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SULPHUR AND PYRITES IN CANADA

by

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SULPHUR AND PYRITES IN CANADA

by

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I. INTRODUCTION

For many years, Canada has depended upon cheap readily available Frasch-mined sulphur from the United States. However, with the marked industrial expansion of recent years and the rapid depletion of reserves this source can no longer be expected to meet all of Canada's requirements.

Canada, like most industrial countries, is being forced to seek other sources of supply. Fortunately, few technical difficulties exist since practical processes for sulphur recovery are available for the main alternative sources. The element, in various forms, can be recovered from base metal smelting operations, natural gas, bituminous sands, stack gases, anhydrite and pyrites deposits. Of these, there is an abundant supply in Canada.

The problem which confronts industry is primarily one of economics and convenience. Under present conditions, the alternative sources cannot compete with Frasch-mined sulphur. However, a continuing scarcity of brimstone will make the exploitation of these sources commercially feasible. Already, several important projects for the recovery of by-product sulphur are underway and others are in the proposal stage.

This report reviews production and consumption in Canada and describes possible alternative sources of domestic supply as well as the vast reserves of pyrites which are known to exist.

In order to obtain a clear picture of the sulphur problem, it might be best to consider the general situation outside Canada, first.

World Sulphur Production

The largest reserve of pyrites in the world, located in Portugal and the southern part of Spain, is estimated to contain 500,000,000 tons of pyrite with a recoverable sulphur content of more than 200,000,000 tons. Major deposits are also located on the island of Cyprus and in Norway, Sweden, Finland, Japan, Italy, Russia, Germany and Canada. The latest estimate of world reserves of pyrites - 908,000,000 tons - was made in 1926 by the 14th International Geological Congress at Madrid.

Up until World War II the bulk of European requirements was obtained from mines in Sicily and from pyrite bodies in Spain, Portugal and Norway. Because of a lower price and United States dollar-aid policy, most European countries switched from former sources to the Frasch-mined sulphur of the United States. Many European pyrite mines were closed and operations of the sicilian sulphur deposits were curtailed. Some time will be required until they regain pre-war output. Furthermore, it is unlikely that sulphur from these sources could compete economically with present world prices. Only under duress will many European acid plants switch from burning elemental sulphur to Sicilian sulphur or pyrites.

During the early years pyrites was a source of more than 50 per cent of the world sulphur requirements. From 1900 to 1948 inclusive, the apparent world consumption was 214 million tons. Pyrites contributed 114 million tons and native sulphur deposits 100 million tons.

The present situation is in striking contrast. The estimated world supply of sulphur, or its equivalent, in long tons, from all sources is indicated in the following table:

World Production of Sulphur, All Sources*

Country	1935-39 Average	%	1950	%
United States	2,569,000(1)	31	5,966,000(1)	51
Japan	1,093,000	13	859,000	7
Italy	738,000	9	628,000	5
Spain	1,116,000	14	558,000	5
Norway	418,000	5	311,000	3
Portugal	195,000	2	295,000	3
Cyprus	173,000	2	389,000	3
	6,302,000	76	8,906,000	77
Other 26 Countries	1,898,000	24	2,794,000	23
Total	8,200,000	100	11,700,000	100

Between 1935-39 period and 1950.

U.S. sulphur production (all sources) increased - 134%
U.S. brimstone production increased - 146%
Foreign production (all sources increased - 2%

(1) In 1935-39 period 85% represented brimstone; in 1950, 90% represented brimstone.

It can be seen that the United States produces over half the world's supply.

* Canadian Chemical Processing, June, 1951.

United States Production, Consumption and Trade

In the past ten years, elemental sulphur production in the United States rose about two and a half times. However, per capita domestic consumption increased from 35 pounds in 1935-39 to about 75 pounds in 1950. This, coupled with greater demands from abroad and the difficulty of finding new salt-dome deposits, resulted in a steady decline of stock pile reserves and a stringent allocation to domestic and foreign markets.

Brimstone producers have, for many years, spent large sums of money searching for new deposits of sulphur, but successful explorations are rare. Of over 200 discovered Gulf Coast salt domes only 12 have produced sulphur and five have already been exhausted. After the discovery of a sulphur-bearing salt dome great risk is still involved because a complete mining plant to supply hot water and compressed air must be built at the site before it can be determined if the sulphur can be mined successfully in commercial quantities.

The discovery of a new sulphur deposit by the Texas Company while drilling for oil on the Gulf Coast in Louisiana was announced by Freeport Sulphur Company in 1951. It is expected that this deposit will require an investment of from 10 to 15 million dollars to produce at the rate of 500,000 tons a year by the end of 1953.

Several other domes are being prepared for production in Louisiana and Texas. However, production and consumption of sulphuric acid has been rising at a rapid rate over the past several years and if civilian and defence requirements continue to rise at the same rate, the sulphur supply situation will remain 'tight' for a long time to come. It has been estimated that the United States will need 8 million tons yearly of elemental sulphur by 1960. If this proves to be correct it seems evident that the supply of brimstone will be more rigidly allocated in 1960 than it is now unless the use of other sources of sulphur is greatly expanded in the meantime.*

The shortage was first felt in the latter half of 1950. For the year as a whole, United States brimstone production was 5,350,000 long tons compared to total sales of 5,700,000 long tons. The difference of 350,000 tons was made up by withdrawals from stocks of sulphur previously mined. In order to meet current needs from current production in the first half of 1951, the allocation of overseas sulphur shipments was cut to 86% of the exports of the first 6 months of 1950.

The following table shows the production, consumption and exports of sulphur, or its equivalent of the United States:

* Canadian Chemical Processing, June, 1951.

United States Production, Consumption, Exports of Sulphuric Acid Or Its Equivalent

	Long Tons		
	1939	1945	1950
Production	2,342,000	4,204,000	5,350,000
Consumption	1,786,000	3,316,000	4,259,000
Exports to:			
Canada	163,000	248,000	390,000
United Kingdom	129,000	223,000	470,000
Other(1)	439,000	585,000	581,000
Total Exports	731,000	1,056,000	1,441,000

(1) Large shipments were made in 1950 to France, Union of South Africa, Brazil, Australia, and New Zealand.

The following tables outline the United States production and trade figures of sulphur, by sources, for 1900, 1935-39 period, and 1950.

United States Production of Sulphur by Sources in Long Tons

	1900	%	1935-39 Aug.	%	1950	%
Brimstone	3,000	4	2,175,000	84	5,350,000	90
Pyrites (contained sulphur)	82,000	96	222,000	9	391,000	6
Other Sources	None		172,000	7	225,000	4
	85,000		2,569,000		5,966,000	

United States Exports and Imports of Sulphur
in Various Forms in Long Tons

	1900	1935-39 Aug.	1950
Exports			
Brimstone	none	566,000	1,441,000
All other sources	none	none	none
Imports			
Brimstone	168,000	3,000	none
Pyrites (contained sulphur)	180,000	195,000	100,000

Canadian Production and Consumption

There are no elemental sulphur deposits known to exist in Canada comparable to those of the Gulf Coast region of the United States. All production has been based on alternative sources. In the past, production was limited to pyrites from Canadian deposits; at present, to by-product pyrite and smelter gases.

Pyrite Mining. From 1915 to 1918, the total Canadian production of sulphur was derived from pyrites, or pyrrhotite, obtained from the Eustis and Weedon mines in Quebec; the Goudreau Lake, Northpines, Sulphide, Queensboro, Craig and Bannockburn mines in Ontario and the Anyox and Sullivan mines in British Columbia. Ontario was the major producer with Quebec second and British Columbia third.

No mines operate in Canada, today, solely for the production of pyrites, since it cannot be mined profitably in competition with elemental sulphur from the United States.

By-product Pyrite. All the pyrite which is produced in Canada, at present, is obtained as a flotation by-product of base metal mining operations. Such production has been considered a small-profit operation bringing only from $2.00 to $2.50 per short ton, f.o.b. the mine, to the producers.

In 1950, it was produced by the Noranda, Waite, Amulet, Quemont and East Sullivan mines in western Quebec and by the Britannia mine in British Columbia. The production amounted to a sulphur equivalent of 150,828 tons. Britannia mine is operated by Britannia Mining and Smelting Company Limited, a subsidiary of Howe Sound Company of New York. The mine has been a regular contributor to Canada's output for many years. The pyrite is obtained as a by-product from the copper-gold-silver operations at Britannia Beach, B.C.

About 65% of the by-product pyrite is exported. Nearly all of this goes to the acid manufacturers in the United States. Most of the remainder is consumed in the acid plants of Nichols Chemical Company Limited at Valleyfield, P.Q., Sulphide, Ontario and Barnet, B.C. The rest is used by St. Lawrence Paper Mills Limited in its sulphite mill at Three Rivers, P.Q. The latter is the only paper company in Canada presently burning pyrite as a source of sulphur.

Sulphuric Acid and Sulphur Dioxide from Smelter Gases

The Consolidated Mining and Smelting Company of Canada, Limited, at Trail, B.C., converts the sulphur dioxide in the smelter gases to sulphuric acid. The entire output is used to manufacture fertilizer at its nearby plant.

The only other Canadian production from smelter gases is at the sulphuric acid plant adjoining the Copper Cliff smelter of the International Nickel Company of Canada. This plant, owned by Canadian Industries Limited, has been in operation for several years. It has produced from 35,000 to 45,000 tons of 100 per cent sulphuric acid (12,000 to 15,000 tons sulphur equivalent) annually. Major expansion is underway. By 1953, the plant is expected to produce 90,000 tons of liquid sulphur dioxide annually for the pulp and paper industry.

For many years, sources of domestic supply have been limited to those mentioned above. The following tables give the figures for production, consumption, export and import:

Canadian Output of Sulphur, 1947-49

By Provinces*

	Pyrite			Smelter Gas			
	Sales	Sulphur Content		Sulphur Content		Total	Sulphur
	Tons	Tons	Value	Tons	Value	Tons	Value
			$		$		$
1947							
Quebec	105,271	48,688	187,112	...	...	48,688	187,112
Ontario	...	...	...	15,931	159,310	15,931	159,310
B. Columbia	72,993	33,949	244,315	123,213	1,232,130	157,162	1,476,445
Canada	178,264	82,637	431,427	139,144	1,391,440	221,781	1,822,867
1948							
Quebec	145,205	69,463	263,330	...	...	69,463	263,330
Ontario	...	...	...	15,550	155,500	15,550	155,500
B. Columbia	38,865	17,663	149,658	126,787	1,267,870	144,450	1,417,528
Canada	184,070	87,126	412,988	142,337	1,423,370	229,463	1,836,358
1949							
Quebec	186,071	88,804	348,777	...	...	88,804	348,807
Ontario	...	...	...	12,630	126,300	12,630	126,300
B. Columbia	64,405	28,777	247,677	131,660	1,316,600	160,437	1,564,277
Canada	250,476	117,581	596,154	144,290	1,442,900	261,871	2,039,384

* Dominion Bureau of Statistics.

Production, Imports, Exports, and Consumption of Sulphur In Canada, in Short Tons - 1940-1950 *

Year	Pyrites Shipped	Sulphur Content	Smelter Gases Sulphur Content	Total Sulphur	Imports	Exports	Apparent Consumption
1950	317,065	151,620	150,730	302,350	390,330	111,650	580,030
1949	250,480	117,580	144,290	261,870	280,560	90,560	451,870
1948	184,070	87,130	142,340	229,470	354,620	50,250	533,840
1947	178,260	82,640	137,140	221,780	361,430	56,340	526,870
1946	201,940	96,540	138,230	234,770	273,500	68,050	440,220
1945	227,720	110,200	139,910	250,110	248,850	75,480	423,480
1944	250,070	121,770	126,320	248,090	235,960	90,840	393,210
1943	284,580	139,450	118,060	257,510	218,530	104,510	371,530
1942	379,490	182,780	120,930	303,710	290,120	166,450	427,380
1941	303,360	149,130	110,130	260,022	235,270	129,630	365,670
1940	127,770	63,230	107,400	170,630	215,600	40,380	345,850

The deficiency in domestic production will probably exist for many years but projects are currently underway in Canada, which make the long term outlook encouraging. These projects are described in other sections of the report.

Uses of Sulphur

Sulphur has always been the inconspicuous and humble servant of industry and agriculture. Until recently it attracted little attention because, in plentiful supply, it caused consumers little worry. However, industry became acutely aware of the sulphur shortage in 1950 when allocation was instituted, first, by the producers, and then by an international committee.

Sulphur enters into the manufacture or processing of nearly every industrial product. In the initial stage of consumption, sulphur is generally converted into a secondary product, the most common being sulphuric acid. This sulphur, in the form of acid, element, or sulphite, is consumed by the end-use industry. In the final step, the products of these industries contribute, in turn, the countless other articles such as foodstuffs, soaps and detergents, clothing, gasoline and lubricants, automobiles and aeroplanes, construction materials, tires and tubes. The list of end products could be expanded to include almost everything we eat, wear, or use.

The amount of sulphur going into different products varies widely but representative sulphur requirements of a few typical products have been reported as being:

* Dominion Bureau of Statistics.

37.5 pounds for each ton of newsprint.
1 pound for each pound of viscose rayon.
174 pounds for each ton of 3-8-3 fertilizer.
2/5 pound for refining each barrel of crude oil.
18 pounds for each ton of steel.
65 pounds for each ton of rubber.
35 pounds for the average automobile.

About seventy-five per cent of the annual United States sulphur consumption is converted into sulphuric acid. On the basis of 100 per cent sulphuric acid the 6,000,000 tons of elemental sulphur, or its equivalent, consumed in the United States in 1950, would produce approximately 18,000,000 tons of acid. The fertilizer industry, by far the largest consumer, used about 5,500,000 tons of acid. The next largest amount, 2,600,000 tons of acid, went into the production of detergents, plastics, dyes and other chemicals. The petroleum refining industry used 1,500,000 tons; paints and pigments 1,000,000 tons; rayon and cellulose film 800,000 tons; iron and steel 650,000 tons; explosives and other products about 500,000 tons. About twenty-five per cent, however, was used in forms other than acid. A large part of this went to the pulp and paper industry with smaller amounts being used in the manufacture of rubber, insecticides, fungicides and various other products. *

The end-use pattern of sulphur, as sulphuric acid, in Canada varies widely from that outlined above for the United States. The Dominion Bureau of Statistics reports the sulphuric acid consumption in Canada in 1949, by industries, as follows: *

Sulphuric Acid Consumption Canada, 1949	Net tons of 100% acid
(a) By Industries -	
Fertilizers	488,405
Heavy Chemicals	57,571
Explosives	19,423
Non-ferrous metal smelting and refining	12,944
Textiles	14,969
Coke and gas	34,512
Petroleum refining	15,399
Leather tanning	1,997
Iron and Steel	17,274
Electrical apparatus	4,624
Plastics	5,974
Soaps	4,792
Adhesives	599
Miscellaneous chemicals	2,328
Sugar refining	253
Pulp and paper	2,342
Vegetable oil	94
Total	683,500

* Engineering & Mining Journal May, 1951.

Sulphuric Acid Consumption Canada, 1949	Net tons of 100% acid
(b) By Provinces -	
Nova Scotia	8,025
New Brunswick	513
Quebec	125,845
Ontario	136,624
Manitoba	1,698
Saskatchewan	315
Alberta	2,546
British Columbia	407,934
Canada	683,500

This 683,500 net tons of 100 per cent acid are equivalent to about 230,000 tons of elemental sulphur. The pulp and paper industry in Canada, in 1949, consumed 258,000 tons of elemental sulphur with the rubber, insecticide and fungicide industries consuming about another 3,500 tons.

