite, chalcopyrite, and molybdenite. Galena is a minor mineral intimately associated with the chalcopyrite. Cairnes (1937, p. 36) mentioned the presence of "considerable feldspar" in the quartz. This was not seen by the writer, though in places small 'schlieren' or thin lenses of pegmatitic material only a few inches long could be seen in the sheared pyroxenite along the vein zone.

The molybdenite is everywhere extremely finely divided, pulverulent, or amorphous. It occurs in irregular patches in vein quartz, but mainly as fine coatings on fractures and along the margins of the quartz veins. In the shear zone away from the vein quartz it occurs, as mentioned above, as smeared coatings on the planes of post-ore movement. Its mode of occurrence would suggest a fairly late age of deposition with respect to the other sulphides. The pyrite and chalcopyrite occur as irregular subrounded patches within the vein quartz; the pyrite shows, normally, good crystal outlines, whereas the chalcopyrite is massive. There appears to be no sympathetic variation between the various minerals.

Other Occurrences

West Summerland—Stevenson (1940, p. 90) mentioned a prospect "near West Summerland", where molybdenite occurs in a quartz vein at the contact of granite and schist. A certain amount of trenching and stripping had been carried out and 246 pounds of 0.3 per cent MoS_2 material was shipped.

Cairnes (1937) mentioned the occurrence of molybdenite in deposits at *Fairview camp*, on the west slopes of the Okanagan Valley above Oliver. There minor amounts of molybdenite occur in quartz veins with free gold, pyrite, galena, sphalerite, and chalcopyrite.

At the *Silver Star mine*, on the west side of Similkameen River 10 miles south of Keremeos, a quartz vein in a shear zone carries tetrahedrite, galena, chalcopyrite, sphalerite, and molybdenite (Cairnes, 1937).

Grand Forks Area

Occurrences of molybdenite have been reported and described from mineral deposits near Greenwood, from the ores of the Franklin camp on Granby River, and from two localities east of Christina Lake.

Brock (195 pp. 51-69A) described the occurrence of minor amounts of molybdenite in shear-zone replacement veins, together with magnetite, pyrrhotite, chalcopyrite, arsenopyrite, specularite, galena, and sphalerite, in the Boundary Creek district due north of Greenwood.

In the ores of the Franklin camp, molybdenite is commonly associated with chalcopyrite in shear zones in granodiorite (Stevenson, 1940, p. 80).

The *Copper No. 2 claim,* is in the McKinley group on the east side of Granby River, opposite Franklin townsite. There molybdenite occurs with pyrite and small amounts of gold, silver, and copper, in highly silicified limestone, probably at a contact with the granodiorite (B.C. Min. Mines, Ann. Rept. 1923, p. A179).

The *Gloucester property* is on the Gloucester Creek slope of Franklin Mountain. Copper ore carries chalcopyrite, bornite, pyrite, and molybdenite (Drysdale, 1912, p. 138).

At the *Leah property,* near the Copper No. 2 claim on the east side of Granby River, bornite, chalcopyrite, pyrite, and molybdenite occur in slips in granodiorite that is cut by narrow dykes of alkali syenite and capped by limestone (B.C. Min. Mines, Ann. Rept. 1923, p. A179).

At the *Mother Lode mine,* 8 miles north of Grand Forks on the Granby River, a complex silver-lead-zinc ore carries minor amounts of molybdenite with pyrite, galena, sphalerite, and chalcopyrite; small amounts of gold and platinum are also present. The minerals occur in quartz veins cutting highly silicified sediments (Freeland, 1933, p. A123; O'Neill and Gunning, 1934, p. 104).

Molybdenum Nos. 1, 2, and 3 Claims—McCrae Creek

This prospect lies on the northern slopes of the valley of McCrae Creek, a small stream draining westerly into Christina Lake. It lies about ⅔ mile west of the old Christina Lake - Paulson road at a point about 7½ miles north of the junction of the Christina Lake road with the main Rossland - Grand Forks Highway. A new stretch of the Trans-Canada highway is (1958) being constructed up the south side of McCrae Creek and this will eventually give easier access to the area.

No work has been carried out since Stevenson (1940, pp. 19, 20) examined the property in June 1938 and the writer has little to add to his description. According to Stevenson the mineral claims were staked in 1937 by E. and J. C. Ness and are owned by the estate of the late J. B. Thomson.

The workings lie on a steep, wooded hillside at an elevation between about 1,000 and 1,400 feet. The workings seen by the writer consist of two trenches and an irregular blasted area. The old shaft described by Stevenson could not be found.

The uppermost working is a trench about 50 feet long and 5 feet wide by 2 to 3 feet deep; it trends N80°W. It has been driven across the foliation of a very coarse quartz-feldspar gneiss—almost a gneissose pegmatite—which consists mostly of feldspar, quartz, and biotite. Much of the quartz and feldspar occurs as a graphic intergrowth. The foliation in this gneiss strikes N65°E and dips 30°SE. Very little molybdenite was seen in this trench. Stevenson took samples for 10 and 30 feet respectively along the north wall, and both assayed 0.04 per cent MoS_2. Picked material from the ore dump assayed 0.2 per cent MoS_2.

From the northeast end of this trench the northeast end of the next lower trench is 130 feet away in a S30°W direction. This working is a rather irregular trench, partly in overburden and partly in the gneiss. It is about 20 feet long and a maximum of 10 feet wide. The trend of its longer axis is N55°W. The gneiss exposed mainly as large, loose blocks covering bedrock, is not quite as coarse and pegmatitic as in the uppermost working, except in a few bands and patches. Molybdenite is visible as occasional flakes of the order of 1 to 2 mm in diameter. It is preferentially concentrated in a coarse, pegmatitic zone at the northwest end of the trench. Stevenson mentions a concentration at the southeast end also, in a zone about 18 inches wide. A sample across this zone assayed 0.8 per cent MoS_2; picked material from the dump assayed 1.4 per cent MoS_2.

About 1,000 feet down the hillside to the southeast from the second working is an irregular blasted area, consisting mainly of a low face or cut in the rocks of a small ridge. This cut exposes 2½ feet (true thickness) of coarse, whitish feldspathic gneiss between walls of dark grey biotite paragneiss striking N25°E and dipping 25°SE.

Molybdenite is not at all obvious and is probably all confined to the coarse gneiss; in this, large irregular segregations of vein quartz carry a few specks and flakes of the molybdenite. Stevenson's sample—across "3 feet of the best mineralization"—assayed 0.04 per cent molybdenite.

The occurrences thus consist of scattered flakes of molybdenite in quartz-feldspar-biotite gneiss, and it seems that the most abundant molybdenite is connected with the very coarse parts of the gneiss; the occurrence may perhaps be classed as being of the pegmatitic type. However, the pegmatitic patches and schlieren are probably due to granitization of metamorphic differentiation; they do not appear to be injected dykes or veins. Exposures are very limited and it is possible that the mineralization extends over a large area. However, the grade appears to be so low that the chances of finding quantities of molybdenite are slight.

About ½ mile southwest from these workings, along the hillside, the writer found a 1-inch zone of rusty paragneiss that carried sparsely disseminated flecks of molybdenite along the edges of a ½-inch band of quartz-feldspar pegmatite. A small chip sample of this band gave 0.38 per cent MoS_2. Thus, a wide area on the northern slopes of McCrae Creek seems to be sparsely mineralized with molybdenite. But paucity of outcrop makes prospecting difficult and the grades so far revealed are not very encouraging.

Midas Group

Stevenson (1940, pp. 16-18) reports:

This molybdenite property includes the Midas Nos. 1 to 4 mineral claims staked in May 1938, by F. O. Friske and owned by A. J. Cleeton of Cascade. This property was examined by the writer in June 1938.

The claims lie in the Trail Creek Mining Division to the northeast of the flag-station 'Tunnel' on the Kettle Valley Branch of the Canadian Pacific Railway. Tunnel is at mileage 50, as measured westerly from Nelson. From Tunnel the property is reached by leaving the railway at Mile 47.5 and proceeding up the relatively open hillside and along the ridge-top in a southwesterly direction for approximately 2½ miles. There is no well-defined trail.