The following table, prepared by the Department of Defence Production, shows the consumption of sulphur or its equivalent, by industry, for 1949 and 1950 and includes estimates of consumption requirements for 1951, 1952, and 1953, in thousands of tons of sulphur.

Current and Estimated Future Consumption of Sulphur or Its Equivalent - Canada

Industry	1949	1950	Estimated Demand 1951	1952	1953
Pulp and Paper	258.0	287.0	320.0	325.0	330.0
Fertilizers*	158.0	160.0	175.0	185.0	200.0
Heavy Chemicals & Explosives	28.2	29.0	32.0	37.0	40.0
Coke and Gas	11.4	11.5	11.6	11.6	11.7
Textiles	6.5	6.6	10.0	10.0	10.2
Iron and Steel	5.5	5.7	6.0	6.5	6.7
Oil Refining	4.9	5.4	5.8	6.2	6.4
Non-ferrous metal smelting	4.2	4.3	4.3	4.3	4.3
Rubber products	2.0	2.0	2.1	2.3	2.3
Insecticides	1.5	1.5	1.6	1.6	1.6
Bleaching and Wastage	20.8	20.0	20.0	20.0	20.0
All other	1.0	1.0	1.0	1.0	1.0
TOTAL	502.0	539.0	589.4	610.5	634.2

* A large part of the increase in demand for sulphur used in fertilizer production will be met by roasting pyrrhotite tailings stockpiled at Trail, B.C. It is expected that by the beginning of 1953 operations will be underway there with an increase in capacity of about 90,000 tons per year of 100% sulphuric acid.

The pulp and paper industry - the major consumer - needs sulphur in a form which can be used in producing sulphur dioxide gas for its sulphite plants -- such as elemental sulphur, pyrite, or liquid sulphur dioxide. Attempts to increase the Canadian production of sulphuric acid from smelter gas, oil refineries, pyrites, or other sources would offer no aid to the pulp and paper industry. Consequently, most Canadian efforts to increase the 'sulphur' supply are concentrated on recovering elemental sulphur (Noranda Mines Limited) or liquid sulphur dioxide (Canadian Industries Limited at Copper Cliff).

A comparison of end-use consumption of sulphur in the United States and Canada, expressed in approximate percentage of total consumption, is shown in the following table:

End-Use Consumption of Sulphur - Canada and U.S.A.

Industry	% Total Consumption United States	Canada
Fertilizers	34	30.0
Chemicals and Miscellaneous	24	5.4
Petroleum refining	10	1.0
Pulp and paper	7	53.0
Rayon and Cellulose film	7	1.2
Paints and pigments	6	- *
Iron and Steel	4	1.1
Insecticides & fungicides	3	0.3
Other metallurgical	2	0.8
Rubber	2	0.4
Industrial explosives	1	- *
Total	100	93.2*

* The remaining 6.8 per cent of the Canadian consumption is contained in the previous table under the headings;- coke and gas, bleaching and wastage, and all other. Paints, pigments and industrial explosives are contained under other headings in the same table.

Prices

Elemental Sulphur. Sulphur has always been one of the less expensive elements required by industry. In the latter half of 1950 the price of elemental sulphur, per long ton, f.o.b., Gulf Coast ports, was advanced from $18.00 to $22.00. With freight charges added, elemental sulphur can be laid down at $30.00 to $38.00 per long ton at Canadian consumers' plants. At the higher price figure, elemental sulphur costs the consuming industry approximately 1.8 cents per pound.

Freight Rates. The displacement of other sulphur sources by brimstone over the past 30 years is a direct result of its cheapness and the ease with which it can be handled and transported. One ton of elemental sulphur is equivalent to 2 tons of liquid sulphur dioxide or about 3.3 tons of 66°Be acid. Naturally, a prime consideration of any prospective producer of equivalent sulphur in the form of pyrite, liquid sulphur dioxide, or sulphuric acid must take into consideration the cost of freight to a consuming centre. With present freight rates of better than 2 cents per ton mile it would cost $2.00 to move one ton of pyrite 100 miles.

Spanish Pyrites. The price of Spanish pyrites was quoted until mid 1951, in the Engineering and Mining Journal, Metal and Mineral Markets, at 14 to 16 cents per long ton unit (22.4 pounds) of contained sulphur, c.i.f., guaranteed 48 per cent sulphur. Thus Spanish pyrite, under this quotation, having a 50 per cent sulphur content would cost 50 x 16 = $8.00 per long ton, c.i.f., New York. Since mid 1951 Spanish pyrites has not been quoted in Trade Journals.

By-Product Pyrite. The price paid for by-product pyrite from Canadian base metal mines is a matter of negotiation but over the past several years it has averaged between $2.00 and $2.50 per short ton, f.o.b. the mine, for total output over a period of years. Sulphur content of Canadian pyrite shipments has been about 47 per cent. Rumours have been circulated in news articles of the press that 'prices of around $5.00 per ton for pyrite at the mine are being offered'. Offers of up to $8.00 per ton for pyrite of 48 per cent sulphur content have been circulated. Such rumours have lacked confirmation. There has been no announcement of any contracts having been signed at any of the 'reported' figures. In 1950 the Canadian shipments of 317,065 tons of pyrite, having a sulphur content of 151,619 tons, was valued at $679,648, or $2.11 a ton.

II. OCCURRENCE OF PYRITES IN CANADA

General

Large deposits of pyrite are known to occur at several locations in Canada. From the turn of the century up to about 1920, before the pre-eminence of Frasch-mined sulphur, large shipments of high grade pyrite were made from mines in Newfoundland, the Eastern Townships of Quebec, and Ontario.

Almost massive bodies of pyrite were mined, in conjunction with chalcopyrite, at Pilleys Island in Notre Dame Bay area, Newfoundland and at the Eustis (now Albert Metals Corporation) near Sherbrooke, Quebec. Ascot Metals Corporation and Suffield Metals Corporation with properties near Sherbrooke, are developing copper-lead-zinc orebodies with pyrite as possible by-products. Quebec Copper Corporation Limited has acquired the former Huntingdon, Ives, and Bolton properties in the Sherbrooke area and is carrying on an extensive diamond drilling program. Louvicourt Goldfield Corporation has also bought property in the area. In western Quebec, Noranda Mines Limited has blocked out about 100,000,000 tons of 50 per cent pyritic material carrying low copper. It also leased 50 acres of the MacDonald Mines property on which substantial pyrite reserves have been blocked out.

In Manitoba, Hudson Bay Mining and Smelting Company Limited at Flin Flon has stockpiled about 26,000,000 tons of tailings estimated to average 25% sulphur, 25% iron, 0.21% copper, 0.89% zinc, and 0.023 oz. gold and 0.37 oz. silver to the ton.

In British Columbia, large tonnages of pyrite associated with copper and zinc sulphides have been indicated by diamond drilling in the Ecstall River deposits near the junction of the Ecstall and Skeena rivers, about 35 miles above Port Essington.

Old Mines

Many mines in Ontario that produced pyrite for acid manufacture before 1920 might bear re-examination under the stimulus of a better price for pyrite and a continuing sulphur shortage. Shipments of pyrite grading above 40 per cent sulphur were made from several properties in Eastern Ontario, and the Northland Pyrites mine about 12 miles north of Timagomi. The Goudreau Lake deposits, 18 miles southwest of Missinaibi, consist of large pyrite lenses of good grade material and probably constitute one of the largest reserves of pyrite on the continent. Production from open pit and shallow underground workings was continuous for a number of years. The Northpines (Vermilion) Pyrites mine, about 7 miles west of Sioux Lookout, regularly shipped good grade pyrite until about 1922. It has been idle since then, but underground workings were relatively shallow and pyrite reserves were by no means worked out or delimited. Many other pyrite locations in Ontario are on record.

In compiling the following list of occurrences of pyrites, reference was made to a large number of publications, both Provincial and Federal. Included among these references are the following:

1. Newfoundland Geological Survey Information Circular No. 4 on "Mines and Mineral Resources of Newfoundland" - by A.K. Snelgrove. (1938).

2. Newfoundland Geological Survey "Copper Deposits of Newfoundland" by G. Vibert Douglas, David Williams, Olaf N. Rove, and others. (1940).

3. New Brunswick Annual Reports of the Department of Lands and Mines.

4. Quebec Department of Mines Report on "The Copper Deposits of the Eastern Townships of the Province of Quebec" by J. Austin Bancroft. (1915).

5. Quebec Department of Mines Annual Reports.

6. O.B.M. Report, 1907, "Iron Pyrites in Ontario" by E.L. Fraleck.

7. O.B.M. Report, 1911 "Vermilion Lake Pyrite Deposits" by E.S. Moore.

8. Memoir No. 167, Mines Branch, Department of Mines - 1912 "Pyrites in Canada" by Alfred W.G. Wilson, Phd.

9. O.B.M. Report, 1915 "The Productive Area of the Michipicoten Iron Ranges" by Arthur L. Parsons.

10. Summary Report 1919, Mines Branch, Department of Mines "Investigation of Pyrites Resources", by A.H.A. Robinson.

11. O.B.M. Reports from 1900 to 1922 - for history of operations, production, and miscellaneous.

12. British Columbia Annual Reports of the Minister of Mines.

Pyrites in Newfoundland

Since pyrites is an all inclusive term for all iron sulphide minerals containing from 25 to 50 per cent sulphur the classification of pyrites deposits in Newfoundland must overlap those deposits which are generally considered as copper prospects. Copper mining is the oldest important mineral industry of Newfoundland and during the latter half of the 19th century many deposits were discovered and operated by "gophering" mining methods. Many of these occurrences were closed by 1900 and little systematic exploratory or development work has ever been conducted on them. Pyrite is found in association with chalcopyrite in deposits worked to date.

The following resume of former operations, lists all the major occurrences on which work has been done. Some of the properties are being actively explored and developed by Canadian mining interests at present. Such activities and associations are also noted. For a complete list the reader is referred to Bulletin No. 20 on "Copper Deposits of Newfoundland" published by the Newfoundland Government in 1940.

Notre Dame Bay Area

Pilleys Island Mine
Gull Pond Prospect
Buchans Mining Company Limited
The Terra Nova Mine
Betts Cove
Little Bay and Sleepy Hollow Properties
Chapel Island
Lockport Pyrite Mine
Mud Pond
Rendell-Jackman
Sunday Cove Island
Tilt Cove
Wild Cove

Pilleys Island Mine

Pilleys Island, three by four miles in extent, lies in the central part of Notre Dame Bay a half mile from the mainland off the northeast coast. The occurrence of pyrites on Pilleys Island was known as early as 1875. Pyrites Company Limited (a British company) operated the mine from 1891 to 1899 and shipped over 300,000 tons of ore during that period. The Pilleys Island Pyrite Company acquired the property in 1901 and produced over 225,000 tons of ore up to 1908. At that time it was discovered that the orebody was cut off by faulting. The property was subsequently acquired by the Blast Furnace Products Corporation of New York and in 1919 and 1920 diamond drilling, under the direction of N.O. Lawton, disclosed the faulted portion of the orebody with an estimated 600,000 tons of ore. Lawton estimates that about 225,000 tons of this is cupriferous pyrite with 3 per cent copper, 44 to 48 per cent sulphur, and the remaining 375,000 tons is non-cupriferous pyrite with 46 to 50 per cent sulphur content.

The underground workings are shallow with the bottom level (7th) at a vertical depth of only 291 feet from the shaft collar. Three kinds of ore were shipped in former operations:

(1) Brownlump - a massive nearly pure iron pyrites, non-cupriferous, assaying 45 to 51 per cent sulphur, 42 to 48 per cent iron and 0.07% copper.

(2) Hardcopper lump - a cupriferous pyrite assaying 44 to 48% sulphur, 36 to 44% iron and 2 to 3% copper. This type of 'ore' constituted about 25% of the total ore shipped.

(3) Fines - screenings from the brown ore and crushed white (pure pyrite) ore and assaying 42 to 46% sulphur with no copper.

The old mine limits down to the 7th level are considered to be worked out (Lawton) with the exception of about 20,000 tons of hard cupriferous pyrite tied up in 7th level pillars assaying 46% sulphur and 2 1/2 to 3 1/2% copper. There are also about 30,000 tons of non-cupriferous pyrite in extensions of previously worked ore areas.

It was announced early in 1951 that a new company to be known as Pilley's Island Copper (1951) Limited, is to be formed to take over the property from Blast Furnace Products Corporation. Furnaces for exploration and development are to be provided jointly by Frobisher Exploration and Halcrow Swayze Mining Company Limited.

Gull Pond Prospect

This property is situated 16 miles south of Halls Bay in Notre Dame Bay, northeast coast. It was discovered in 1905 and over a period of time was explored by trenching, shallow shafts, diamond drilling and geophysical means. The Buchans mine area lies about 40 miles to the southwest.

Diamond drilling has indicated the main orebody to be a pitching lens averaging about 50 feet in width, approximately 1150 feet long with a vertical depth of 400 feet. About 1 1/4 miles southwest of this main orebody is a smaller deposit of similar characteristics. Diamond drilling to date has indicated 2,160,000 tons averaging 2.62 per cent copper in the main orebody. The main ore minerals in the deposit are chalcopyrite, pyrite and pyrrhotite.

Falconbridge Nickel Mines recently optioned the property and in 1950-51 conducted further geophysical surveys, diamond drilling and general exploration. If former ore estimates are corroborated, the sinking of a 600 foot shaft with lateral development is planned.

Buchans Mining Company Limited

The Buchans Mine is operated by American Smelting and Refining Company Limited on a percentage of net profits basis with Anglo-Newfoundland Development Company Limited which owns the property. The large, high grade ore reserves blocked out are sufficient to maintain current mining operations from 300,000 to 350,000 tons annually for many years. By far the major part of production is derived from the main orebody which is reported to average 1.6% copper, 9.2% lead, 20.1% zinc and 9.4% iron with minor gold and silver values. The ore is a massive intimate mixture of fine-grained sphalerite, galena, chalcopyrite and pyrite. Three concentrates are produced at Buchans and shipped from Botwood, which is 92 miles by rail from Buchans, for overseas refining.

The mill tailings are estimated to contain about 6 per cent iron in the form of pyrite from which could be recovered from 20,000 to 30,000 tons of pyrite annually. This pyrite would contain from 40 to 45 per cent sulphur. At present no recovery of pyrite from current mill tailings is being made.

The Terra Nova Mine

This mine on Baie Verte was discovered before 1862 and there is little information available on its production record prior to closing down in 1915. A production of 11,000 tons in 1903 and 19,312 tons in 1904 is noted in "The Mineral Industry" (New York). The ore is said to have averaged 2.41% copper and 37.23% sulphur with minor zinc, gold and silver values. The old stock dump which was accumulated during 1914-15 was estimated to contain 20,000 tons of ore averaging 2.5% copper, 37.8% sulphur, 0.049 oz. gold and 0.29 oz. silver. This tonnage estimation and sampling was carried out in June 1939 and is reported by Olaf N. Rove in 'The Copper Deposits of Newfoundland' published in 1940. Some detailed geological mapping and geophysical work has been conducted in the mine area during recent years.

Betts Cove

The mine area of this former pyrite copper producer has collapsed. It is on the west side of Notre Dame Bay about eight miles southwest of Tilt Cove with the nearest settlement being Nippers Harbour three miles to the southwest.

It was opened up in 1875 and closed in 1883 following the cave-in of a mineralized rock copping which had been undermined. In 1900 and 1906 minor efforts were made to reopen the mine but no production resulted. The pyritic copper deposits of Betts Cove are lenticular masses of pyrite and chalcopyrite with some banding of later sphalerite. It appears that chalcopyrite increases with depth and although mine workings are reported to have extended to only about 200 feet in depth according to Hawley 'In the course of the excavating, some enormous pockets of ore were come across'.

Between 1875 and 1878 Betts Cove mine shipped 95,000 tons of ore which is reported to have averaged nearly 10 per cent copper after hand sorting and jigging of the run-of-mine ore. No estimate of reserves are available. Of the three ore dumps remaining on the property two appear to have been rejected because of high zinc content which in grab samples taken by Olaf N. Rove in 1939 yielded 4.14 to 5.06 per cent zinc and 0.39 to 1.83 per cent copper with 6 dwt. of gold and 18 dwt. of silver per long ton. Grab samples from the third dump yielded 9.42 per cent copper with minor percentages of zinc and gold.

No recent activities on this former producer have been noted. There were 2,450 tons of iron pyrite along with 130,682 tons of 'ore' shipped during its production period.

Little Bay and Sleepy Hollow Properties

The abandoned Little Bay mine workings are in an east-west valley about 1/2 mile east of the town of Little Bay and about 1/3 mile south of the southern shore of Indian Bight in Green Bay, Notre Dame Bay area.

The ore occurrences on both properties are found in extensively chloritized shear zones cutting pillow lavas. These shear zones trend generally N 45° E. and the Sleepy Hollow workings are about 1000 feet N.W. of the main workings of the Little Bay mine. The ore consists of disseminations, stringers and lenses of pyrite and chalcopyrite in the chlorite schist.

The Little Bay mine was discovered in the spring of 1878 and operated continuously from then until 1893 during which time an estimated 200,000 tons of 2 1/2 to 10% copper ore are reported to have been mined from the main orebody over a length of 600 feet to a depth of 1400 feet. Widths of mined ore are reported to have been from five feet to more than 20 feet. The eastern section of the mine is reported to have collapsed due to pillar robbing with subsequent pillar failure down to the 1000 feet level. Diamond drilling to the east of the old workings in 1921-22 is reported to have cut copper ore (24 ft.) of 2.35% grade. Estimates of ore remaining on the Little Bay Mine dumps range from 216,000 tons of 1.48% copper to 300,000 tons of approximately 2% copper.

The mineralization and ore occurrences of the Sleepy Hollow mine are identical to and associated with that of the Little Bay Mine. Several prospect pits and shafts have been put down along the major chloritic shear zone.

Chapel Island

A norite sill up to 40 feet in thickness dips southward at 70° and is exposed along the northwestern shore of Chapel Island, on the eastern side of Notre Dame Bay, for several hundred yards. Two exploratory shafts have been put down and both are reported to have cut massive sulphides.

The ore, which is mostly massive, is composed chiefly of pyrrhotite, pentlandite, and chalcopyrite, and is confined to the norite. A grab sample from the dump is reported to have contained 3.05% nickel and 1.47% copper. In addition to the solid ore, the basic sill carries disseminated sulphides. Very little exploratory work and no diamond drilling has been done on this showing.

Lockport Pyrite Mine

This former 'pyrite' mine is in the western part of the New Bay map area on the peninsula between Glover Harbour and Lockport in the Notre Dame Bay area. No records of operations are available but it is thought the mine was operated between 1870 and 1890. The workings consist of three 'fairly large' open pits and two shallow shafts of about 25 foot depth, both of which have caved. Extensive mine dumps, containing much mineralized rock and ore, surround the workings.

Pyrite is by far the commonest sulphide present, chalcopyrite being a minor constituent. The deposits occur in fine-grained graywacke locally altered to green chloritic schist and take the form of disseminations thoughout the schist and as narrow veins frequently associated with quartz in the altered zone. Recent sampling across six feet on one of the pit walls in a zone of cupriferous pyrite returned values up to 2.02 per cent copper and 25.85 per cent sulphur. There has been only limited exploration on this property to date and further work might result in further ore disclosures.

Mud Pond

This copper prospect lies on the western side of Mud Pond about 1 mile west of Mings Bight and is reached by trail from Mings Bight settlement. It was discovered in 1951 by the Newfoundland Prospecting Syndicate and subsequent stripping and test pitting were carried out on two locations about 400 feet apart.

An 18 foot thick mineralized zone is exposed in No. 1 test pit for a length of 35 feet parallel to the strike of the greenstone. The lower 3 feet of the zone are heavily mineralized with pyrite and chalcopyrite and made up of small lenses of these minerals. These replaced the chlorite schist occurring in the east-west shear zone. The remainder of the 18 foot thickness is composed of slightly silicified greenstone, throughout which pyrite and chalcopyrite are sparsely disseminated. Sampling of the zone in the No. 1 pit across the 18 feet (chip) returned 1.66% copper, and across the lower 3 feet (channel) returned 7.62% copper.

No mineralization is in evidence in No. 2 pit. Further exploration of the No. 1 zone extension appears warranted.

Rendell-Jackman

This property, at the end of Southwest Arm of Green Bay opposite Kings Point settlement, lies about a mile from the shore. Three shafts, one 60 feet deep and two 120 feet deep, have been sunk on the showings. These are reported to be in the form of two lenses, 600 and 450 feet in length. They lie in a crescent-shaped area of chloritic schist in pillow lavas.

The ore minerals consist of chalcopyrite and pyrite with a higher percentage of pyrite showing in the smaller lens. A grab sample from No. 3 shaft dump (smaller lens) assayed 4.4% copper and 43.3% sulphur. A grab sample from No. 1 shaft dump, sunk on a 45° incline on the larger lens, assayed 3.1% copper and 6.6% sulphur.

During the summers of 1935 and 1936 Hans Lundberg, Limited, of Toronto, conducted a geophysical survey of the property and the adjoining area. In 1939 the Geological Survey of Newfoundland had 5 diamond drill holes put down across the mineralized shears having a total footage of 1,956 feet. This drilling was rather disappointing as the best sections cut by the 5 holes were one 2-foot width of 4.65% copper and one 3-foot width of 2.39% core with disseminated mineralization in the chloritic shear zone. Near No. 3 shaft there is a dump of hand-picked ore of about 1200 tons, containing 3 to 4% copper.

With the present high prices for copper and the increasing demand for pyrite, further testing of this property might be warranted.

Sunday Cove Island

The Miles Cove mine is about 1/4 mile inland from Miles Cove on the southeast shore of Sunday Cove Island, Notre Dame, which lies to the west of Pilleys Island. The deposits occur in nearly vertical quartz veins and in the sheared, chloritized pillow lavas. The width of the shear zone in which the ore bodies, or lenses, occur, attains a width of about 100 feet.

It is reported that 210 tons of 10% copper ore were shipped in 1899. The 50 tons of low grade ore remaining on the dumps consists of massive, banded cupriferous pyrite, and quartz carrying chalcopyrite and pyrite. A grab sample of a piece of the better ore on the dump assayed 10.75% copper, 24.65% sulphur with low gold and silver values.

Two pits were sunk on surface showings in 1898 and some lateral development at shallow horizons was undertaken. Hans Lundberg Limited, of Toronto, conducted a geophysical survey of the property and some adjoining ground in the early thirties. The results of this survey are not known but no work has been done in the mine workings since 1899.

Tilt Cove

The Tilt Cove copper mine was discovered in 1857 and was operated more or less continuously from 1864 till 1918. In 'Copper Deposits of Newfoundland', published by the Geological Survey of Newfoundland in 1940, several comprehensive reports of operations and future possibilities are made by various mining engineers and geologists. The property is situated to the north of Notre Dame Bay.

The East Mine of the Tilt Cove property is considered to be worked cut. The ore at the East Mine consisted of massive pyrite with scattered small veinlets of chalcopyrite. As mentioned in Douglas's report on 'Copper Deposits of Newfoundland' two diamond drill holes were put down during the summer of 1938 in this area. The one put down beneath the main open pit workings failed to cut ore at depth. The hole put down to explore the quartz porphyry contact to the southeast of the main pit cut 20 inches of good grade copper ore. No record of production from the East Mine is available but output during the 1890's reached a peak of 60,000 to 70,000 tons of cupriferous pyrite a year. According to an estimate made by Poillan and Poirier there is 74,100 tons of remaining material on the East Mine dumps averaging 1.08% copper.

The West Mine of the Tilt Cove property during its period of operations, 1864 to 1912, shipped an estimated 84,448 tons of material averaging 9.1% copper. The ore here occurs as replacement of basic, andesitic lavas which have been intruded by quartz diorite porphyry and pyroxenite. The mineralization occurs as veinlets and impregnations of chalcopyrite and pyrite in chloritized lavas. This is in contrast to the East Mine where the ore was almost wholly composed of massive, slightly cupriferous pyrite. It has been estimated that the run-of-mine ore of the West Mine during its period of operations averaged 2.7% copper.

In summing up the present position of the West Mine, David Williams, in Copper Deposit of Newfoundland, estimates that:

(1) 100,000 tons of readily available 2% copper ore are on the dumps.

(2) 250,000 tons of 2% copper ore are in place down to sea level.

(3) An unknown tonnage of 2% copper ore is in place in the flooded workings below sea level.

Wild Cove

This prospect is about a mile east of Twillingate North on the eastern side of Notre Dame Bay. A trench, about 20 feet in length, alongside the road has opened up a vein about 4 feet thick which is sparsely pyritized and carries chalcopyrite, sphalerite and traces of galena in a quartzose gangue. David Williams has estimated the copper content at less than 2 per cent.

A poorly mineralized, oxidized capping is present some 40 yards northwest of the trench denoting a probable extension of the vein. A shallow shaft has been sunk about 20 feet from the trench on the vein extension.

Other than the work outlined above no exploratory work has been undertaken on this property and although no large body is indicated further prospecting appears warranted.

West Coast Deposits

Gregory River

The Gregory River deposits lie about 5 miles inland from Shoal Point, which is about halfway between Bay of Islands and Bonne Bay. The copper-bearing veins are found in fissures and shear zones in gabbro and occur within a rugged area about 2 1/2 miles from east to west and less than 1 1/2 miles from north to south. Chalcopyrite is, by far, the most abundant sulphide present and is found in a predominantly quartz gangue. The veins show rapid pinching and swelling both laterally and vertically.

The showings were discovered in 1921 as a result of tracing copper ore in the bed of the Gregory River. Subsequent prospecting located 8 veins which were trenched, test-pitted, and sampled with assays ranging from 4 to 18 per cent copper over 4 to 30 foot widths. Proven lengths of the various lodes range up to a maximum of 710 feet.

Details of the work is outlined by Olaf N. Rove in 'Copper Deposits of Newfoundland' and even if results were half as good as reported the property merits further attention.

York Harbour

This property is located about 20 miles west of Corner Brook, south of Bay of Islands, on the west coast of Newfoundland.

The ore minerals consist of sphalerite, chalcopyrite, and pyrite occurring as lenses, disseminations, and stringers in a chloritic schist. Operations at the property prior to closing in 1913 are reported to have yielded 30,000 tons of ore with no overall grade given. However, it is reported that 3,000 tons shipped in 1905 assayed as follows:

1st shipment of 1500 tons - 3.53% copper, 7.0% zinc, and 36.4% sulphur.

2nd shipment of 1500 tons - 2.70% copper, 0% zinc, and 35.0% sulphur

There is little evidence of any exploration having been conducted along the strike of the ore zone and only limited lateral development was undertaken from the 6 levels driven from the main shaft (70° incline) which was sunk to about 300 feet vertical depth. A grab sample of ore taken by A.K. Snelgrove, Newfoundland Government Geologist, from the mine dump assayed:

Copper	-	9.38%
Zinc	-	20.74%
Sulphur	-	25.68%
Silver	-	1.0+ oz.

Independent Mining Corporation Limited of Toronto has recently optioned the property from Harvey and Company of St. John's, the owners of the property. Geophysical exploration to be followed by exploratory diamond drilling is planned.

New Brunswick, Nova Scotia

Provincial reports, and those of the Geological Survey of Canada contain references to occurrences of pyrite in several localities in Nova Scotia and New Brunswick. However, there is no record of the mining and shipment of pyrite from any of the occurrences which are, apparently, of a disseminated nature or occur as narrow stringers with quartz in shear zones.

In the Geological Survey Memoir No. 18 on the Bathurst District, New Brunswick, several iron ore occurrences in Gloucester County are described. These consist chiefly of magnetite and usually have marked, banded structures. Disseminated sulphides (pyrite and chalcopyrite) occur scattered throughout the banded magnetite bodies. Toward the footwall which carries pyrite, the ore usually contains increasing amounts of the sulphide. In his description of the Nipisiguit Iron Ore Deposit, about 17 miles S.S.W. of Bathurst, G.A. Young, says of the largest body, "At one point, within 6 feet of the wall, the ore for a width of 6 inches is heavily charged with pyrite in fine grains and in minute parallel lines and streaks, usually very short, but in some cases an inch or so in length. In other cases, near the footwall the pyrite was less uniformly distributed, and tended to occur in very narrow, distinct, vein-like masses of comparatively large grains showing distinct crystal faces".

The three orebodies comprising the Nipisiguit Iron Ore deposit have shown widths from 40 feet to over 100 feet with indicated lengths of over 2000 feet and a depth of 400 feet. This data was obtained from trenching, magnetometer survey and diamond drilling. From the lags and cores of 10 early drill holes, G.A. Young estimated the following analysis of the No. 1 orebody,-

Iron - Average between 47 and 51 per cent; range from 39.6 to 58.7 per cent.

Sulphur - Average between 0.17 per cent and 0.27 per cent; range from 0.009 to 2.433 per cent.

Phosphorus - Average between 0.77 per cent and 0.89 per cent; range from 0.385 to 1.222 per cent.

The Nipisiguit deposit with others in the Bathurst area may, at some time, be a source of pyrite. The character of the magnetite ore which has a quartz, feldspar, and schistose gangue, suggests that upgrading by magnetic means might be applicable. Pyrite could then be separated from the waste rock by gravity separation or flotation.

Deposits of nickeliferous pyrrhotite, associated with pyrite and chalcopyrite, have been known in the vicinity of St. Stephen for more than 60 years. A description of this deposit, with work performed to 1938, is contained in the 1938 annual report of the New Brunswick Department of Lands and Mines. The following is taken from that report:

> "The 'Rogers' lens was prospected by about 2000 feet of trenching and 4000 feet of diamond drilling. The results indicate a body shaped like an inverted pyramid, covering an area of 15,000 square feet at the surface and extending to a depth of about 250 feet. The estimated tonnage is about 150,000. Some trenching and two diamond drill holes were made on the 'Hall-Carrol' property about 2000 feet south of the Rogers. The preliminary work indicates a sulphide body approximately 400 feet long and 10 to 28 feet in width. This vein-like mass is not considered of great importance. The geophysical surveys indicated pronounced anomalies in several other localities and the logical assumption is that they represent sulphide bodies which should be explored by trenching and drilling.
>
> "The deposits consist of rather solid nickeliferous pyrrhotite and some chalcopyrite, so that the mineralization is identical with that of Sudbury. The sulphide bodies are in sharp contact with the surrounding gabbro which closely resembles the parent rock (norite) of the Sudbury nickel ores. Sydney H. Ball who made a geological report on the property states that the sulphides were probably deposited by hot waters originating in the gabbro mass soon after is solidified. An average analysis of the ore from the Rogers lens is as follows:- 45.5 per cent iron, 24.5 sulphur, 0.9 copper, 1.5 nickel, 0.1 cobalt, 0.1 zinc, 0.007 phosphorus, 1/4 oz. silver, and 30 cents gold. Platinum, arsenic, antimony or lead are not present. The nickel content is uniform, but the copper content is more irregular."