The showings are extremely old and the surface work is all caved. The main workings are two adits, at approximately 5,000 feet elevation, on the easterly side of a northly trending ridge and approximately 80 feet below the crest. This ridge is the top of a spur that extends down to the north between Brooklyn and Pup Creeks. There is also an open-cut and caved shaft on the easterly side of the ridge only a few feet below the top at a point approximately 1,000 feet to the south of the adits.

The ridge-top in the vicinity of the workings is quite open, the timber having been burnt by a large fire about 1932. The slopes on either side are steep and covered by either talus or a veneer consisting of talus and soil; the overburden is not deep.

There are no camp-buildings on the property.

The Midas molybdenite deposit consists of small amounts of molybdenite in quartz stringers and in slightly-brecciated syenite. Very little mineralized material was found in place by the writer. Small amounts of fluorite, chalcopyrite and more abundant pyrite, and magnetite and hematite occur with the molybdenite.

The most abundant rock on the property is syenite. It is a medium-grained rock, somewhat porphyritic in texture, of a definite-pink colour and consists mostly of pink potash feldspar. The syenite is cut by feldspar-porphyry dykes that range from 4 to 8 feet in width, strike easterly, and dip 70 degrees northward; only two such dykes were seen on the property. One narrow andesitic dyke was seen, in the upper adit. This dyke is 18 inches wide, dark-green in colour and relatively fresh in general appearance.

An adit has been driven to the west for 104 feet into the hillside from a point 85 feet below the crest at a point approximately 2½ miles southerly from mileage 47.5 on the railway. The working has been driven north 87 degrees west as an open-cut for 20 feet, then as an adit for 32 feet, then north 66 degrees west for 40 feet, then south 81 degrees west for 25 feet and lastly north 50 degrees west for 7 feet to the face. At the portal a shaft has been sunk on a 70-degree slope northwestward, a minimum distance of 10 feet. The shaft was filled with water at the time of the writer's examination (June 1938). From the open-cut, the adit follows the south wall of a westerly striking feldspar-porphyry dyke for 72 feet. This dyke ranges from 6 to 8 feet in width and dips 70 degrees northward. At 32 feet from the portal an 18-inch, andesite dyke strikes northwesterly across the adit, but on reaching the foot-wall of the porphyry dyke it bends and follows this to a point 40 feet farther in where the adit leaves both dykes.

A small dump of approximately half a ton, was seen at the portal, but very little mineralized material could be found in place. The only mineralization consisted of a few splashes of hematite and magnetite along the contact of the syenite and feldspar-porphyry dyke at the portal. The shaft has been sunk at this point and it is presumed that the molybdenite on the dump was found in the shaft and in the vicinity of, if not actually along, the contact. The mineralized material on the dump consists of blebs of molybdenite ranging from $\frac{1}{16}$ to $\frac{1}{2}$ an inch in diameter, that occur in narrow quartz stringers or slightly brecciated syenite. Small amounts of fluorite and chalcopyrite, and in places much pyrite, and magnetite and hematite occur with the molybdenite; of these minerals, molybdenite is one of the least abundant. A sample representative of dump material assayed: molybdenite 2.1 per cent; gold nil; silver nil; copper 0.1 per cent.

A second adit has been driven from a point south 80 degrees east from and 40 feet below the first adit. This working has been driven in a direction south 80 degrees west as an open-cut for 12 feet, thence in the same direction as an adit for 30 feet, then north 70 degrees west for 16 feet to the face. A winze filled with water at the time of the writer's examination (June 1938) has been sunk at 30 feet from the portal. From the mouth of the open-cut, a second open-cut has been driven northwesterly for 4 feet and westerly for 8 feet to an incline shaft sunk 10 feet on a 60-degree slope westward. Both the adit and entry open-cut follow the hanging-wall of a feldspar-porphyry dyke. This dyke strikes westerly and dips 70 degrees northward; it is not the same dyke as the one exposed in the upper adit.

The second open-cut follows the foot-wall of the dyke. Other than the feldspar-porphyry, the rock is pink syenite. No mineralized material could be found in place, but about 50 pounds of molybdenite-bearing material was seen in a small dump. The mineral association is similar to that as described for the upper adit.

At a point approximately 1,000 feet to the south along the ridge, an open-cut extends in a direction north 10 degrees west for 12 feet to what was apparently a shaft, now entirely caved. From the shaft a trench extends along the hillside in a direction south 70 degrees west for 25 feet; this trench is largely caved. Molybdenite and its yellow oxidation product, molybdite, occur in short stringers in pink syenite within a zone approximately 6 feet wide that strikes northwesterly across the caved shaft. The stringers average 1 foot in length by 1 inch in thickness and contain, in addition to molybdenite, abundant magnetite and hematite. A picked sample from a small pile of mineralized material at the mouth of the cut assayed: molybdenite 0.3 per cent; gold nil; silver nil; copper nil.

Rossland Area

Molybdenite occurred in small but variable quantities in the sulphide ores of the Rossland mining camp. So far as is known, very little, if any, was recovered. Its occurrence in the Rossland ores has been described by Drysdale (1915a, p. 78), Bruce (1917), and Eardley-Wilmot (1925, pp. 46-47).

Drysdale wrote:

> Molybdenite occurs in a fine-grained massive form and as scaly aggregates in masses or veinlets, associated with the other sulphides of the ores. At the Velvet mine on Sheep Creek 10 miles west of Rossland, there is a lens of soft flaky molybdenite 2 feet wide by 3 inches across. The mineral is a common mineral in the veins of the Coxey and Novelty claims on the west slope of Red Mountain. Here, it is the massive- fine-grained variety. In the Novelty ore arsenopyrite with but little chalcopyrite is present, while in that from the Coxey, arsenopyrite is almost absent and chalcopyrite rather abundant. The two claims are located on different parts of the same vein.

Molybdenite also occurs on the St. Elmo and Deer Park claims and is most abundant in the Giant ore, associated with arsenopyrite a little chalcopyrite and magnetite. It forms frequently along small fractures in the rock, and at the intersections of such fractures develops into masses, in some places a foot in diameter, of pure molybdenite. The pulp from samples of 3,000 tons of ore shipped, according to information supplied by Mr. R. Marsh, ran 3 per cent in molybdenum (Mo). In a stope of the Jumbo mine, against the main mass of alkali syenite, the ore is rich in molybdenite. Molybdenite is occasionally found in the Centre Star and War Eagle mines where it is very fine-grained and usually forms very thin layers along fracture-planes. In the lower levels of the War Eagle mine it is intimately associated with free gold where the gangue is altered diorite porphyrite.

Eardley-Wilmot (p. 47) gave a little further information on the Coxey mine:

The main work on the property was done about 1910, before the existence of molybdenite was suspected, and about 300 feet of tunnels were driven into the hillside. The ore ran about 7 per cent copper and $10 to $60 in gold. . . .

During the war (World War I) the mine was worked by two lessees, Messrs. S. L. Williams and John Ruffner. In 1918 they sent to the Mines Branch, Ottawa, 3,423 pounds carrying 10.54 per cent MoS_2 and 2,003 pounds carrying 21.58 per cent MoS_2.

It is interesting to note that 10 to 50 per cent of the gold values in these mines where molybdenite occurs, is in the free state, and is closely associated with dykes of alkali syenite. This metallic gold in the alkaline solutions may have been precipitated by the chalcopyrite and molybdenite. . . .

Salmo Area

Molybdenite occurs in several of the ore deposits in the Salmo mining area. Two deposits—the Molly mine and the Sapples property—have been developed for this mineral alone, but actual production was confined to the Molly. In several other deposits molybdenite occurs as an accessory mineral only.

The main deposits carrying molybdenite occur along the western contact of the Lost Creek granite and at the northern end of an isolated exposure of the same granite on Bennett Creek, a tributary to Sheep Creek. According to J. F. Walker's (1934, p. 23) account of the area, the age of the deposits "can be placed as occurring at a late stage in the intrusion of the Nelson batholithic rocks of Post-Triassic age."