In 1938 Hans Lundberg Limited conducted a magnetic survey of the area in which the Rogers and Hall-Carrol lenses occur. In 1947 The International Nickel Company optioned a large block of ground in the area and conducted further geophysical work in conjunction with limited diamond drilling. The results of their work are not known.

Quebec

General

Production of pyrite, in Quebec, has always been in association with that of copper. The Eastern Townships, from 1859 to 1866 particularly, experienced a mining exploration and development boom during which most of the occurrences, to be described later, were discovered. It was during this period, chiefly, that the hundreds of prospecting shafts and pits were sunk. Two properties had a long, early record of production - the Eustis mine, about eight miles south

of Sherbrooke, discovered in 1865 and the Weedon, or McDonald mine, about 40 miles from Sherbrooke, discovered in 1909. Each of these former producers, like many others, have been incorporated recently into new mining companies. Exploration and development is either underway or is being planned.

The Eustis mine was in operation continuously from 1879 to the mid 1930's with the exception of three years following World War I. The mine, along with the adjoining Albert and Capelton properties, was recently incorporated into Albert Metals Corporation Limited. Weedon Pyrite and Copper Corporation Limited has dewatered the former Weedon mine. Exploration and development are under way. The Weedon mine had a recorded production shipment of 565,000 tons of ore from 1909 to 1920, which is reported to have averaged 41.0 per cent sulphur, and 3.5 per cent copper. Suffield Metals Corporation Limited is operating the former 'Suffield' mine; Ascot Metals Corporation, Limited, the Moulton Hill mine, about 2 miles east of Sherbrooke. Quebec Copper Corporation Limited is currently examining the Huntingdon, Ives, and Bolton properties by diamond drilling. Results are encouraging. Other companies are also active in the area.

By-product pyrite, in the form of flotation concentrates, is being produced from several western Quebec mines. Noranda Mines Limited recovers pyrite from its cyanide mill tailings; Waite Amulet Mines, Limited has produced pyrite from its flotation circuit since 1944; Quemont Mining Corporation Limited began recovery of pyrite as flotation concentrate in 1950 and East Sullivan Mines Limited in January 1951. There has been no recorded production of lump pyrite in Quebec since the closing of the Weedon mine in 1920.

Eastern Townships

Eustis Mine - Ascot twp.
McDonald Mine - Weedon twp.
Capelton Mines - Ascot twp.
Howard Mine - Ascot twp.
Moulton Hill Mine - Ascot twp.
The Suffield Mine - " "
King Mine - " "
Victoria Mine - " "
Huntingdon Mine (Ives Mine, Bolton Mine) - Bolton twp.
The Stratford Pyrite Deposit - Stratford Twp.
The Garthby Mine - Garthby twp.
Mining Properties, 1850-1900

Eustis Mine - Ascot twp., Con. IX, Lots 2 and 3

This property, discovered about 1865, is about seven miles south of the city of Sherbrooke and was formerly owned and operated by the Eustis Mining Company. It is one of the properties in the area controlled by The Albert Metals Corporation, Limited.

The main orebody consisted of a series of sulphide lenses dipping about 35° to the southeast. The largest of the lenses was nearly 800 feet in length along the dip with a strike length of 250 and widths varying from a few inches to over 70 feet. Other lenses, occurring en echelon, were of the same general shape but smaller. The main shaft was sunk, on an incline, to a vertical depth of about 3200 feet or slope depth of 7000 feet.

In former operations over 500,000 tons of ore, grading under 2% copper and from 40-45% sulphur, were shipped. The ore occurred as pyrite with minor chalcopyrite and was in demand by sulphuric acid manufacturers in the United States. The property was closed down in the early 1920's when demand for pyrite slackened off due to the advent of Frasch-mined sulphur.

McDonald Mine (or Weedon Mine) - Weedon twp., Range 1, Lot 22

Exploration work was begun on this property, which is about 3? miles northeast of Sherbrooke, in 1909. Weedon Pyrite and Copper Corporation Limited, incorporated in 1950, now owns the property and has dewatered the old mine workings. By May 1951 the company had completed a geophysical survey, started surface diamond drilling and made plans for rehabilitating the mine workings.

Development work was carried out on several levels in former operations (1910-1921) from an 800 foot inclined shaft. The ore consists of pyrite with minor chalcopyrite. A production of 584,000 tons of ore is reported from 1913-21 and at time of closing the company reported an indicated 200,000 tons of ore in place.

Ore, in former operations, was shipped to the Nichols Chemical Company at Capelton, P.Q. for acid manufacture and to United States points. Some early ore shipments carried about 5 per cent copper.

Capelton Mines - Ascot twp. near Sherbrooke

Albert Mine	-	R. VIII, Lot 3
Capel Mine	-	R. VIII, Lot 4
Crown Mine	-	R. IX, Lot 4

The first discoveries were made on the Capelton properties about 1863 and it was the discovery of the bodies on the Crown mine property that led to the discoveries on the Eustis property, on the adjoining lots. The mines were operated almost continuously for about 30 years and were finally closed in 1908 with the deepest shaft having reached a depth of about 1800 feet. The deposits are similar to those mined on the Eustis property, consisting of pyrite with chalcopyrite, but were smaller in extent and more irregular in their distribution.

The several orebodies worked on the property strike roughly northeast and dip to the southeast. They varied greatly in size but in general were lenticular with widths ranging from narrow vein-like bodies to masses over 50 feet wide. Much of the ore mined graded 5% copper and one body of fair size contained about 15% copper. The

pyrite was much in demand and was shipped to the acid works at Capelton (G.H. Nichols & Company) as well as to United States points. A small smelting plant was erected at Capelton to treat the higher grade copper ores and the cinder from the acid works.

Albert Metals Corporation Limited now control the Albert and Capel mines along with the Eustis, Victoria, and other properties in the Sherbrooke area.

Howard Mine - Ascot twp., Range XI, Lot 5

This property, originally known as the Gillis, was operated by the Grasselli Chemical Company of Cleveland which developed the orebody through a single shaft of over 200 foot depth. Mining operations ceased when the ore dipped onto the property of the adjoining King mine.

The ore appears to have been nearly pure pyrite carrying low copper in the form of chalcopyrite. As in other mines in the area the body mined was lenticular and other bodies may occur at depth or en echelon. Only limited exploration work was undertaken.

Moulton Hill Mine - Ascot twp., Range III, Lots 23 & 24

Operations on this property were carried on intermittently from 1885 to 1895 during which time peak shipments of about 1000 tons of pyrite (45% sulphur) were made to acid plants in the United States. From 1889 to time of closing the mine was operated by the Grasselli Chemical Company of Cleveland, Ohio.

The deposit consisted of nearly massive pyrite with very minor chalcopyrite and at surface was from 4 to 6 feet wide. The orebody was reported to have widened to about 50 feet at 70 foot depth from which depth the massive character of the ore changed to a dissemination of the sulphide minerals in the enclosing sericite schists. The country rock is a sericite schist carrying quartz veins and stringers with fair pyrite mineralization. The property was closed in 1895 because of the change from massive pyrite, suitable for acid works, to pyrite dissemination requiring beneficiation.

The mine was operated from 1942 to 1945 by Aldermac Copper Corporation for Wartime Metals when a mill was installed. From the inclined shaft, having a slope depth of 442, considerable lateral development was carried on from three horizons. During the last six months of this operating period about 38,000 tons of ore treated in the mill yielded, roughly, 3,280,000 lb. of zinc, 1,880,000 lb. of lead, 770,000 lb. of copper with silver and gold. Operations were suspended when war contracts were cancelled.

Ascot Metals Corporation, Limited, acquired the property in 1949. They have deepened the shaft to provide three more levels at 100 foot intervals and by exploration and underground development have broadened the ore picture. Present ore reserves, as established by the Company, are given as 229,800 tons averaging 0.8 to 1.0% copper, 1.2% lead, 5.0% zinc, and 1 oz. per ton silver. In earlier reports no

sulphides other than pyrite and very minor chalcopyrite are mentioned. Evidently, with depth, the changeover from massive pyrite mineralization to sulphide dissemination in the sericite schist has resulted in the introduction of base metal values. The mill has a rated capacity of 500 tons per day.

The Suffield Mine (Griffith Mine) - Ascot twp., Range XI, Lots 2 and 3

In early operations the Sherbrocke Mining and Smelting Company sank a 200 foot shaft and carried out lateral development at the 80 and 200 foot horizons. All work was suspended about 1893 and no shipments of ore were reported from these early operations. Early reports of the ore occurrences describe it as consisting of disseminated pyrite and chalcopyrite in a schistose rock composed mainly of quartz and sericite mica. Low values in gold and silver were reported as well as very minor galena and sphalerite dissemination.

Suffield Metals Corporation Limited, a wholly-owned subsidiary of Ascot Metals Corporation, was formed in 1950 to acquire this mine which is about 4 1/2 miles from Ascot's Moulton Hill property. Extensive surface diamond drilling in 1950-51 is reported to have indicated 4 zones with a total of 1,217,800 tons of ore averaging 4.84% zinc, 0.60% lead, 0.21% copper, 1.12 oz. silver, and 0.018 oz. gold per ton. Ore is trucked to the Ascot mill for concentration.

King Mine - Ascot twp., Range XI, Lot 4

The orebody worked on the Howard property extends, on dip and strike, onto that of the King mine. For several years, prior to closing in 1910, exploratory work was conducted from a shallow (165 feet) incline (35°) shaft and some lateral development was undertaken. The ore occurrence apparently differs from that of the Howard mine in that it occurs as sulphide stringers in the sericite schist rather than the massive type. In general the sulphides were reported to occur in the form of disseminations or as narrow stringers in a sericite schist parallelling the schistosity. Pyrite is the predominant sulphide present with chalcopyrite and minor sphalerite. Assays of up to 12% copper were obtained by the original operators from some portions of the underground workings.

Apparently no diamond drilling has ever been conducted on the property and exploration work has been rather limited. Mineralization here appears to resemble that encountered on the Moulton Hill and Suffield properties. Further exploration and development appears warranted.

Victoria Mine - Ascot twp., Range VIII, Lot 4 (N.E. 1/4)

This property adjoins the Capelton mines on the northeast and lies on strike of the ore bearing zone in which the Eustis and Capelton orebodies were found. Prior to 1866 a shaft was sunk to about 75 feet on the schist which was heavily impregnated with pyrite and chalcopyrite.

It was exposed for more than 100 feet with a maximum width of 20 feet. The schists strike N.E. and dip from 40° to 60° to the southeast. The shaft was sunk on a lenticular body of massive pyrite with chalcopyrite about 6 feet wide. It was reported to have passed out of the 'ore' at about 25 foot depth. Assays taken across the schist near the shaft collar are reported to have yielded from 1 to 2 per cent copper.

This property is now owned by Albert Metals Corporation. No recent work has been reported. Further work appears warranted.

The Huntingdon Mine - Bolton twp., Range VIII, Lot 8
The Ives Mine - Bolton twp., Range IX, Lot 2
The Bolton Mine (or Canfield, or Canadian) - Range VIII, Lot 6

Quebec Copper Corporation Limited, upon incorporation in 1950 acquired the above three properties and following a resistivity survey of the Huntingdon property, diamond drilling was begun in 1951 in the vicinity of the old mine workings. The three properties lie on a north-south schistose band of serpentinized rocks about 80 miles east of Montreal and about 60 miles west and south of Sherbrooke. Mineral occurrences are similar to those described above in Ascot township and mineralization consists predominantly of pyrite with chalcopyrite and, in places, low lead, zinc, and precious metal values. Present exploration work being undertaken by Quebec Copper Corporation is concentrated on the Huntingdon property (August 1951).

The Huntingdon mine has a long period of operations which began in 1865. It was worked intermittently until closing in 1890. Pierre Tetreault, Montreal, in 1912 pumped out the old Nichols shaft down to 275 feet but exploration was suspended after an examination of the workings to that depth. The ore consists chiefly of a chloritic slate and diorite carrying disseminated pyrite, chalcopyrite and pyrrhotite and occasional patches of massive sulphides. Two shafts were sunk on this property, - the Huntingdon (Nichols) shaft to about 600 feet and the Wright shaft to 200 feet.

About 80,000 tons of material was removed by former operators who hand-cobbed the run of mine ore and shipped a product carrying from 10% to 14% copper. Recent sampling by Quebec Copper Corporation Limited across a 60 foot width of schist in the westerly zone averaged 2.64 per cent copper and across a width of 6 feet in the eastern zone 8.44 per cent copper. Recent drilling under the western zone has returned copper values across 10 to 25 foot widths in the vicinity of old mine workings.

Ore occurrences at the Ives Mine to the north are similar to those of the Huntingdon but work to date has indicated them to be smaller. This mine operated about the same time as the Huntingdon. Two shallow shafts, 60 and 100 feet deep, about 300 feet apart, with some lateral development, constituted the mine workings. Run of mine ore was hand-cobbed to 10-12 per cent copper and shipped to Great Britain.

The Bolton mine adjoins the Huntingdon on the north. Two shallow shafts were sunk on a band of chloritic slate carrying disseminated pyrite and chalcopyrite. Apparently mineralization here, though not as extensive as on the Huntingdon or Ives, was quite similar in character and lies in the same band of chloritic slates.

The Stratford Pyrite Deposit - Stratford twp., Range VI & VII, Lots 6, 7, 8, 9.

This property, about 40 miles northeast of Sherbrooke, was discovered in 1910 as a result of the prospecting activity which followed the finding of the Weedon Mine about 8 miles to the southwest. An old shaft was deepened in 1914 to about 75 feet. Subsequently 1600 tons of pyrite, grading about 46 per cent sulphur, were shipped. The pyrite in the shaft was about six feet in thickness.

Limited surface work indicates the presence of two lenticular, rather small bodies of ore composed mainly of pyrite with some chalcopyrite and pyrrhotite. An assay of a specimen of the pyrrhotite yielded 0.93 per cent copper and 0.09 per cent nickel. The enclosing sericite schists are similar in composition to those found at the Weedon, Moulton Hill, Eustis and other deposits in the general Sherbrooke area.

The Garthby (or Lac Coulombe) Mine - Garthby twp., Range I, N. and Range I, S., Lot 22.

This property is about 12 miles north and west of the Weedon mine. In 1863 a shaft was sunk on an outcrop of chlorite schist heavily mineralized with pyrite and containing some chalcopyrite. Total width of the zone was reported to be about 20 feet with no record of its length. Some shallow prospecting pits were sunk on both sides of the road which runs northwest of Garthby. This work appears to have been done in fairly heavy sulphide mineralization as a sample of the dump material yielded 45.32% sulphur, 40.45% iron, and 0.36% copper. No extensive exploration was ever carried out on this prospect and there is no record of shipments.

In his report on "The Copper Deposits of the Eastern Townships of the Province of Quebec", J. Austen Bancroft outlines in detail the development and exploration carried out on a great number of prospects and mines in the area. Most of the work from 1860 to 1900 was in search for copper but invariably pyrite was found in association with the copper minerals and sometimes zinc and lead sulphides were also reported. The major developments have been outlined above and to the list might be added the Harvey Hill mine in Leeds Township which had a long, intermittent period of operations following the discovery of 'copper ores' there about 1750. The Acton mine in Acton township about 40 miles northwest of Sherbrooke sporadically shipped high grade copper ores (about 10%) to Great Britain over a period of years.

Interest in the ore deposits of the Eastern townships has revived with successful operation of the Moulton Hill mine by Ascot Metals Corporation Limited and the bringing into production of the Suffield Mine by Ascots' subsidiary, Suffield Metals Corporation Limited. Other companies who have properties in the area and are carrying out exploration and development work are: Quebec Copper Corporation Limited (Huntingdon, Ives and Bolton mines), Weedon Pyrite and Copper Company (Weedon mine) and Albert Metals Corporation Limited (Eustis, Albert, Capel, Victoria and other mines).

Mining Properties, 1850-1900

On many other properties limited exploration work was conducted from 1850 to 1900 and shipments of copper ore and pyrite were made from some. Mr. Bancroft outlines, in detail, this early work in his report and the following list has been taken from that source. Most of the deposits mentioned are merely occurrences and would appear to warrant no further exploration.

Copper Deposits West of the Sutton Belt

The Acton Mine, Range III, Lot 32, Acton.
Upton Township, Ranges XX and XXI, Lots 49, 50 and 51.
Roxton Township, Range III, Lot 23.
Durham Township, The Durham Mine, Range VII, Lot 21.

Copper Deposits of the Sutton Belt

Sutton Township

Sweet's mine, Range X, Lot 8; Range X, Lot 8, N 1/4, Range X, Lot 10; North Sutton Mining Co., Range X, Lot 11; Range XI, Lot 7; Range XI, Lot 10; Range XI, Lot 11; North Sutton Mining Co., Range XI, Lot 12.

Brome Township

Washer's mine, Range IV, Lot 2; Canada Copper Mining Co., Range V, Lot 5; Bedford Mining Co., Range VI, Lot 6; Range VII, Lot 6; Tibbet's Hill mine, Range VIII, Lot 12; Range VIII, Lot 13; Range VIII, Lots 18 and 19, and Range IX, Lot 21; Range IX, Lot 25.

Shefford Township

Range II, Lot 26; The Glencoe Mining Co., Range II, Lot 27; The Waterloo Mining Company, Range III, Lot 28.

Stukely Township

The Grand Trunk mine, Range I, Lot 6; Range I, Lot 7; Lambe & Shepherd's mine, Range II, Lot 7; The Logan mine, Range VI, Lots 9 and 10; Range VII, Lot 8; Range VIII, Lot 8; Range IX, Lot 5; Range IX, Lot 6; Range X, Lot 4.

Ely Township

Range I, Lots 11 and 12; Ely Copper Mining Co., Range II, Lots 9 and 10; Range III, Lot 12; The Ely mine, Range VII, Lot 3.

Melbourne Township

The Bower's mine, Range I, Lots 7 and 8; The Goldspring mine, Range II, Lot 6; The Rahell Hill mine, Range III, Lot 2; The Balrath mine, Range IV, Lot 2; Range IV, Lot 3.

Cleveland Township

The St. Francis mine, Range XII, Lot 25.
The Jackson Mine, Range XIII, Lot 26.

Leeds Township

The Harvey Hill mine, Range XV, Lot 17.

Copper Deposits Between the Sutton and Ascot Belts

Potton Township

The Lake Memphremagog (or Smith's) mine.

Bolton Township

Libby's mine, Range VII, Lot 24; Range VII, Lot 25; Holland mine, Range VII, Lot 26; Range VII, Lot 27; The Ferrier Shaft, Range VIII, Lot 4; The Canfield (Bolton or Canadian) mine, Range VIII, Lot 6; The Huntingdon mine, Range VIII, Lot 8; Range IX, Lot 1; The Ives mine, Range IX, Lot 2; Range IX, Lot 3; Range XII, Lot 3.

Brompton Township

Range IV, Lot 6.

Garthby Township

Range I, S.E., Lots 26 and 27; The Garthby Copper Mining Company, Range II. S., Lot 19, The Garthby or Lac Coulombe mine, Ranges I.N. and I.S., Lot 22.

Copper Deposits of Hatley, Ascot and Stoke Townships

Hatley Township

The Reid Hill mine, Range I, Lots 27 and 28; Range II, Lot 28; The Johnson mine, Range III, Lot 27; Range IV, Lot 25; The Fish mine, Range IV, Lot 26; The Shannon mine, Range IV, Lot 27; The Parnell Copper Mine, Range VI, Lot 10.

Ascot Township

The Moulton Hill mine, Range III, Lot 23; The McDonald mine, Range III, Lot 24; Old Moulton Hill mine, Range IV, Lot 15; Range IV, Lot 17; The Boudreau mine, Range IV, Lot 24; Range V, Lot 17; Range V, Lots 18 and 19; The Nutter or the Dufort mine, Range V, Lot 20; Range VI, Lot 16; Archambault mine, Range VI, Lot 19; The Griffith mine, Range VI, Lot 20; The Smith Iron Mine, Range VI, Lot 21; The Clark mine, Range VII, Lot 11; The Sherbrooke mine, Range VII, Lot 12; The Capelton mines (the Albert, Walter, etc.), Range VIII, Lots 3 and 4, and Range IX, Lot 4; The Victoria mine, Range VIII, Lot 4;

Range VIII, Lot 7; The Ascot mine, Range VIII, Lot 8; The Wilson mine, Range VIII, Lot 8; Range VIII, Lot 9; The Dundin mine, Range VIII, Lot 10; The Lennoxville mine, Range VIII, Lot 11; The Parks mine, Range VIII, Lot 12; Range VIII, Lot 13; The Short mine, Range VIII, Lot 14; The Eustis mine, Range IX, Lots 2 and 3; The Calhoun mine, Range IX, Lot 5; The Marrington mine, Range IX, Lot 6; The Hepburn mine, Range IX, Lot 7; The Newhell Hill (or the Hill) mine, Range IX, Lot 8; The Belvedere Copper mine, Range IX, Lot 10; The Magog mine, Range IX, Lot 11, Range X, Lot 1; Range X, Lot 7; Range XI, Lot 1; Mr. Norton's mines, Range XI, Lots 2, 3 and 4, The Suffield mine, Range XI, Lots 2 and 3; The Silver Star, Range XI, Lot 4; The Howard mine, Range XI, Lot 5.

Stoke Township

Range V, Lot 22 (a) and 22 (b).

Copper Deposits of Weedon and Stratford Townships

Weedon Township

Mention is made of Lots 1, 20 and 21 of Range I, of Lots 11, 12, 13, 14, 17, 18, 19, 20 and 21 of Range II and of Lots 18, 20 and 23 of Range III; The Weedon or McDonald mine, Range II, Lot 22.

Stratford Township

Range II, S.W. Lot 36; Range II, S.W. Lot 37; Range II, S.W. Lot 38; Range II, S.W. Lot 39; Range III, S.W. Lot 37; Range III, S.W. Lot 38; Range III, S.W. Lot 40; The Stratford Pyrite Deposit, Ranges VI and VII, S.W., comprising portions of Lots 6, 7, 8 and 9, Range VI, S.W., Lots 10 and 11; Range VII, S.W., Lot 4; Range VII, S.W., Lot 5; Range VII, S.W., Lot 6; Range VII, S.W., Lot 9.

Western Quebec

Noranda Mines Limited (Horne Mine)
Barvue Mines Limited
Normetal Mining Corporation Limited
Delandore Sulphur & Iron Mines Limited
Atlas Sulphur and Iron Mines
Arnora Sulphur Mining Corporation

The overall by-product output of pyrite from Noranda, Quemont, Waite-Amulet, and East Sullivan mines in western Quebec has shown an annual increase over the past several years. These mines together with Britannia Mining and Smelting Company, British Columbia, have accounted for the total production in recent years of pyrite in Canada. The sulphur equivalent in pyrites shipped in 1950 amounted to 150,828 tons which, assuming a 47 per cent sulphur content, is equivalent to 314,225 tons of pyrite.

Noranda Mines Limited

Horne Mine - Noranda Mines Limited has on the lower levels of its Horne Mine at Noranda, the largest developed body of pyritic material on the continent. This reserve is estimated to contain 100,000,000 tons averaging 50 per cent pyrite with low zinc, copper, and gold values.

MacDonald Mines - The Noranda Mines Limited has also leased, for 50 years (May 1950), a block of 50 acres of the MacDonald Mines property in Dufresnay township, about 8 miles north of the Noranda mine. The leased block of ground has been developed underground. Indicated ore reserves are estimated by MacDonald management as 9,000,000 tons averaging about 80 per cent pyrite with low zinc and 9,000,000 tons of same pyritic content with about 3.5 per cent zinc. No production plans for the MacDonald ground have been made by Noranda but the developed reserves of good grade pyrite could be brought into production quickly.

Noranda Mines Limited, has developed on a laboratory scale, and recently in a 25-ton-per-day pilot plant operation, a process for recovering elemental sulphur from a typical finely ground flotation concentrate. Essentially, it is a process that volatalizes most of the labile atom of sulphur in the pyrite with subsequent sintering of the solid residue, made in the first step, producing a high-quality iron oxide sinter and sulphuric acid from the sulphur dioxide gas formed. About one third of the sulphur in the pyrite is recovered as elemental sulphur and the remainder as sulphuric acid. By processing 300 tons of pyrite concentrate a day, assuming 50 per cent sulphur content, a recovery of about 18,000 tons of elemental sulphur a year can be expected along with a sulphur equivalent of about 35,000 tons as sulphuric acid. No announcement has been made by company officials of a decision to build a commercial plant for treatment of pyrite concentrates. The feasibility of the recovery of elemental sulphur from pyrite is one of economics. Plant site would probably be located where markets for the high-grade iron oxide sinter and sulphuric acid exist.

Barvue Mines Limited

Barvue Mines Limited have completed financing plans for bringing its zinc-silver property in Barraute township into production at a 4,000 ton per day rate in 1952. From diamond drilling records to May 1951, the company estimates ore reserves of 17,300,000 tons averaging 3.2 per cent zinc, and 1.1 ounces of silver to the ton. This occurs to a 700 foot depth in a 2,500 foot length of ore zone with both ends open. The zinc concentrates from Barvue will be roasted in a plant to be built at Arvida, Quebec, by Aluminum Company of Canada, Limited. An estimated 40,000 to 50,000 tons of sulphuric acid will be recovered annually. This acid will be used by Aluminum Company of Canada at its Arvida works. The calcined concentrates will be shipped to the United States for recovery of metal content.

In addition to the companies noted above which are currently shipping pyrites, many other companies active in western Quebec report the presence of pyrites on their properties.

Normetal Mining Corporation Limited

Normetal Mining Corporation Limited, with mine and concentrator in Desmeloizes township, about 40 miles north of Noranda, is considering the recovery of pyrite from its copper-zinc operations and shipments are expected to begin about mid 1952.

Delandore Sulphur and Iron Mines Limited

This company holds a large group of claims in Delestre township, 18 miles northeast of Senneterre, on which a large body of pyritic material has been outlined by diamond drilling and geophysical exploration. The company reports, from work performed in the late 1930's, that a zone 5000 feet long was indicated, having an average width of about 100 feet. The zone was reported to be heavily mineralized with pyrites of low gold values. The seventeen holes were put down over a length of 2,400 feet and the zone was tested to a maximum depth of 900 feet. No tonnage or grade estimate of pyrites in this deposit has been reported by the company.

Atlas Sulphur and Iron Mines

Atlas Sulphur and Iron Mines, incorporated in 1951, holds 36 claims in Ducros and Delestre townships, which adjoin those of Delandore. A property amalgamation is being negotiated at the present time for the acquisition of the claims of Delandore Sulphur and Iron Mines Limited and Parent Lake Mines Limited.

Arnora Sulphur Mining Corporation

Arnora Sulphur Mining Corporation, formerly Arnora Gold Mines, has optioned its group of 5 claims in Joannes township, 12 miles east of Noranda, to United States interests. The company reports that diamond drilling in 1945 located areas of pyrite but no tonnage or grade estimate has been reported. A geophysical survey has recently been completed. Press releases report the company to be diamond drilling one of its two pyrite properties recently acquired in Languedoc township, about 30 miles north of Noranda. The two properties adjoin groups held by American Metals Company where a diamond drilling program has just been completed.

Pyrite in Ontario

General

The first recorded production of iron pyrites in Ontario was made by the Madoc Mining Company in 1901, from its property near Bannockburn in eastern Ontario. In that year 7,000 tons of pyrite, having a value of $17,500, where shipped to acid manufacturers in Buffalo and Cleveland.

Until pyrite shipments ceased in 1930 with the closing of operations at the Caldwell mine of Canadian Pyrites Limited at Flower Station, about 1,600,000 tons of lump pyrite were shipped from Ontario mines.

The following table shows the shipments from Ontario mines in short tons of pyrite for the years 1910-1922, with value of shipments. Sulphur content of the pyrite varied from 32 to 48 per cent but no separate record is available to show the sulphur content of the ores as mined.

Pyrite Production, Ontario, 1910-1922

Year	Pyrite Shipped (in Short Tons)	Total Value $	Average Value/ton $
1910	33,812	98,353	2.91
1911	43,629	118,457	2.71
1912	20,744	71,043	3.42
1913	71,620	171,687	2.39
1914	107,258	264,722	2.46
1915	145,315	353,498	2.43
1916	175,593	471,807	2.68
1917	286,049	1,111,264	3.88
1918	270,966	1,144,737	4.22
1919	117,178	366,422	3.13
1920	148,651	618,283	4.15
1921	27,785	101,306	3.64
1922	11,235	39,763	3.55

The following list records the major producers of pyrite, from 1910 to 1922, and their property locations:-

Name of Producer	Mine Location or Name
1. Algoma Steel Corporation, Limited	Helen
2. Canadian Sulphur Ore Company, Limited	Queensboro
3. Nichols Chemical Company, Limited	Goudreau(a)
" " " "	Sulphide
" " " "	Vermilion Lake (Northpines)(b)
4. Rand Consolidated Syndicate	Goudreau
5. Grasselli Chemical Company	Caldwell mine (at Flower Station)
6. Northland Pyrites Mine (1906-1910)	Northland (on James Lake, Timagami Area)

(a) Formerly known as The Madoc Mining Company

(b) Formerly known as The Northern Pyrites Company, Limited, which was a wholly owned subsidiary of the General Chemical Company, New York.

Eastern Ontario

Brockville District

Billings Mine
Sloan Prospect
Shipman Prospect
McIlwraith Mine

Hastings District

Bannockburn Pyrite Mines
Hungerford Mine
Canada Mine
Hungerford Western Extension
Ontario Sulphur Mines, Limited
Queensboro Mine
Canadian Sulphur Ore
Company's Property
Davis Prospect
Farrell Prospect
McKenty Prospect
Little Salmon Lake Prospect
Gunter Prospect

Other Eastern Ontario Prospects

Snooks Prospect
Ladore Prospect
Stalker Prospect
Foley Prospect
Caldwell Prospect
McKinnon Prospect

Pyrite Under Hematite in Eastern Ontario

Reported Hematite Occurrences in Eastern Ontario

Brockville District

Billings Mine - Elizabethtown township, Concession II, Lot 19.