Molly Mine

The old workings of the Molly mine are on the steep southerly slopes of Lost Creek, a north-bank tributary of the south fork of Salmo River. They are approached by leaving the Nelson-Nelway Highway at a point about 9¾ miles south of Salmo and following an old road along the steep northern bank of the south fork of Salmo River for about 1½ miles, to Lost Creek. A rough branch-road runs northeasterly up the northwest side of Lost Creek for about 2¾ miles to a point about 600 feet below the workings. The Lost Creek road is probably accessible for 4-wheel-drive vehicles all the way to this point. A dilapidated bridge crosses the creek to the mine camp on the southern bank, and from this, a zig-zag trail leads up to the old mine.

The geology and workings of the Molly mine have been described in detail by several workers. The more important publications include those of Drysdale (1915b), Eardley-Wilmot (1925, pp. 36-38), J. F. Walker (1934, p. 84), and Stevenson (1940, p. 54-57). According to Eardley-Wilmot the four claims covering the property were staked in July 1913 by S. N. Ross, H. E. Bennett, and J. A. Benson, and worked by them later that year. In 1914 the property was leased for 6 months by Bell Brothers of Salmo. In 1915, Merton Merrill of the British Columbia Molybdenite Company held a $100,000 lease on the property; in the following year the mine was under lease by the International Molybdenum Company of Renfrew. Later the claims were acquired by the Consolidated Mining and Smelting Company, which carried out work at intermittent periods from 1926 onwards. Stevenson mentioned that this company did "considerable diamond-drilling" prior to 1934. The claims are still held by Consolidated Mining and Smelting Company.

According to a table published by Eardley-Wilmot (1925, p. 38) the total production of the Molly mine in the years 1914-1917 was 404,920 pounds of ore with an average MoS_2 content of 5.88 per cent. He estimated that this figure corresponds to a run-of-mine grade of about 3½ per cent MoS_2. It seems from observations by the writer and Stevenson that little ore remains in the present mine openings. The possibility of further deposits along the granite-sediment contact, however, cannot be ruled out.

The most recent account of the general geology of the Salmo area is given by Little (1950). His map shows that the Molly mine, in common with the Sapples and Jumbo occurrences to the north, occurs at the western contact between the granite of the Nelson batholith (Cretaceous ?) and sediments (schists, phyllites, argillaceous quartzites, and argillites) of the Lower Cambrian Laib group. These sediments were previously referred to (by J. F. Walker and others) as the Pend d'Oreille series and thought to be Late Precambrian in age. In the neighbourhood of the old workings these sediments (dark grey fine-grained argillaceous hornfels) overlie the granite, and the strike and dip of the contact appears to be sensibly parallel with that of the sediments themselves, i.e. about due north, dipping at 35°W. The sediments exhibit a marked grooving or lineation plunging 25° in a direction S30°W.

The granite, which is very quartz-rich and almost without mica, is markedly jointed or sheeted more or less parallel with the contact. Molybdenite occurs in this sheeted zone rarely more than 10 feet thick, close to the contact. According to J. F. Walker the best mineralization appears to have taken place at a point where the contact dips at low angles, as if this were near the top of the granite body. Drysdale mentioned an upper chilled border or 'capping' to the granite, averaging about 6 feet in thickness though varying considerably from place to place. The granite in this 'capping' is a fine-grained aplitic rock sparsely impregnated with a few molybdenite flakes. The molybdenite ore zone is located beneath this capping. The molybdenite lies along the interlocking joint planes as well as being disseminated throughout the granite between them. Drysdale remarks that in places the granite in the ore zone becomes blocky and contains less orthoclase than normally. In such places the ore becomes leaner or even barren. The granite underneath the sheeted zone is also very massive and blocky and lacking in molybdenite. Thus the most obvious control of the ore deposition is the zone of sheeted granite. However, the sheeted zone is not evenly mineralized and in places is barren. Some possible controlling structures for this localization were noticed by the writer and these will be discussed below.

The workings themselves reveal very little of the original ore, but on the dumps most blocks carry between 1 and 5 per cent molybdenite. This would constitute a good concentrating ore but seems to have been rejected during hand-sorting. The total tonnage of this type was not however large and nothing of this quality was seen in situ in the old workings. To judge by the spoil and the figures given by Eardley-Wilmot, the ore shoot at the Molly mine must have been of very high grade, but small.

Ore specimens on the dumps show that the main sulphides were pyrrhotite and molybdenite. J. F. Walker stated that pyrite and chalcopyrite are also present as minor constituents. Specimens were seen in which the main sulphides occurred both separately and together. Molybdenite occurs alone, typically as small radiating rosettes, 1 to 2 mm in diameter, scattered evenly through the granite. Molybdenite also occurs in very rusty blocks of granite as irregularly scattered flakes together with much fine-grained pyrrhotite. In places the latter mineral also occurs alone.

The workings at the Molly mine are illustrated by Figure 28. The portal of the adit was caved and it has been drawn from the description by Stevenson. According to him very little molybdenite can be seen in these underground workings, though Eardley-Wilmot reported that the best ore on the property was found at the bottom of the winze that connects the lower open-cut with the adit.

The main open-cut is an irregular trench generally 6 to 8 feet deep but only 2 feet deep in places. This trench has been driven up the slope of the hillside for 70 to 80 feet starting from a point about 140 feet above the portal of the adit. It is driven almost parallel with the sheeted zone in the granite which dips at about the same angle as the slope of the hillside. The general strike and dip of the sheeted zone here are N20°E and 40°NW. Within the zone, however, individual joints or sheeting planes are not parallel, but converge. The part of the zone that appears to have been stoped the most is a 5- to 6-foot-thick band lying immediately above the foot-wall of the trench. This stoped part continues without break down dip into the winze. It is not accessible for inspection but appears to be rustier than the overlying granite and therefore, possibly, was more intensely mineralized. The overlying granite carries only sparse flakes of molybdenite and shows little of the rusting due to accompanying pyrrhotite.

Under the south wall of the upper part of the trench a small 'room' has been stoped out, and from this an adit leads for a few feet southwards. This adit appears to have been driven in the wall of the trench where two sets of sheeting joints intersect. To the west, in the winze and the lower half of the trench, the attitude of the sheeting is normal—N20°E and 35°NW. At the adit this set intersects an almost horizontal set that is visible in the lower half of the

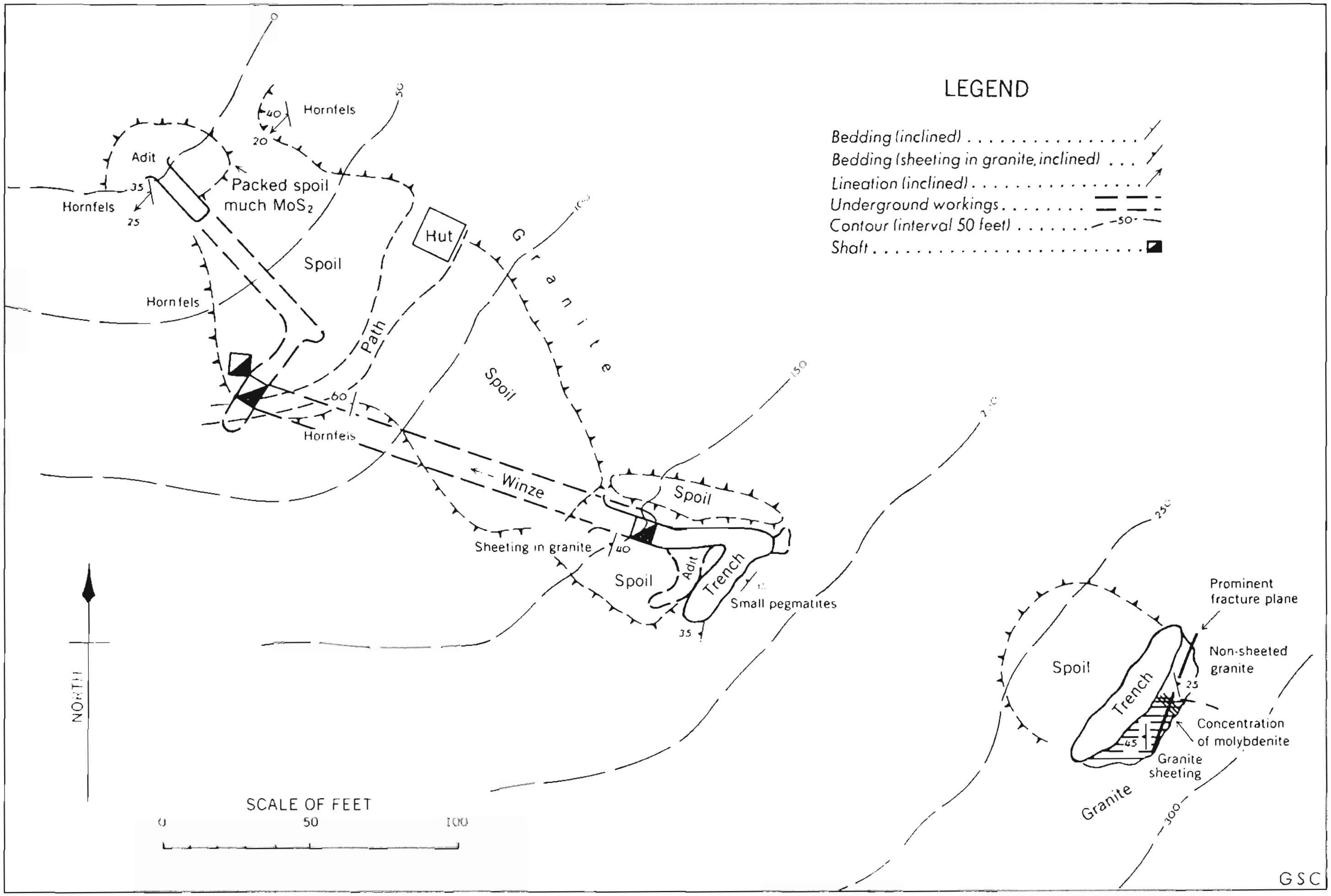

Figure 28. *Molly mine, Salmo, British Columbia. From tape and compass survey, 1958.*

upper part of the trench. It is possible that the intersection of these two sets of joints may have served to localize ore deposition at this spot.

Towards the east (upper) end of this trench a horizontal cut has been driven in a southwesterly direction along the hillside for 30 to 40 feet. This cut has been excavated in sheeted granite, the sheeting dipping at about 35°NW. The foot-wall section is very rusty due to the weathering of moderately plentiful pyrrhotite. Flakes and rosettes of molybdenite are visible but not abundant. It seems that the part of the sheeted zone carrying more molybdenite reaches the surface at this cut—i.e. its dip is there steeper than the slope of the hillside, causing it to out-crop. Irregular bodies of quartz-feldspar pegmatite occur in the granite above this open-cut.

In the easterly end of the main trench a short adit has been driven in the sheeted granite, which is there barren as it is in the foot-wall of what appears to have been the more mineralized zone.

Eastwards along the hillside at the level of the upper end of the main trench are shallow blasted pits in the granite. They reveal discontinuous patches of rusty rock carrying pyrrhotite and molybdenite. The granite in this area is not sheeted and is obviously in the foot-wall of the zone.

Nearly 100 feet higher up the hill to the southeast a horizontal bench has been excavated along the steep hillside. The southeast face of this bench, which is up to 20 feet high, exposes patchily rusted granite carrying flakes of molybdenite sparsely scattered all through the rock between the joints. A markedly sheeted zone occupies the southwestern two thirds of the face of the bench. This sheeting strikes north and dips 45°W. The sheeted zone is underlain to the northeast by blocky, more massive granite, with irregular steeply dipping joints. One very marked joint or fracture plane, striking N10°W and dipping 25°W, intersects this blocky granite and passes through the sheeted zone without any apparent displacement. There is very local but marked concentration of minerals, especially of molybdenite, where this fracture intersects the foot-wall of the sheeted zone. Above this foot-wall concentration, the zone shows only occasional small flakes of molybdenite, whereas at the intersection it comprises about 10 per cent of the rock and occurs as radiating rosettes up to 2 mm in diameter.

This intersection has obviously controlled the deposition of molybdenite at this place, but it would not be justifiable to conclude that any large quantities of ore were localized by this means. However the calculated trend of the intersection of the fracture plane and the foot-wall of the sheeted zone is parallel with the direction of the lower open-pit and the winze. The orebody previously worked seems to have had a pipe-like or strip-like form within the plane of the sheeted zone, and the reason why this ore did not extend sideways—the sheeted zone away from the workings is almost barren—is not clear. Some form of 'linear' control such as the intersection of prominent fracture planes with the sheeting in the granite is a possible explanation of the form of the orebody of the Molly mine.

Drysdale (1915b, p. 255) inferred that

> . . . the molybdenite is slightly younger than the enclosing granite, although from the same parent source, and either accompanied or followed the intrusion of the pegmatite dykes which represent the latest crystallization of the granite magma. In this pegmatitic magma, molybdenum disulphide was probably a prominent constituent. . . . The molybdenite appears to be the result of impregnation at the time of or following pegmatitic intrusions rather than an original constituent of the granite.

From field observations, it seems clear to the writer that the molybdenite at the Molly mine was introduced sometime after the consolidation of the granite, for the connection with somewhat rare pegmatites is not so obvious to the writer as it was to Drysdale. The deposition was controlled by the sheeted zone near the granite-sediments contact and possibly localized within this zone by prominent fractures intersecting the sheeting.

The process was essentially mineralization by Fe-S-Mo, and it resembles, for example, that in the Grenville Region of the Precambrian shield, as well as in other localities. Its ultimate source is open to question. It is doubtful whether a purely granitic origin should be ascribed to so basic a deposit.

Sapples Molybdenite Property

This property consists of the Little Keen, Last Chance, and Lucky Jim mineral claims, staked in 1932 by Jack Sapples of Salmo (Stevenson, 1940, p. 50). It lies about 500 feet above, and ½ mile south of, the junction of Sheep and Bennett (Bear) Creeks—about 5¾ miles due southwest of Salmo. It is reached by driving 3.8 miles southwards along the Salmo-Nelway Highway from Salmo to the Sheep Creek road and then 4.2 miles up this road to an old track that enters from the south. This track leads up to the old mine workings, which lie on a steep, well-wooded hillside sloping to the northeast.

The main reports concerning the geology and workings on the Sapples property are those of J. F. Walker (1934, p. 86) and Stevenson (1940, pp. 51-54). The property was examined and mapped by the writer in September 1958. The workings that show molybdenite consist of a short adit and two open-cuts in the hillside (*see* Fig. 29). In addition there is an 8-foot shaft sunk in the hillside to the south of and some 30 feet higher than the upper open-cut. Southwest of the latter are two apparently very old trenches or cuts which are now collapsed and partly overgrown.