Pyrite mining operations on this property in Leeds county were begun in 1868. The pyrite, which occurred in a series of lenses conformable to the enclosing granite gneiss, was mined by a series of open cuts in the richer shoots of ore. These open cuts were abandoned when depth conditions made them unsafe. The strike of the lenses was northeast and the dip to the southeast. Mining operations ceased in 1879 with the main pit having reached a depth of 250 feet. No further work is recorded.

Record of shipments or their grade is not available but the ore was used for making sulphuric acid in the works of the Brockville Chemical Company. This acid was used in the manufacture of fertilizer and dynamite. Operations closed in 1880.

References to the deposit do not suggest exhaustion of pyrite reserves. No mention is made of underground operations or exploratory work for new lenses.

Sloan Prospect - Elizabethtown township, Concession II, Lot 19.

A 10 by 10 foot shaft was put down to a depth of about 20 feet on a gossan band which strikes northeast and dips to the southeast. This property adjoins the old Billings mine on the east and the gossan band is

likely a continuation of the one occurring on that property. The shaft passed through 6 to 8 feet of gossan and then showed about 3 feet of massive pyrite on the footwall side and 7 feet of mixed pyrite and calcite toward the hanging wall side. About 80 tons of hand-cobbed ore, grading 40 per cent sulphur, were removed from the shaft and shipped to acid works at Buffalo and Capelton.

Shipman Prospect - 6 miles to the west of Sloan Prospect

This occurrence of pyrite and pyrrhotite in gneiss lies on the northern slope of a hill about 60 feet high. Pyrite was mined from a pit about 40 feet long by 30 feet wide. The pyrite occurs as stringers and small shoots much intermixed with pyrrhotite and country rock. The property lies about one-half mile from the railway and one mile north of the St. Lawrence River.

McIlwraith Mine - Darling township, Concession IV, Lot 5.

The Nichols Chemical Company began mining operations, under option, on this occurrence in 1899 and no work has been done since the expiration of the option in 1920. An old shaft was deepened to 75 feet. A tunnel 150 feet long was driven on the vein and exposed about a 90 foot length of mineable ore consisting of good grade pyrite enclosing quartz lenses. A 12 foot crosscut to the south from the tunnel was in ore without having reached the hanging wall of the ore zone. The gossan capping over the ore zone is about 14 feet. Three carloads of ore were shipped from the operation which, after hand cobbing, averaged about 43 per cent sulphur.

Hastings District

Bannockburn Pyrite Mine - Madoc township, Concession VI, Lot 25.

The gossan capping of this pyrite body was removed and shipped to the Hamilton Iron and Steel Company during 1898 and 1899. About 400 tons of material was removed, averaging over 38 per cent iron with low sulphur. In 1900 the American Madoc Mining Company leased the property and began pyrites mining operations by open cut. The original pit, about 80 feet in diameter, reached an eventual depth of 90 feet where it was abandoned as open-cut work became too dangerous due to sloughing of the pit walls. In the meantime, about 500 feet south of the open pit a new pyrite lens was opened and levels were established from a shaft at 60 foot intervals. Overhand stoping was originally employed but this later gave way to a method of underhand stoping as described by A.W.G. Wilson in his report on 'Pyrites in Canada' (Memoir No. 167). The south lens is about 160 feet long and varies from 8 to 15 feet in width. Mining operations were carried to a depth of 275 feet.

During the six years of operation about 580 tons of good grade pyrite per month, averaging perhaps 40 per cent sulphur, were shipped to the General Chemical Company's acid works at Buffalo. Operations were abandoned in 1906 although neither grade nor tonnage showed signs of diminishing.

Hungerford Mine - Hungerford township, Concession XII, Lot 23.

This mine is situated on one of a series of pyrite occurrences on the 'Hungerford Fahlband' which is a zone of sulphide mineralization lying about 5 miles east of Tweed north of the C.P.R. This zone strikes about N. 65° E., is traceable for about two miles, and lies along the contact of schist and diorite. A series of rugged hills about 500 yards north of the zone, locally called the Bald Mountains, is evidence of the intrusion of a pink hornblende granite into the schists. The level farmland to the south is underlain by garnetiferous schist cut by diorite.

The Hungerford mine was opened about 70 years ago by the American Madoc Mining Company as a gold property. The Nichols Chemical Company re-opened the mine in 1903 and from August, 1905, operations continued for many years. Three ore lenses, formerly known as the south, middle, and north lodes, were mined from the main shaft with levels at 100-foot intervals. Widths of the lenses varied from 6 to 22 feet and the north lode when first entered by crosscutting showed 17 feet of massive pyrite. The length of the north lode, from surface indications, was about 500 feet.

The pyrite, coarsely granular, made a high percentage of fines. Gangue material was mainly calcite with minor quartz. A small amount of pyrrhotite is present with an increasing amount toward the footwall of the lenses.

All the ore mined was used directly in the acid works of the Nichols Chemical Company erected on the property at Sulphide. The run-of-mine ore averaged about 35 per cent sulphur with the fines much higher. There is no record of the ore having 'bottomed' in any of the lenses nor of the lenses being worked out.

Canada Mine - Hungerford township, Concession XII, Lot 26.

This property adjoins the Hungerford mine and is on the extension of the same mineralized zone in which the Hungerford mine lies. The gossan band, lying along the side of a depression, strikes east-west and dips at about 50°.

A shaft was sunk to 110 feet in 1907 and some lateral work was done at the 85 foot horizon. Widths of the lens, as encountered in the shaft, varied from 4 to 7 feet and from the material remaining on the dump generally graded above 40 per cent in sulphur. There is no record of shipments nor evidence of much exploratory work.

Hungerford Western Extension - Hungerford township, Concession XII, Lots 21 & 22.

This property, around 1906, was trenched at regular intervals along the strike of the mineralized zone. The western lens, from surface trenching, was opened up for 500 feet and showed, near the line between lots 21 and 22, width of 16 to 18 feet of pyrite ore estimated to contain 42 to 44 per cent sulphur. Calcite was reported as the only gangue impurity. There is no record of work on the eastern lenses, presumed to be extensions of the Hungerford mine orebodies.

Pyrite was also found to the south of the C.P.R. tracks, which cross the southern end of the property, where the gossan band is about 40 feet wide. No work is reported on this zone.

Ontario Sulphur Mines, Limited - Hungerford township
Concession XI, Lot 21 (Part of)

Work was begun on this 150-acre property in 1908 and continued until near the end of 1911. An exploratory shaft was sunk to about 250 feet on a pyrite deposit about half a mile west of the Hungerford mine. Limited lateral work was carried out on the 100 and 200 foot horizons. No information is available on the quantity or grade of ore encountered in the underground exploratory work. A total of 4,821 long tons of pyrite ore, grading 36.5 per cent sulphur, was shipped from the property up to the first of May, 1911.

Queensboro Mine - Madoc township, Concession XI, Lot II

This mine is situated on one of a series of pyrite occurrences on the 'Queensboro Fahlband', similar in characteristics to the 'Hungerford Fahlband'. This mineralized schist zone is near the eastern boundary of Madoc township. It strikes in a general north-of-east direction and can be easily followed for about two miles with stained, rusty, and decomposed schists occurring over that distance.

The Queensboro deposit, about one mile southwest of the village of Queensboro, lies in a depression at the contact of a garnetiferous schist to the south and an intrusion of light grey granite to the north. Two shafts, 85 feet and 30 feet deep, were sunk and limited lateral work was carried out from the deeper shaft. A number of small pyrite lenses were worked with the highest grade ore coming from a series of lenses lying close to the granite contact. The one on which the main shaft was sunk had, at the shaft, a width of 15 feet and length of about 50 feet thinning out towards the ends. To the south lies an extensive area of pyrite mineralization possibly, carrying 35 per cent sulphur.

The mine was operated by the British American Development Company of Toronto and the pyrite, averaging about 47 per cent sulphur, was shipped to the Contact Process Company at Buffalo.

Canadian Sulphur Ore - Madoc township, Concession X, N 1/4 of Lot 9.

Company's Prospect (Wellington Prospect).

High grade pyrite occurs in a series of lenses in a mineralized zone of schisted, Pre-Cambrian, rocks. These lenses, as mined, varied from 4 to 20 feet in width with no lengths being on record. Two shallow shafts were put down. Shipments of ore, after minor hand-cobbing, to Sulphide, Ontario, and to Buffalo, New York, ranged from 40 to 48 per cent sulphur with very low impurities. No information is available on the total tonnage shipped, nor on the average grade. However, it appeared to be a highly desirable ore for the manufacture of sulphuric acid.

Davis Prospect - Madoc township, Concession IX, S 1/2 of Lot 10.

This property corners on the property of the Canadian Sulphur Ore Company. A test pit, about 10 feet deep, was put down on pyrite intermixed with crystalline limestone. A heavy band of gossan occurs on the same lot which, however, was never fully explored. Only a limited amount of test-pitting and trenching was done.

Farrell Prospect - Madoc township, Concession VII, Lot 9.

This property is about 2 miles northeast of the town of Madoc in Hastings county. The country rock of the showing is a calcareous schist with a northwest strike. Test pits were put down along the strike of the schist zone for some distance and encountered either gossan or pyrite. A sample, representing about 75 per cent of the dump material, alongside a 25 foot shaft, is reported as having contained 40.65 per cent sulphur. The pyrite deposit on this prospect is about 5 feet wide with crystalline limestone as the gangue material.

McKenty Prospect - Madoc township, Concession VII, Lot 6.

From this property, which lies about 2 miles east of the town of Madoc, hematite was shipped intermittently over a period of years. A pit, 60 feet deep, was sunk and A.W.G. Wilson reports that all large lumps of apparent hematite on the dump have, when broken a core of pyrite. In Mr. Fraleck's report (O.B.M. Vol. No. 16) on 'Iron Pyrites in Ontario' the opinion is expressed that this is one of many instances throughout Eastern Ontario where hematite constitutes the gossan capping of a sulphide orebody.

Little Salmon Lake Prospect - Cashel township, Concession VII, Lot 23.

This prospect is on the shore of Little Salmon Lake. A hill, 80 feet in height, rises sharply from the edge of the lake and about halfway up the hill, a 40 foot trench has exposed a pyrite deposit, 15 feet wide, at the north end of the trench. A deposit occurs in a chlorite schist striking west. An average of 75 per cent of the pyritic material yielded 38.83 per cent sulphur.

Gunter Prospect - Cashel township, Concession IV, Lot 23.

A shaft, 23 feet deep was sunk on a deposit consisting of alternating bands of quartz and pyrite. The total vein width in the shaft is 5 feet and the pyrite content is said to increase with depth. No gossan is in evidence on the surface. A sample representing two-thirds of the dump material yielded 39.50 per cent sulphur.

Other Eastern Ontario Prospects

Snooks Prospect - Loughborough township, Concession XIV, Lot 7.

On this property a mineralized zone strikes northeast through a coarsely crystalline, impure limestone, and can be traced across the adjoining lot 6 to Desert Lake. On the road allowance, 7 feet of massive pyrite and 25 feet of pyrite mixed with crystalline limestone was uncovered while obtaining material for the road. No work, other than that outlined above has been done.

Ladore Prospect - Dalhousie township, Concession VII, E. 1/2 of Lot 19.

A heavy fahlband strikes north of east along the contact of a coarse amphibolite and a fine-grained gray granite. It was reported that nearly every trench in the marshes and depressions exposes gossan in the form of a good grade of bog iron ore. Two pits, 100 yards apart were sunk to 20 and 22 foot depths in gossan and decomposed rock matter. Seams of pyrite up to a foot in thickness have been found in the trenching and test pitting but no appreciable quantity of pyrites was located.

The same mineralized zone, or fahlband, continues across lot 19, concession VI, along a contact of crystalline limestone and granite. Pyrite mineralization is also present in this zone but in limited quantity.

Stalker Prospect - Clarendon township, Concession VI, Lot 42 (Frontenac county)

A strong fahlband strikes east-west across this property which lies about 2 miles east of the village of Plevna. A shallow pit was sunk on a lens of pyrite which showed a width of 6 feet at that point with a 1 foot quartz vein lying along a hanging wall of clay slate. The footwall of this pyrite lens lies on crystalline limestone. As the fahlband crosses onto lot 42, concession V, the gossan shades into hematite.

Foley Prospect - 5.5 miles north of Enterprise station on the old Bay of Quinte railway.

This deposit occurs in an outlier of crystalline limestone surrounded on all sides at short distances by granite. The irregular deposit consists of small masses of pyrite and pyrrhotite in about equal proportions. The early work consists of a pit, 80 feet long, 40 feet wide, and 10 to 15 feet deep, sunk on pyrite and pyrrhotite intermixed with pyroxene, calcite, mica, and molybdenite.

Caldwell Prospect - Blithfield township Concession I, Lots 1 and 2 (Renfrew county)

Work was begun on this deposit in the spring of 1916. An incline shaft, 12 feet in width, was sunk 60 feet on a well defined vein averaging about 8 feet from hanging wall to footwall. In 1917 the shafts was deepened to 100 feet and about 250 feet of lateral development was carried out at that horizon. In October, 1917, the property was optioned to the Grasselli Chemical Company. During the winter and following spring, a 2500 foot exploratory diamond drilling program was carried out. Shipments of pyrite were begun to the company's acid works at Hamilton, Ontario, during the following year and continued for several years.

McKinnon Prospect - Lanark county, Lavant township

Many years ago, two prospect pits were put down on an exposure of pyrite and pyrrhotite on this property, about four miles north of Lavant station. Both pits are reported as being well mineralized and according

to dip needle readings, the zone extends under overburden, for some distance. Very little exploration work has been done on this prospect and there is no record of former operations or shipments.

Pyrite Under Hematite in Eastern Ontario

The iron ores of eastern Ontario are characterized by a high sulphur content and in several localities are known to be underlain by pyrite. In some cases, properties were operated until the sulphur content, due to the presence of pyrite, became too high for shipment, and the mines were abandoned. The workable depth, as an iron ore deposit, varied from 25 to 60 feet. Pieces of hematite ore containing pyrite cores are found on the old mine dumps. There seems to be little doubt that these hematite deposits were the gossan capping of sulphide ore bodies, subsequently altered from limonite to hematite.

Reported Hematite Occurrences in Eastern Ontario

The following list shows the lot and range numbers of localities in eastern Ontario from which hematite has been reported. Some of these localities are unexplored prospects while others are abandoned iron mines.