The general geology of the Sheep Creek area has been described by J. F. Walker (1934) and Little (1950). The molybdenite occurrence lies at the contact of a small body of fine-grained Nelson granite that outcrops in an area of banded argillaceous and calcareous sedimentary rocks with some crystalline meta-limestones. These sedimentary rocks were classed by Walker as belonging to the Precambrian Pend d'Oreille series, but subsequent work in the area has caused a revision of this classification; Little considered them to be Lower Cambrian and included them in the Laib group. Outcropping a short distance south of the Sapples granite body, is a larger body that is elongated in a northerly

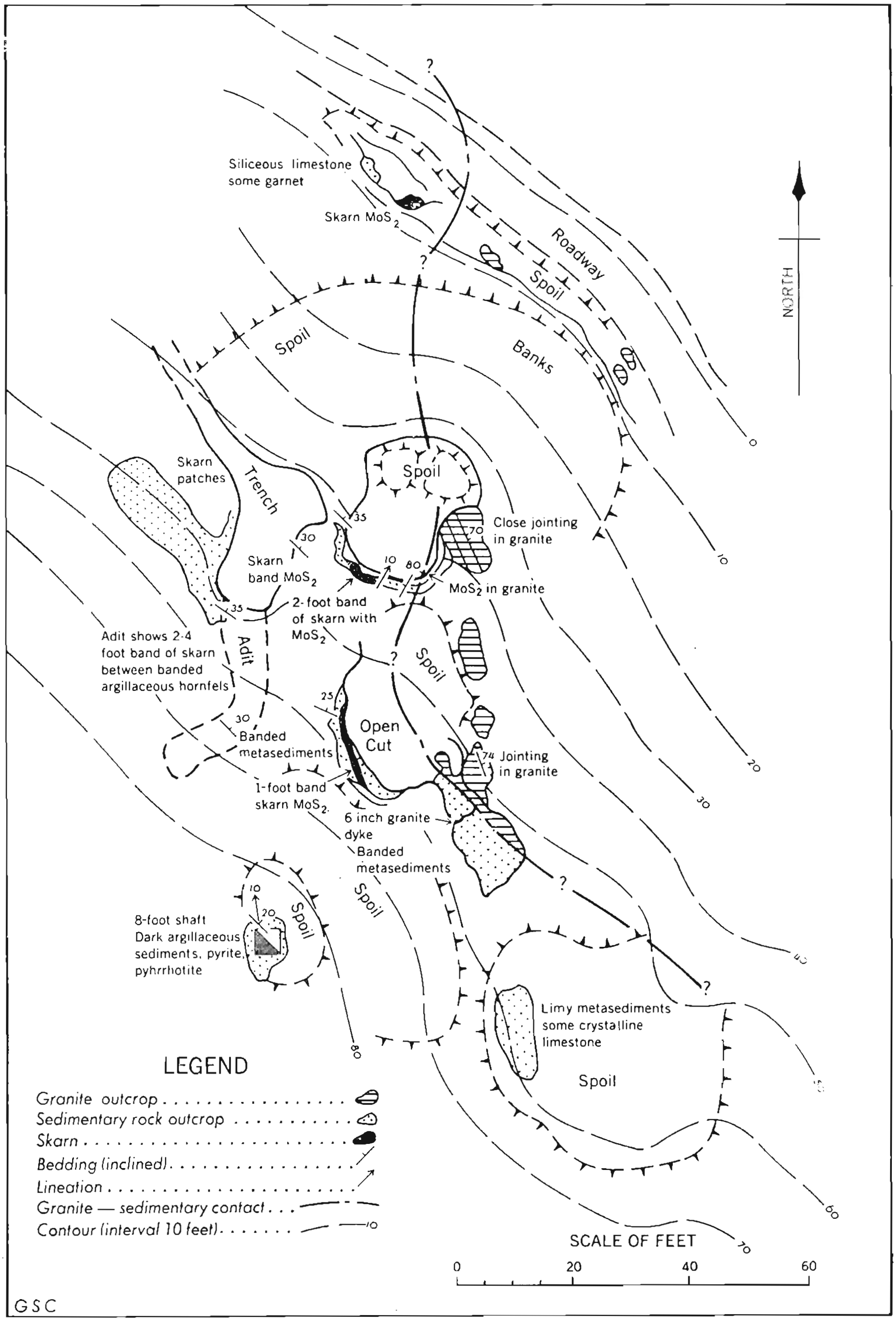

Figure 29. *Sapples molybdenite property, Salmo, British Columbia. From tape and compass survey, 1958.*

direction. No molybdenite deposits have as yet been reported from the contacts of this southerly granite body.

The molybdenite of the Sapples property lies in a belt, nowhere more than about 40 feet wide, that follows the contact between the granite, lying to the north and east, and the sedimentary rocks, lying to the south and west (*see* Fig. 29). The contact can be seen and measured in both open-cuts. In the lower one it strikes about N30°E and dips steeply west; in the upper cut it strikes about N40°W and dips 70°NE. Elsewhere the contact is hidden and its position is conjectural.

One occurrence of molybdenite in the lower open-cut is in the granite itself, but elsewhere the mineral is confined to skarn (possibly a single band) in the metamorphosed sedimentary rocks. The skarn is the result of the alteration of a limestone or impure limy layer and lies within hornfels formed from fine-grained dark argillaceous sediments. As traced away from the granite the contact metamorphism decreases rapidly and the skarn bands grade into crystalline limestone or other less pure calcareous rocks. The molybdenite-bearing zone is thus limited in one dimension by the distance from the granite and in the other by the thickness of the skarn band.

The adit has been driven into banded sedimentary rocks with a general strike of N40 to 50°W and dips between 30 and 35°W. On the east side of the trench leading to the adit, thinly banded argillaceous rocks overlie a 4- to 5-foot band of very siliceous garnetite that shows erratic patches rich in medium-grained molybdenite. Pyrite and pyrrhotite are also disseminated irregularly through this band. The banded argillaceous rocks form the back of most of the level stretch of the adit; beyond this, their strike and dip carry them above the working. The skarn band forms most of the east wall of the level part of the adit and its dip brings it partly into the back and partly into the upper half of the west wall. Its foot-wall can be seen along the west wall. The underlying rocks are dark grey to black, very fine grained and argillaceous—probably connected to hornfels by contact metamorphism. They strike N45°W and dip 35°SW.

In the west wall of the trench, from the adit portal northwards, the skarn band becomes irregular, and most of it is green to white crystalline limestone and impure calcareous rocks. Farther northwest along the hillside a stripped area about 20 feet long shows more impure limestone with scattered irregular patches of garnet skarn. Above the portal of the adit the banded argillaceous rocks overlying the limestone-skarn band are intricately folded on a small scale although maintaining their general strike and dip. The fold axes plunge about 10 degrees in a N40°E direction. These observations seem to show that the contact metamorphism decreases rapidly westwards, away from the granite contact, in the original limestone band.

Beyond about 18 feet the adit swings to the west and has been continued as a raise up the dip of the skarn band, which is there about 30 degrees. The underlying argillaceous rocks form the foot-wall of this raise. There is little or no molybdenite in the skarn band there.

The distribution of molybdenite in the skarn as a whole is very patchy and irregular. The greatest abundance is to be seen on the east wall of the adit, just north of the portal timbers. A chip sample over 2.5 feet taken by the writer assayed 1.37 per cent MoS_2. No bismuth could be detected in this sample. Stevenson (1940, p. 53) reported an assay of 0.5 per cent MoS_2 over 4 feet from this skarn band at a point on the east wall "12 feet back from the face" (i.e. presumably from what is now the portal of the adit, which apparently was not driven at that time).

The lower open-cut, to the east of the adit trench, seems to correspond to the working described by Stevenson as leading to an adit 5 feet long. Subsequent operations have presumably widened this into its present form of an almost-semi-circular pit with a southerly wall about 12 feet high. The eastern part of this working shows fine-grained granite that is very well jointed or even sheeted, the joint planes striking about N30°W and dipping 75°E. They are spaced a foot or less apart. This granite underlies the contact-metamorphosed sedimentary rocks which appear to be disposed in the form of a large asymmetric anticline. They are the same rocks as those seen in the adit. The upper, banded argillaceous rocks in the adit can be followed to the northwest corner of the pit, where, with almost unchanged strike and dip, they overlie impure siliceous limestone and garnet skarn. As the granite contact is approached the sediments are folded over an anticline whose southeasterly limb, against the granite contact, is almost vertical. The axial plunge of the fold is 10 degrees in a N30°E direction.

The upper half of the granite-sedimentary contact, where exposed, is 'frozen' and appears to be sensibly parallel with the banding (bedding) in the folded hornfels. The lower half is, however, a fault contact transgressing the sedimentary bands. The fault plane dips about 70°NW and extends upwards into the granite.

Molybdenite can be seen impregnating the granite on the southeast wall of this pit. It occurs in a gently dipping zone about 1 foot to 1½ feet thick and 5 to 6 feet long in outcrop, dipping towards the southeast corner. Molybdenite is irregularly distributed and is abundant in places. The granite in the zone appears bleached, possibly kaolinized. J. F. Walker (1934, p. 86) mentioned the development of greenish white talc as an alteration product in the granite. Molybdenite was not seen in situ elsewhere in this pit, but the blocks of spoil lying around show that it was originally fairly abundant in the skarn rocks, though erratically distributed. The mineral occurs, together with pyrrhotite, irregularly scattered in the form of flakes 2-4 mm in size and as radiating rosettes of roughly the same size. In the granite, on the other hand, the molybdenite is much finer grained.

Stevenson (1940, p. 53) reported that the best-looking mineralized rock he saw assayed 15 per cent MoS_2 over 2.8 feet and that two samples of mineralized granite near the contact, taken over 2.9 and 1.6 feet respectively, assayed 0.9 and 0.3 per cent MoS_2. Southwestwards, up the hillside from the lower open-pit, is a line of jointed granite outcrops leading to an upper open-cut that trends northwest. The southeastern part of this working shows a very sharply demarcated contact between banded hornfels, to the southwest, striking N60°E and dipping 30°N, and fine-grained closely sheeted granite to the northeast. The sheeting in the granite there strikes northwest and dips 75°SW. The dip of the contact there also appears to be to the southwest.

To the northwest the contact cannot be traced under the rubble on the floor of the open-cut, but apparently it must swing to link with its position in the lower open-pit. In the face of the upper open-cut, 10 feet high, are exposed banded argillaceous metasediments and at least one band of skarn about 1 foot to 2 feet thick. This carries scarce irregular patches of medium-grained molybdenite. No other mineralization was seen by the writer but Stevenson reported two lenses of molybdenite along the contact; one measuring 6 feet by 6 inches gave a sample assaying 0.9 per cent MoS_2.

To the southwest of this open-cut are two large old workings, now mostly slumped and overgrown. The high western face of the largest one reveals banded sediments, mainly impure crystalline limestone. According to Stevenson (p. 54) these workings originally revealed the granite-sediment contact, though they showed only traces of molybdenite.

Some 30 feet higher than the upper open-cut, a 5-foot by 5-foot shaft has been sunk 8 feet in dark grey to black, microcrystalline, hard, siliceous argillaceous rocks striking N43°W and dipping 20°NE. They show a high proportion of finely divided iron sulphide, but no molybdenite, which is to be expected as they are too far from the granite contact.

On the side of the rather overgrown bulldozed 'road' below the workings are occasional outcrops of sheeted granite and a short trench that reveals a small exposure of skarn carrying considerable molybdenite, and a second exposure of light-coloured, unmineralized, siliceous limestone. These outcrops seem to locate the position of the granite-sediment contact to within a few feet.

As mentioned above, the deposit at the Sapples property is limited to a fairly narrow zone at the granite-sediment contact and to possibly one band of skarn in the sediments, so that there is little possibiilty for any large tonnages of mineralized rock. In addition, the distribution of the molybdenite within the favourable zone is extremely erratic. The molybdenite visible in the granite itself appears to be extremely local, and large deposits are unlikely to occur.

Jumbo Property

The Jumbo property lies on the southwestern slopes of Nevada Mountain, on the north side of the valley of Lost Creek. The writer reached the workings from the Jersey mine of Canadian Exploration Limited, by following the pipeline supplying water to the mine eastwards for some 2 miles along the northerly slopes of Lost Creek, and then continuing directly up the valley slopes from a point below the workings.

The adit of the Jumbo prospect is situated at an elevation of about 5,000 feet, on the westerly contact of the Lost Creek granite mass, some 1½ miles north-northeast of the Molly mine. According to J. F. Walker (1934, pp. 85-86), the prospect was "evidently worked to determine the molybdenum value," though the writer could see very little of that mineral. Walker's description of the adit is as follows:

> An upper adit at 5,180 feet runs 328 degrees for 54 feet, to where it branches. One branch follows a direction of 293 degrees for 60 feet. The second branch runs 10 degrees westerly for 20 feet to where it forks, one branch continuing 40 feet westerly and the other 56 feet northerly. In the last-mentioned branch a quartz vein about 4 feet wide, and holding bunches of pyrite, is exposed. The west wall of the vein is granite; the east wall in places is formed by a lamprophyre dyke that nearly but not quite follows the vein. Sediments are exposed in the two most easterly branches of the vein, otherwise it is in granite. Specimens on the dump show molybdenite, galena and sphalerite in vein matter. Molybdenite also occurs in fragments of granite taken from, or close to the contact with the sediments.

The occurrence seems to be of mineralogical interest only.

Emerald Mine

The lead-zinc and tungsten deposits of Canadian Exploration Limited's Emerald Mine lie on Iron Mountain, between Sheep and Lost Creeks, some 8 miles south of Salmo. The geology of the mine has been reviewed by Rennie and Smith (1957). According to verbal information received by the writer at the mine, the tungsten orebodies carry small, variable amounts of molybdenite, together with scheelite, powellite, pyrrhotite, and traces of chalcopyrite. The tungsten workings were closed down at the time of writing and the following notes on their geology are taken from the account by Rennie and Smith.

The host rock is the Laib formation of Lower Cambrian age, consisting locally of 400 feet of crystalline limestone underlain by beds of argillite and argillaceous limestone, locally altered to 'skarn' or 'tactite'. The sediments are cut by two elongated granite stocks. The shape and attitude of these stocks are believed to have been governed partly by pre-granite faulting and partly by pre-granite folding of the sediments. The tungsten orebodies occur as quartz- and pyrrhotite-rich contact replacements of east-dipping limestone or limy beds, underlain by fractured competent argillites and truncated by west-dipping granite surfaces. Generally, ore is deposited where the host rock has been fractured, permitting the entry of mineralizing solutions. Late magmatic, tungsten-bearing hydrothermal solutions have emanated from the granite and to some degree have migrated up the granite surface to deposit scheelite as bedded replacements along the granite contact, or, where the fracturing of the underlying argillite has permitted penetration of the argillite, the solutions have deposited scheelite in bedded skarn and in pyrrhotite-rich replacements of limestone on the limestone-argillite contact.

The geological environment of the Emerald orebodies, in particular the skarn-type ores, resembles very strongly that at the Sapples property some 3 miles to the northeast. In the latter, molybdenite is the dominant mineral, whereas in the Emerald orebodies it occurs as an accessory to the tungsten mineral.

New Gordon Property

The workings on this property lie 1 mile west of Erie on the Salmo-Trail Highway and 300 feet above and to the north of the road. J. F. Walker (1934, p. 88) gave the following description:

A quartz vein, carrying some pyrite and a little molybdenite, strikes 20 to 25 degrees and dips steeply northwest. It cuts a stock of Nelson granite at right angles to its northern contact and lies 500 feet from it. The outcrop of the vein measures about 7 by 15 feet and a 30-foot shaft has been sunk on it. An adit has been driven approximately 475 feet in a direction of 345 degrees to intersect the vein, and follows it for 70 feet along a direction of 20 to 25 degrees. An irregular vein up to 5 feet in width is exposed.

Other Occurrences

Molybdenite has been reported as an accessory mineral from several other mines and prospects in the Salmo, Ymir, and Nelson areas.

At the *Free Silver mine* on Quartz Creek near Ymir, molybdenite occurs with other sulphides in veins cutting monzonite (Stevenson, 1940, p. 87; Eardley-Wilmot, 1925, p. 50).

At the *Second Relief mine* (Relief-Arlington G.M., Ltd.) on Erie Creek northwest of Salmo, fissure veins in greenstone carry gold, pyrite, pyrrhotite, chalcopyrite, and molybdenite (Cockfield, 1936, pp. 7-12).

Nelson Area

Molybdenite has been found in pegmatitic quartz veins cutting hornblende-biotite granite of the Nelson batholith in the bed of the Kootenay River, some 4 miles west of Nelson (T. L. Walker, 1911, p. 55; Eardley-Wilmot, 1925, p. 50).

Revelstoke Area

Two rather isolated molybdenite-bearing deposits have been described in detail by Stevenson (1940, pp. 67-73) from the Revelstoke area.