(From A.W.G. Wilson's 'Pyrites in Canada' Memoir 167-1912)

County	Township	Range	Lot (s)
Hastings	Marmora	IX	6,12,13,14
	"	X	13,14,16
	"	XI	16
	Madoc	I	18, 19
	"	II	2, 18
	"	V	11, 12, 13, 15, 17, 18
	"	VI	4, 7, 9, 10, 12, 13
	"	VII	6, 8, 9
"	Huntingdon	XIV	9
"	Faraday	X	21
	"	XI	21
Frontenac	Portland	IX	6, 7
	"	X	7
	"	XII	5
Leeds	Crosby	VI	5
	Bastard	IX	24
Lanark	Bathurst	IV	4
	"	X	22, 23
	"	XI	21
	"	XII	21
"	North Sherbrooke	XI	11
	"	XII	11
"	Dalhousie	IV	1
	"	XI	11
	"	XII	11
	Darling	III	22
	"	IV	16, 22
	"	XI	22, 23, 24, 26 & 27
	"	XII	26, 27

Western Ontario

Helen Iron Mine
Tip Top Copper Mine
Steep Rock Lake
Furlonge Lake
The Nickel Lake Iron Range
    Brunette's Claims
    Wallace Claims
    The Nickel Lake Mines Limited
    Watten Township

Turtle River and Pipestone Lake Iron Ranges
The Atikokan Iron Range
    West of Sabawe Lake - R. 403 and 212X
    West of Sabawe Lake - 138X and 139X
    East of Sabawe Lake - Atikokan Iron Mine

Conmee Township
    The North Half of Lot B, Morrison Claims
    The North Half of Lot B, The General Chemical Company's Claims
    South Half of Lot C, Concession V.
    Lot B

Lake Nipigon

Helen Iron Mine Pyrite Deposits

The hematite orebody on which initial iron mining operations were begun about 1900 contained pockets of granular pyrite grading from 42 to 50 per cent sulphur. Lenses of this pyrite occurred throughout the hematite deposit and pyrite was reported to occur to the east, north, and west of the hematite orebody. When a lens was encountered in the course of mining operations the pyrite tended to 'run'. Care was taken to prevent it becoming mixed with the high grade hematite in shipments.

The Helen hematite body occupied the eastern end of a large pit-like depression. It was roughly elliptical in outline with an east-west axis about 500 feet long and a north-south width of about 300 feet. It was bounded on the east by a steep hill of iron carbonate, on the north by cherty carbonate and quartz porphyry schists, on the south by quartz-porphyry schist, and on the west by pyritous and cherty iron carbonates.

In 1919 mining operations on the hematite body were suspended due to ore exhaustion. Total recorded production from this operation (O.B.M. 1919) show that 2,780, 236 tons of hematite and 51,930 tons of pyrite were shipped. No mention is made in the above-mentioned report of further pyrite reserves.

Tip Top Copper Mine - Thunder Bay district

This property is about 9 miles southwest from Kashabowie station on the Canadian National Railway. It lies about 4 miles west of Shebandowan lake and on the east shore of Round lake and is roughly 20 miles west of the Shebandowan nickel-copper deposits.

The ore consists of chalcopyrite, pyrrhotite, and pyrite and carries low gold values in addition to copper. The occurrence is essentially a copper prospect but massive pyrite lenses in the mine would grade better than 40 per cent sulphur. The main 90 degree incline shaft was sunk to 200 feet and limited lateral development work was carried out on 4 levels. Two shallow shafts, 50 and 20 feet deep, were also sunk. In 1903, production of 4000 tons of ore, averaging 8 per cent copper, was reported.

E.S. Moore in his 'Report on the Tip-Top Copper Mine', Ontario Bureau of Mines, Report Vol. XX, Part I, 1911, describes the geological associations of this property.

Steep Rock Lake Deposits

Steep Rock lake is north of Atikokan station, a divisional point on the Canadian National Railway, about 140 miles west of Port Arthur. As a result of a thorough search for iron ore deposits in the area, pyrite bodies, possibly of considerable size, have been discovered.

MacKenzie and Mann locations, A.L. 460, A.L. 461, and A.L. 462, are on the west side of Steep Rock lake about 3 miles north of the railway. A pyrite vein was traced from the north end of A.L. 460 southward through 461, and it outcrops again on the north and west shores of a small lake in A.L. 462. In 1903-4, five diamond drill holes cut the vein over a length of 600 feet and core intersections of good grade pyrite of from 6 to 21 feet were obtained from 125 to 150 foot depths. Analyses of cores showed a sulphur content of better than 40 per cent sulphur. Nothing has been done to develop the deposit since this drilling.

The Strawhat lake pyrite deposits are at the southern end of Strawhat lake, about 4 miles southwest of Atikokan station. Strawhat lake, forming part of mining locations 857X, and 858X, lies about a quarter of a mile west from the south end of the southeast arm of Steep Rock lake. The occurrence is described by E.L. Fraleck in the 16th report of the Ontario Bureau of Mines, and since nothing has been done on the property to add to the information contained in his report, it may be quoted verbatim:

> "A very large deposit of iron pyrites has been uncovered at the southern extremity of Straw Hat lake. This is reached by a trail to the westward from the southern part of the eastern arm of Steep Rock Lake. The work done comprises trenching, test pitting, and four diamond drill holes on locations 857 X and 858 X. The south trench shows a width of pyrite of over 140 feet, the eastern sixty feet of which would be quite high grade at shallow depth, as the only impurity was gossan. The ore showed unequal banding and nodular weathering. The eastern protion of the trench is somewhat siliceous, and would not run more than 38 to 40 per cent of sulphur. A test pit 100 yards to the north near the camps shows very fine pyrites under a heavy capping of limonite, and hematite.

The hill on which the south trench is located is thirty feet high, and the whole gully to the west appears to be underlain with pyrite. Diamond drilling disclosed the pyrite in the form of a vast crescent, between the horns of which lies a deposit of hematite, an occurrence resembling very much that of the Helen Iron Mine".

Furlonge Lake Deposits

Furlonge lake is about 35 miles due north of Fort Frances and about 10 miles north of Manitou sound, the north end of the north arm of Rainy lake.

The four mining claims, J.L. 150, J.L. 151, F.F. 240, and F.F. 255, comprising the holdings of Drummond Mines, Limited, cover about 170 acres of land bordering and under Furlonge lake. A limited amount of surface exploration and development work on the property, outlined four lenses of pyrites, having the following surface dimensions:-

No. 1 lens	.....	118 by 30 feet
2 "	.....	110 by 24 "
4 "	.....	50 by 13 "
6 "	.....	60 by 14 "

The sulphur content of average samples from the number 2, 4, and 6 lenses was reported to be 41.62; 40.68; and 37.63 per cent respectively. Other lenses of pyrite are likely to be found on the claims. Their location, 41 miles from rail, is a deterrent to development since transportation would likely involve barge and aerial tram.

The Nickel Lake Iron Range

This is a belt of banded iron formation traceable by its iron-stained, gossan-bearing outcrops along the Canadian National Railway, across the townships of Watten and Halkirk, from the east shore of Rainy lake to Bears Passage. The iron formation consists essentially of silica, occasionally interbanded with magnetite, but more often containing pyrite and pyrrhotite, especially the latter. Some outcrops, however, show only massive pyrite and exploration has been undertaken at several locations in search of pyrite bodies.

Included in this group are the following properties:

Brunette's Claims - Watten twp., K. 206.
Wallace Claims - Watten twp., F. 85; F. 86.
The Nickel Lake Mining Co. - Watten twp., P. 577; P. 580; G. 616; G.617.
Lot 2, Concession III - Watten twp.

Brunette's Claims

These claims, in Watten township, are on the west side of the entrance to Rocky Islet bay, one of the many arms of Rainy lake. The iron range here lies a short distance north of the railway near mileage 224.

Trenching and test pitting was carried out along the strike of the zone for a quarter of a mile or more. The first trench, on the shore of the entrance to Rocky Islet bay, appeared to have been put down through dark brown limonite and relatively clean pyrite, as indicated from material alongside the trench.

Inland from this first trench shallow pits were dug along the rocky right hand bank of the gully. Material from these pits showed limonite with silica and clay and some cellular quartz left by leaching out of sulphides. No unaltered pyrite or pyrrhotite was found around these pits.

Most of the work on the claims was done still farther inland where, to judge from the excavated material around numerous pits, trenches and prospect shafts, the iron formation is made up largely of a mixture of pyrrhotite and pyrite, of which the former is much the more abundant.

In November, 1918, these sulphide deposits were being explored by diamond drilling, for the Grasselli Chemical Company. (Taken over as an operating division of C.I.L. in 1929).

Wallace Claims (F 85, F 86)

These claims are in the township of Watten, Concession II, Lots 11 and 12 and were held in the name of J.A. Wallace, Fort Frances. Prospecting, surface trenching, and some test pitting was carried out, just south of the railway at mileage 216, in 1918.

Trenching through stratified clay disclosed three roughly parallel bands of rock and pyrites in the underlying, folded iron formation, all having a general east-west strike. The two northerly bands are each about 5 feet wide; the southerly band, about 7 feet. The greatest width of clean pyrite exposed in any of the bands is not over 1 foot. Pyrrhotite is associated with pyrite in the most northerly band. No work has been done on these claims since 1918 and lateral extent of the pyritous bands is not known.

The Nickel Lake Mining Company

P. 577, P. 580, G. 616, G. 617

Mining locations P. 577 and P. 580 take in the narrow strip of land between Nickel lake to the north and Grassy Portage bay to the south, on lots 7 and 8, Concession II, of Watten township. The Canadian National Railway runs southwestward across the locations following the lake shore closely. G. 616 and G. 617 cover the adjoining land under the waters of Nickel lake. These four mining locations, together with others in the immediate area, were owned by the company.

The rock on the east and south shore of Nickel lake is a lean siliceous iron formation which, along the southshore of the lake, carries large quantities of iron sulphides - pyrite and pyrrhotite. Massive pyrite outcrops close to the water's edge on the south shore where a shaft was sunk in 1918. The band of pyrite is about 12 feet wide where it outcrops and strikes roughly east-west, parallel to the iron formation which encloses it. The showing dips steeply to the north and goes under the water of the lake on strike.

The six feet of pyrite that makes up the north half of the band is practically pure except for a little intermixed silica, and is coarsely crystalline, granular, and friable. An analysis of an average sample taken across this part of the outcrop gave 46.06 per cent sulphur. The pyrite on the south side is mixed with interlaminated bands of carbonaceous slate or schist, and thin sheets of granular white quartz. Black, carbonaceous schist forms the south wall of the deposit; the north wall is quartzite.

The shaft location is within 100 feet of the Canadian National Railway main line. Some exploratory diamond drilling was done in 1902 with funds being supplied by Cleveland, Ohio, backers. No record of the drilling results is on record. The property remained idle until 1918 when the Nickel Lake Mining Company was formed and did the work outlined above. The property has remained idle since 1919.

Watten township, Concession III, Lot 2

Iron range rocks also outcrop about a mile northeast of Nickel Lake on the hills north of mileage 214 on the C.N.R. Considerable areas of heavy gossan are also present. There is no record of work having been done on these gossan areas and no information is on record of the nature of the underlying rocks.

Turtle River and Pipestone Lake Iron Ranges

The Turtle river iron range, and the Pipestone lake iron range, lying respectively east and north of the Nickel lake iron range have received little attention as possible sources of pyrite. However, from their similarity to the other western Ontario iron ranges it is reasonable to expect them to contain deposits of pyrites.

The Atikokan Iron Range

Between Atikokan and Kawene stations on the C.N.R., bodies of magnetite associated with a good deal of pyrite and pyrrhotite have been found strung out along the valley of the Atikokan river for about 16 miles. This iron-sulphur bearing belt, known as the Atikokan iron range, is broken topographically by Sabawe lake into an eastern and western portion. On the western portion of the range the mixed sulphides are mainly pyrrhotite, but on the eastern end (Atikokan mine) there are large bodies of mixed magnetite and pyrite.

West of Sabawe Lake - R. 403 and 212X

These magnetite-pyrrhotite deposits lie just south of the Atikokan river about a half mile north of mileage 134 on the C.N.R.

On 212X test pitting revealed a considerable body of pyrrhotite and further west, on R. 403, numerous trenches and test pits exposed irregular lenses of mixed pyrrhotite and magnetite. The zone in which these lenses occur has an overall width of about 1000 feet and an estimated length, by magnetic survey, of 2,900 feet.

D.B. Rockwell, the engineer in charge of the exploration program conducted in 1908-09, estimated 2,530,000 tons of material carrying 59.80 per cent iron and 20.40 per cent sulphur.

West of Sabawe Lake - 138X and 139X

These deposits resemble in occurrence those described on mining locations R.403 and 212X. They lie in a zone of about 250 feet maximum width and over an indicated length of 2,600 feet. Surface work and diamond drilling, done in 1908 and 1909, under the superivision of R.H. Flaherty of Port Arthur, proved up an estimated 1,827,000 tons of material on mining location 138X averaging 55.73 per cent iron and 20.38 per cent sulphur.

East of Sabawe Lake - Atikokan Iron Mine

On the eastern end of the Atikokan iron range considerable pyrite, mixed with magnetite, is found in the Atikokan iron mine. The mine is about a mile east of Sabawe lake and is connected to the main line of the C.N.R. by a 3 mile long spur at a point about 128 miles west of Port Arthur.

The iron range rocks outcrop on mining locations E10 and E11, forming a steep, narrow ridge, 3,800 feet long, with a 400 foot maximum width, and rising from the surrounding swamp about 100 feet. The ridge is made up of interlaminated greenstone, green schists, and lenticular bodies of magnetite some of which carry much pyrite. In parts of some of the lenses on the south side of the ridge, pyrite is the most abundant constituent.

Analyses of lenses cut by development adits, driven around 1908-1910, are detailed by A.H.A. Robinson in the Mines Branch summary report for 1916. Widths of lenses cut varied from 7 feet to 35 feet and assays over these widths ranged from 14.93 to 25.75 per cent sulphur and 45.10 to 57.33 per cent iron.

Conmee Township

Exploration and development work was undertaken on a number of mining locations in Conmee township in search of pyrite deposits. The mining locations were taken up on lots B, C, and D, Concession V, about a mile south of Mokoman, a station on the C.N.R. about 31 miles north of Port Arthur. All the known deposits are within a mile of the track.

The pyrite, in all the deposits, is closely associated with banded cherts, jaspers, and magnetite of the iron formation which is abundant in the township. Outcrops are few and small due to a fairly heavy covering of drift but the iron formation can be readily traced by dip needle.

The North Half of Lot B, Concession V - Morrison Claims

The Davis Sulphur Ore Company, of New York, in 1901 sank a shallow shaft on a deposit of pyrite that outcrops in the bed of Brule creek near the northeast corner of Lot B.

E.B. Fraleck, who examined the shaft occurrence in 1906, said:- "The deposit strikes northeast near the contact of conglomerate and the Mattawin iron range. A deep covering of bouldery gravel obscures the surface, and the deposit can only be examined where a small pit has been sunk on the bank of Brule creek. The bottom of the test pit is 5 feet below the level of the creek, and about 80 tons are on the dump. The pyrite-bearing zone appears to be about 30 feet wide."

The occurrence is one of replacement, wholly or in part, of the conglomerate by pyrite, which even when massive retains that structure. The more soluble pebbles have been completely replaced by pure pyritic nodules with a roughly spherical outline. In the other portions of the conglomerate the substitution is more or less incomplete, the pebbles of pure silica being entirely unchanged.

An average sample of ore on the dump yielded 29.20 per cent of sulphur.

The North Half of Lot B, Concession V - The General Chemical Company's Claims

Immediately south of the Morrison claims - and also on the north half of Lot B, Concession V - two mining claims were held under option by the General Chemical Company of the United States whose Canadian operating subsidiary is the Nichols Chemical Company.