L. H. Group

The L.H. group comprises the mineral claims, *L.H.*, *L.H. No. 1*, and *L.H. No. 2*, staked in 1938 by W. W. Lynes, Sicamous, B.C. and O. Hoglund, and owned by the same men. The writer examined this property in August, 1939.

The property is approximately 3 miles northwest of Malakwa, a station and small settlement on the Canadian Pacific Railway and on the Trans-Canada Highway, approximately 36 miles west of Revelstoke. From Malakwa station, the property is reached by a motor-road that follows the west side of Eagle River northerly for a distance of 2.2 miles, as measured from the station. From this point a fairly steep trail is followed for 8,000 feet to the camp-cabin at an elevation of 2,720 feet; this is a good pack-trail for approximately one-third of the distance from the end of the motor-road.

The workings are in the bed of a creek. The hillside on either side of the creek is steep, heavily wooded and covered with extensive overburden.

Most of the molybdenite occurs (1) in a shear-zone approximately 4 feet wide that strikes north and dips 25 degrees westward within pink granite, and (2) in widely-spaced shears that occur in the granite in the hanging-wall of the main shear-zone. The molybdenite occurs as paper-thin films in the curving slips associated with the shears and occasionally as scattered grains in the more massive granite between the shears. Samples taken across the shear-zone and elsewhere in the granite where molybdenite occurs, indicate that, although the molybdenite as a mineral is conspicuous, the actual molybdenite content is low; the highest assay obtained was molybdenite 0.4 per cent.

The rocks on the property include pink granite, granite-gneiss, quartz-mica schist and a few lamprophyre dykes.

The pink granite appears to be a belt approximately 100 feet wide that strikes north and is bounded on the east by granite-gneiss and on the west by quartz-biotite schist and granite-gneiss.

The granite is medium in grain and light pink in colour. It is cut by the molybdenite-bearing shear-zone and by numerous shear-planes, spaced 1 inch to 4 inches apart, which strike north and dip 45 degrees westward.

A widespread development of sericite is indicated by the large amount of compact sericite within the shears, and by the complete sericitization of the feldspars in the granite. In addition to the molybdenite, a few stringers of quartz and scattered grains of pyrite occur within the granite.

The granite-gneiss is a grey, coarse-grained rock, consisting mostly of potash feldspar, quartz and biotite. It is distinctly gneissic and some phases possess a marked augen texture, characterized by the wrapping of large biotite flakes around lens-shaped fragments of feldspar. The foliation of the gneiss is vertical and strikes north 22 degrees east. The gneiss extends for an unknown distance both westerly up-stream and easterly down-stream from the pink granite, and appears to be the most abundant rock in the region.

Quartz-mica schist and interbedded massive quartzite extend up-stream for approximately 150 feet from the west side of the pink granite. The schist strikes fairly uniformly to the northeast, but the dip is variable, ranging from nearly horizontal to 25 degrees southeastward.

Close to the granite the schist is cut by a 15-foot-wide biotite-lamprophyre dyke that is approximately vertical and strikes to the north. A short distance farther up-stream, quartzite is cut by a similar dyke that is here only 4 feet wide, and strikes easterly and dips 20 degrees southward. A third lamprophyre dyke, 4 feet thick, strikes northeasterly across the creek from near the portal of the adit; this dyke dips 20 degrees northwestward.

The workings consist of a short adit on the southwest side of the creek and shallow open-cuts on the northeast side.

The adit has been driven in a direction south 75 degrees west for 20 feet. The first 5 feet of the adit cuts the mineralized shear-zone which strikes northerly and dips 20 degrees westward; the remaining 15 feet of the adit passes out of the shear and the face is in relatively massive granite. The shear-zone is in the granite and adjacent to the hanging wall side of a 4-foot lamprophyre dyke that strikes northeasterly across the creek and dips 20 degrees northwestward. On the southwest side of the creek the dyke is wholly in pink granite, but on the northeast side it is wholly in granite-gneiss. It is to be noted that the contact between the pink granite and granite-gneiss strikes northerly across the creek from a point just east of the dyke at the portal of the adit.

The following samples were taken: No. 1, 4.5 feet vertically across the shear at the portal assayed molybdenite nil; No. 2, 4 feet vertically across the shear 4 feet in from the portal on the north side of the adit assayed molybdenite nil; No. 3, 4 feet similar to the last but on the south side of the adit assayed molybdenite nil; No. 4, across 6 inches of crushed matter at the face assayed molybdenite 0.2 per cent; No. 5, black gouge from a slip at the face assayed molybdenite 0.2 per cent; No. 6, 4.8 feet vertically in the face assayed molybdenite 0.4 per cent.

The banks of the creek have been stripped clean for a distance of approximately 60 feet up-stream from the adit. On the southwest bank the shear-zone is exposed for approximately 20 feet northerly from the adit. A sample taken across it assayed molybdenite nil. The main shear-zone, as exposed in the portal of the adit and for a short distance upstream, does not continue as a definite zone across the creek; it seems to have been dissipated as a number of narrow, closely-spaced shears 2 inches or less wide. A small open-cut has been made on the most prominent of these at a point 40 feet northerly from the adit. However, samples across these mineralized shears assayed molybdenite nil. Up-stream from the open-cut the granite is cut by many shears, some of which contain films of molybdenite. Several samples were taken, but only one assayed anything in molybdenite. This sample, taken across a shear at a point 30 feet up-stream from the open-cut assayed molybdenite 0.3 per cent.

Inasmuch as the molybdenite is confined to the pink granite and more locally to shear-planes within this granite, further prospecting should be confined to areas along the continuation of this belt, either southwesterly diagonally down the hillside, or northeasterly diagonally up the hillside. Inasmuch as the slopes are covered by abundant overburden, the creek-beds should be examined where they cut the projected extension of this belt.

Sterling Property

(*Stevenson, 1940*)

The Sterling property comprises the following mineral claims: *Sterling Nos. 1 to 6,* inclusive, *White Rock Nos. 1 and 2* and *White Pine Nos. 1 to 3.* These claims were staked in 1938 and 1939 and are owned by August Smith, A. D. Coueffin, J. L. Mason and Harry Sawyer, all of Revelstoke, B.C. The writer examined this property in August 1939.

The property is 34 miles north of Revelstoke on the Big Bend Highway. The camp-cabin is on the east side of the highway at a point 700 feet southerly from the 34-mile Post. The workings, east of and approximately 100 feet above the road, consists of three short adits, open-cuts and strippings.

The hillside slopes gently upwards east of the road and is covered by large timber and thick underbrush, so that prospecting, except in the creek-beds, is difficult.

The deposit consists of molybdenite, pyrrhotite, and pyrite disseminated in bodies of massive, siliceous rock that are enclosed in quartz-muscovite schist and phyllite. The siliceous rock consists of abundant orthoclase and albite, and, lesser amounts of quartz and disseminated sulphides. It undoubtedly represents the high-temperature replacement of the schist and, or phyllite, by feldspar and quartz. Remnants of what appear to be muscovite schist in the siliceous bodies, suggest that quartz-muscovite schist was the rock replaced.

The largest replacement body, as exposed in No. 3 adit, has a width of 40 feet; its length could not be determined. The second largest, as exposed in No. 2 adit, has an exposed width of approximately 35 feet and may be the same body as that exposed in No. 3 adit. A thinner replacement body occurs approximately three-quarters of a mile northerly from those described above. This body ranges in width from 1 foot to 2 feet, and has a probable length of 175 feet.

In all these bodies the sulphide content is small. Although the pyrrhotite is fairly evenly scattered, the molybdenite is of erratic distribution. Assays of the best mineralization range, in all the bodies, from molybdenite nil to a maximum of 0.6 per cent.

The bodies of high-temperature replacement will be referred to in the following descriptions as silicified material, or as silicified zones. It is to be noted that the term silicified zone refers in this instance to silicification by quartz, orthoclase and albite, and not, as is more usual, to silicification by quartz alone.

From a point that is 300 feet east of the cabin, the 'No. 1' adit is driven north 32 degrees east for 12 feet, then north 22 degrees east for 36 feet, then north 32 degrees east for 90 feet to the face. From the face, a raise has been driven easterly on an angle of 30 degrees for 14 feet, then vertically for 11 feet to the top.

The only mineralization in this adit consists of disseminated pyrrhotite in the silicified rock near the portal; molybdenite and other sulphides are absent.

Commencing at the portal, the adit passes through 48 feet of completely silicified sediments, and then through 90 feet of black, lustrous phyllite to the face. Near the face the phyllite strikes north 55 degrees west and dips 25 degrees northeastward and at 60 feet from the portal it strikes about north and dips 25 degrees eastward. The silicified sediment near the portal strike north 25 degrees east and dip 25 degrees southeastward. At 46 feet from the portal a strong fault, strike north 35 degrees west, dip 42 degrees northeastward, containing 8 to 12 inches of gouge, has been cut by the adit.

From a point that is 60 feet in a direction north 84 degrees east from the portal of the 'No. 1' adit, an open-cut extends for 34 feet easterly to the portal of 'No. 2' adit that is driven north 76 degrees east for 30 feet to the face. Commencing at its mouth, the open-cut passes through 18 feet of overburden, then through 16 feet of massive, siliceous rock. This rock extends into the adit for 18 feet from the portal; from thence to the face, the adit passes through silvery quartz-muscovite schist that strikes northeasterly and dips 25 degrees northwestward. At 18 feet, 22 feet and 24 feet from the mouth of the open-cut, and from 10 feet to 20 feet from the portal, in the adit, and, at the face, short discontinuous lenses of quartz, parallel with the walls of the workings, have been exposed. These lenses, ranging from a few inches to 18 inches in thickness and from 1 foot to 8 feet in length, contain small amounts of molybdenum, pyrite, galena and sphalerite. Samples taken across the lenses showing the best mineralization assayed from molybdenite nil to 0.6 per cent.

Stripping of the northwest bank of the creek, at a point 50 feet northeasterly up-stream from the mouth of the open-cut, exposes a small 4-inch patch of galena, pyrite and quartz in a larger area of massive, siliceous rock.

'No. 3' adit is driven from the southeast bank of the same creek that flows southwesterly past the mouth of 'No. 2' adit. The portal of No. 3 adit is 255 feet in a direction north 21 degrees east from No. 2, and is driven north 30 degrees east for 70 feet to the face. At 52 feet from the portal a branch-working is driven south 86 degrees west for 22 feet.

Commencing at the portal, the No. 3 adit passes through carbonaceous phyllite for 28 feet, then to the face, through partly silicified quartz-muscovite schist that strikes northeasterly and dips 40 degrees northwestward. At 50, 58 and 66 feet from the portal, the main adit cuts lenses of quartz and at 5 and 18 feet from this working the branch-working cuts similar lenses. These lenses range from 1 inch to 14 inches in thickness and from 6 inches to 4 feet in length. Other than quartz, they contain only a little pyrite; no molybdenite was seen. Apart from the quartz lenses, the only other mineralization in this adit consists of pyrrhotite, pyrite and small amounts of molybdenite disseminated through the siliceous replacement-rock. Two checkerboard samples taken across the face of the side-working assayed molybdenite 0.4 per cent and 0.3 per cent, respectively.

Seventy-five feet northeasterly up-stream from the third adit, stripping along the southeast side of the creek exposes a flat-lying lens of quartz 14 inches thick by 3 feet long, which contains pyrite and some molybdenite. A sample taken across the lens assayed molybdenite 0.4 per cent.

Showings of molybdenite outcrop approximately 500 feet up-stream from the highway-crossing in the bed of a small creek, locally known as Galena Creek, that crosses the highway 0.6 mile northerly from the cabin.

The workings on these showings consist of combined open-cuts and strippings.

From a point 20 feet south of the creek-bed, an open-cut is driven 5 feet easterly to a 4-foot face. This working cuts an irregular lens of barren quartz at the face and on the walls, which dies out within an exposed length of 8 feet. The lens cuts silvery, quartz-sericite schist that strikes north 35 degrees west and dips 40 degrees southwestward. A zone of massive silicified rock of irregular width extends from the north side of this cut northeasterly across the creek. This zone ranges from 1 foot to 2 feet in thickness, strikes northwest and dips southwestward with the enclosing schists. The silicified rock consists of abundant orthoclase and albite, lesser amounts of quartz, and scattered pyrrhotite and molybdenite. Three samples taken of the best mineralization assayed molybdenite nil and 0.5 per cent.

The silicified rock is cut by two barren quartz lenses; by one in the open-cut first described, and by another at 40 feet northeasterly from the cut.

No. 2 working, 40 feet in a direction north 25 degrees east from No. 1, is an irregularly blasted area that extends 4 feet easterly and 12 feet northerly. It exposes molybdenite and pyrrhotite in the northeastern extension of the silicified rock. A sample taken across 1 foot of the best mineralization assayed molybdenite 0.5 per cent.

No. 3 working, 35 feet northerly from No. 2, is a combined stripping and open-cut that extends 10 feet along the strike, and 4 feet down and 2 feet across the dip of the silicified rock and enclosing schist; the schist strikes north 25 degrees west and dips 45 degrees southwestward. This exposure is probably the northern extension of the silicified rock exposed in and between No. 1 and No. 2 workings. Scattered molybdenite occurs in this exposure and a sample taken across the 2-foot thickness of the zone assayed molybdenite 0.2 per cent.

Three trenches have been dug to the north of No. 3 working, but none of them expose any molybdenite. The farthest trench, 100 feet northerly from No. 3, exposes 1 foot of the silicified rock, which contains only a little pyrrhotite.

As measured between this working and No. 1, the zone of silicified rock appears to have a strike length of approximately 175 feet and a thickness ranging from 1 foot to 2 feet.

56160-5—21½

Other Occurrences

In the Trout Lake area, southeast of Revelstoke, three minor occurrences of molybdenite have been reported. At the *Copper Chief mine* on the west side of Trout Creek, molybdenite occurs in a small vein following a diorite dyke (Gunning, 1929, p. 84; B.C. Min. Mines, Ann. Rept. 1917, p. 191). On the *Molybdenum and Prodigal claims* on Trout Creek, 2½ miles from Trout Lake, chalcopyrite, pyrite, galena, and molybdenite occur in a quartz vein (T. L. Walker, 1911, p. 54). On the *Lucky Boy prospect*, molybdenite is a minor constituent of ores containing galena, tetrahedrite, sphalerite, chalcopyrite, pyrite, and scheelite (Eardley-Wilmot, 1925, p. 47).

From the *Garvey and Foss claims* on the Duncan River, north of Kootenay Lake, Gunning (1929, pp. 34-35) mentioned an occurrence of molybdenite in quartz veins cutting mica schist. Pyrite and arsenopyrite are accompanying minerals.

In the region north of Revelstoke, in addition to the Sterling group, the following minor occurrences have been reported.

On the *Cotton Belt property,* on Grace Mountain north of Seymour Arm, molybdenite occurs in a silver vein (Eardley-Wilmot, 1925, p. 50).

The *Hard Pan mine* on Galena Creek is a short distance north along the highway from the Sterling occurrence. There an 18-inch quartz vein carries pyrite, pyrrhotite, and molybdenite, with, in parts, some silver, lead and zinc (B.C. Min. Mines, Ann. Rept. 1932, p. A181).

From the *White Pass,* near Glacier Station, Gwillim (1920, p. 125) reported an 8-foot quartz ledge with "good molybdenite".

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INDEX

The original printing of Map 1045A-M3 was accompanied by a separate list of references referred to by number on the right hand side of the map. When the map was reprinted for inclusion in Economic Geology Report 20, Molybdenum deposits of Canada, the list of references was inadvertently omitted. Herewith is the list for insertion in the pocket of your copy of the report.

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

REFERENCES

To accompany

MAP 1045A-M3, METALLOGENIC MAP

MOLYBDENUM IN CANADA

By

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OTTAWA

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