A large amount of trenching, test pitting and stripping was done on the two claims prior to 1917 but the workings, now caved and weathered, reveal little to the eye. Pyrite, with gangue, was reported to have been exposed in one stripping for more than 75 feet in width; in another, some distance to the northeast, 25 feet of mixed gossan, leached rock and pyrite were exposed.

The results of the diamond drilling program carried out in 1917 by the General Chemical Company are not known but it is reported that workable bodies of good grade pyrite were outlined. At any rate, the company subsequently leased the property for a number of years on a royalty basis. The General Chemical Company owned and operated pyrite mines at Northpines, Goudreau, and Sulphide, all in Ontario. There is no record of any shipments of pyrite from their property in Conmee township. A.W.G. Wilson, in Mines Branch Memoir 167 on Pyrites in Canada, refers to this property as the 'Mokoman property'.

South Half of Lot C, Concession V

Near the northwest corner of the claim, sometimes known as the Morton Lease, two prospecting shafts were sunk and the surface between them was stripped. A section across the stripped area showed 2 feet of pyrrhotite, 6 feet of mixed pyrite and pyrrhotite, 15 feet of mixed pyrrhotite and rock and 12 feet of pyrite with some silica. On the uphill side of the stripped area the sulphides were overlain by about 8 feet of mixed granular quartz, leached rock and impure limonite.

Lot B, Concession V

On the northeast quarter of the south half of lot B, lumps of pyrite lie alongside some caved-in trenches. In a nearby stripped area a band of pyrite, 2 to 3 feet thick, occurs in a twelve-foot band of rusty quartzose rock between greenstone and banded iron formation.

Other locations in Conmee township on which pyrite, pyrrhotite, and iron formation have been mentioned in literature include the following:-

Mining location R. 702.
North half of Lot C, Concession V.
South half of Lot C, Concession V.
Lot D, Concession V. (Pyrite float).

Lake Nipigon: T.B. 3423 (Mike Ralph's Claim).

This prospect is about two miles south and west of Jackpine, a station on the C.N.R. 135 miles east of Port Arthur. A rusty band of chlorite schist crosses the claim striking westerly. A small pit, put down on an outcropping of the schist in a swamp, showed pyrite in the chlorite schist under an 18-inch capping of gossan. The nearly vertical schist band is about 60 feet wide and can be traced by a dip needle.

A sample of pyrites from the pit bottom gave, an analysis, 22.9 per cent sulphur, 41.5 per cent iron, and 1.6 per cent zinc. The one shallow pit is the only recorded work on this claim.

Sudbury District

Jefferson Iron Mine
Township of Norman
Balfour and Creighton Townships

The Woman River iron range is a 40-mile belt of iron-bearing rocks. It starts near the northeast end of Rush Lake and runs southwestward across the Rush river and along the Woman and Ridout rivers.

East of the Rush river the range consists of a cherty, banded iron formation accompanied by, and at places in contact with, a parallel belt of iron-stained siliceous rock carrying magnetite, pyrrhotite, pyrite, and iron carbonate.

Jefferson Iron Mine (Smith claims).

A.H.A. Robinson in his 'Investigation of Pyrites Resources' (Mines Branch Summary Report for 1919) describes the occurrences in some detail. W.E. Smith of Sudbury, owned 22 mining claims, or all the known exposures on the Woman River iron range east of the Rush river. Starting from the east bank of Rush river, these claims extended northeastward in a continuous chain for about 4 miles, across the

territory between Sahkatawichtah lake to the south and the townships of Dale and McOwen to the north. They comprised, from east to west consecutively, claims W.D. 715 to W.D. 736. The distance from W.D. 715 at the eastern end of the chain of claims, to Stackpool station on the C.N.R. is about 14 miles.

The band of iron formation with the accompanying sulphide-bearing zone have been traced by trenches, test pits, and outcrops for the full length of the claims group. The rusty, pyritous zone - as distinguished from the cherty banded iron formation - averages perhaps 40 feet, and attains a maximum of about 150 feet in width. It is made up of magnetite, pyrrhotite, pyrite, quartz, iron carbonate and varying amounts of laminated rock.

A number of samples from various pits, trenches, and outcrops showed the sulphur content as ranging from about 25 per cent to 40 per cent and iron content above 40 per cent. Low zinc values were encountered in some locations.

Township of Norman: Concession VI

Outcrops of pyrite associated with banded iron formation occur about 2 miles northwest of Wanapitei lake in Concession VI of Norman township. They lie about 5 miles east of the C.N.R. and about 2 miles northeast of the 'Whistle' nickel mine.

Gossan outcrops associated with banded iron formation and greenstones can be traced from a point on the north bank of Past creek, near the boundary of the Indian reserve, northward to the south boundary of Parkin township. Near the creek the gossan is about 80 feet wide and a sample of material from one of the old pits, on analysis, gave 34.62 per cent sulphur and 41.34 per cent iron.

Pyrite, mixed with quartz, occurs in another pit about half a mile north of the creek near the boundary of Parkin township. A sample from this pit, on analysis, gave 32.51 per cent sulphur and 32.80 per cent iron.

Iron carbonates were present in both samples and very minor zinc content was noted. Other pits and trenches in the gossan zone showed only a little pyrite, pyrrhotite, and impure magnetite scattered through the rock.

A.H.A. Robinson, after examination, reports on some occurrences of pyrite and pyrrhotite in the Sudbury district as follows:-

Balfour and Creighton Townships

Along the northern edge of a low rocky ridge, which running southwestward across lots 6 and 7, concession I, of the township of Balfour, and lots 8 and 9, concession VI, of Creighton, about 3 miles south of the Canadian Pacific Railway between Chelmsford and Larchwood stations, forms the southern boundary of the flat clay farm land that fills the Chelmsford basin, the existence of sulphide bodies is indicated by some large gossan-covered areas and the material lying around old prospect workings.

The deposits themselves are no longer accessible in the abandoned workings, and most of the information now available as to their nature is such as can be inferred from an inspection of the dumps. Pyrites, galena, zinc blende, chalcopyrite, quartz, calcite and other carbonates, appear to have formed the vein filling; black graphitic (Onwatin) slate the wall rock. Mottled (Onaping) tuff lies just south.

Some large chunks of clean looking pyrites can be seen on the dumps, and considerable bodies may possibly occur in the old workings or under the unexplored gossan-covered areas; but whatever value the deposits may have would appear to lie in their metallic contents rather than in the sulphur.

Lots 6 and 7, Concession 1, Balfour Township

At the old workings on lot 6, concession I, Balfour township, said to belong to George Irwin, of Sudbury, zinc blende and galena appear to have been the minerals found in greatest abundance.

Heavy gossan covers considerable areas on lot 7 to the west.

Lot 9, Concession VI, Creighton Township

The dumps at the old shaft on this lot show mixed pyrites, zinc blende, galena, and chalcopyrite. Some of this material had been sacked for shipment, apparently as copper ore. There are also some large chunks of clean looking pyrites, now crumbling to pieces under the weather.

The property is owned by M. Meehan, of Sudbury, and Alphonse Olier, of Chelmsford.

Kenora to Sudbury - near C.P.R., Lake of the Woods

Ptarmigan Bay
Shoal lake and West Hawk lake
Rochon Claims: D.704 and D.707
Guthrie Claims
Eagle Lake Deposits
Net Island
North Twin Island
English River
Southern Claims
Northern Claims
North Shore of Lake Superior
- Rossport
- Schreiber
- Mudge Prospect
- The Davis Sulphur Ore Company
- Morley Prospect
- Mining Location, R. 638
- " " R. 425
- Sulphur Lake
- Various Locations on the North Shore of Lake Superior.

Pyrite occurrences are described by A.C. Lawson, in his report contained in 1885 annual report of the Geological Survey of Canada, as occurring on the shore and islands of the Lake of the Woods.

Ptarmigan Bay

Pyrite occurs as nodules, up to an inch in diameter, in micaceous slate and black argillaceous slate on the shores of Zig-zag point and Corkscrew island in Ptarmigan bay. The carbonaceous schists (slates) have a vesicular structure and attain widths of up to 20 feet with pyrite nodules occurring in the vesicles. Pyrite is also found in large vein-like masses in the schist. No exploratory or development work is on record.

Shoal lake and West Hawk lake

A.L. Parsons in the O.B.M. report for 1911 describes pyrrhotite occurrences of considerable size a little west of the Lake of the Woods, near the Ontario-Manitoba boundary.

On the south side of Shoal lake, near the mouth of Carl bay, a vein of almost massive pyrrhotite is found outcropping on the shore of the lake. The vein is about 12 feet wide and lies between altered trap. Another pyrrhotite vein, about 4 feet wide, is reported at the east end of Carl bay at the contact of granite and altered trap. Very little work has been done on either showing.

In the West Hawk lake area, south of Ingolf, pyrrhotite occurs in two or more parallel bands, striking nearly east-west, from a point two or three miles east of the lake to a point several miles west of the west end of the lake. The pyrrhotite occurs in a schistose rock with the widths of the pyrrhotite bodies varying considerably. Just east of West Hawk lake the main body is about 150 feet wide with evidence of dissemination in the wall rocks for several hundred feet, as evidenced by the rusty, weathered outcropping. The pyrrhotite is reported to carry low gold values. A.L. Parsons reports that "nickel has been looked for, but up to the present only very small percentages of this metal have been detected by analysis".

Rochon Claims: D.704 and D.707

These claims are about 2 1/2 miles south of the town of Keewatin and within half a mile of the west shore of Rat Portage bay of the Lake of the Woods. They were originally staked for gold. Gossan bands and rusty zones occur at several locations on these claims. Early work, in search of gold, failed to locate any massive bands of pyrite. Test-pitting and trenching of the weathered, rusty zones disclosed disseminated pyrite and pyrrhotite in a light-coloured porphyritic schist and schistose agglomerate striking a little north of east.

Guthrie Claims

A.H.A. Robinson reports on this occurrence as follows,-

"On page 175 of the Sixteenth Annual Report of the Ontario Bureau of Mines, 1907, E.L. Fraleck describes three mining locations, A. 274, A. 257, and A. 273, as being located on a fahlband a mile and a half north of Riddell siding on the Canadian Pacific Railway.

"There is no longer a Riddell siding on the railway and the only claims in the locality described by Fraleck that are now on record in the Mining Recorder's office at Kenora are S.772, S.773, S.774, and S.775, lying east and south of Octopus lake, staked by Dave Guthrie, of Kenora. Pine station, on the Canadian Pacific Railway, is about a mile and a half south of them.

"No work is now being done, and there is nothing further of interest to add to Fraleck's description of the locality, which is as follows:-

"A heavy fahlband strikes in a northeast direction along a range of bare hills. In all the valleys and depressions along the range high grade limonite is found. Some of this may have resulted from the decomposition of pyrites in place, but for the most part it has been derived from oxidation along the hills and subsequent deposition in the depressions. It was impossible to arrive at the depth of the limonite, but the surface area was quite extensive. No high grade gossan was observed in place on the hills, and the fahlband was, in the main, low grade. A small test pit, however, near the shore of a lake disclosed promising gossan and very fair pyrite. The country rock is a felsitic schist, cut by numerous pegmatite dikes. It is said that later operations have disclosed a considerable body of mixed pyrite and pyrrhotite".

Eagle Lake Deposits

The Canadian Pacific Railway skirts the shore of Eagle Lake at Vermilion bay, 56 miles east of Kenora. Eagle River station, 10 miles farther east, is 4 miles from Eagle lake, with which it is connected by road and by a river of the same name. The river is navigable from the lake to within a mile of the station.

Net Island

Net Island is near the west shore of Eagle lake, 10 or 12 miles from Eagle river and 15 or 16 miles from Vermilion bay. A vein, 4 to 12 feet wide on surface, occurring on the northern part of the island, was first opened as a possible source of iron. In 1910-11 the vein was opened up by stripping, test-pitting, some diamond drilling, and the sinking of a small shaft. The vein, at surface, is oxidized and consists mainly of limonite with minor hematite and magnetite. Freshly broken material consisted largely of pyrite with some chalcopyrite.

A small shaft, 22 feet deep, was sunk through a gossan capping of the deposit near the top of a low rocky ridge. On the surface, near the shaft, there is 18 feet of gossan between well-defined walls. The vein was traced eastward from the shaft, by dip needle and gossan outcroppings, to a shallow pit about 300 feet distant at the foot of the ridge. In this pit 21 feet of pyrites were uncovered against the north wall; the south wall was not worked. A sample from this pit (A.H.A. Robinson) yielded on analysis 23.85 per cent sulphur, 53.23 per cent iron, 0.44 per cent zinc, and 0.05 per cent copper.

The country rock is a bright green chlorite schist which in places appears to grade into massive greenstone. The vein has a nearly vertical dip and strikes approximately east-west. Vein extensions to the east of the pit are obscured by clay flats. To the west of the shaft there are exposures of rusty rocks on the line of strike but no exploratory work was done in this direction.

North Twin Island

A small outcrop of magnetite, associated with rusty rock and some pyrite, was found on the shore of this island on the strike of the deposit on Net Island which lies about half a mile to the west. A diamond drill hole was reported to have cut pyrite at about 50 foot depth.

English River

Several zones of pyritous rocks, or fahlbands of considerable size, are known to occur in a belt of Keewatin rocks about 14 miles southwest of English River station on the Canadian Pacific Railway.

Numerous mining claims were staked on these fahlbands and considerable trenching, test-pitting, and stripping was carried out on them in 1917-18. One group of claims (southerly group of Nicuso Syndicate) surrounds and includes two small lakes (Pine and Cryderman lakes). Another group of claims (northerly group of Nicuso Syndicate) lies a short distance north of Pine lake and includes a small pond sometimes called Paul Stone's lake.

Southern Claims

On the southern claims a pyrite-bearing band of black, carbonaceous rock, which outcrops on the south shore of Pine and Cryderman lakes, crosses the claims in a general westerly direction. A pit on the south shore of Cryderman lake, about six feet deep, has been sunk in black graphitic slate heavily mineralized with pyrite. Only one side of the deposit was uncovered, exposing about 12 feet of mixed pyrite and slate. Another pit, 250 feet to the east, showed about 12 feet of the same material with neither wall uncovered.

The pyrite occurs partly as spherical nodules up to several inches in diameter filling cavities in the slate, and partly as crystalline, granular pyrite and silica interbanded with the graphitic slate.

Samples, taken by A.H.A. Robinson, of (1) the mixed nodular pyrites and pyritous slate, (2) the general run of the banded pyrites, and (3) the purest looking of the banded pyrites, yielded on analysis:-

	(1)%	(2)%	(3)%
Sulphur	24.7	24.5	30.1
Iron	23.5	23.0	30.0
Zinc	0.84	0.64	0.64
Insoluble.....	35.9	45.3	25.7

Robinson says that "what is seemingly the same band of black, pyritous schist that is exposed on Cryderman lake outcrops again about three-quarters of a mile eastward, on K.715. Here an open-cut into the bank, on the south side of Pine lake, exposes a deposit 12 or 14 feet wide, of mixed graphitic slate, limonite, pyrrhotite, pyrites, and quartz underlying eight feet of dense gossan."

Northern Claims

Occurrences of pyrite as nodules or as siliceous material in graphitic schists is found on the northern claims near the upper end of Paul Stone's lake. Trenching has exposed about 15 feet of siliceous pyrite interbanded with the schist lying alongside ten feet of banded iron formation. A sample of material from this pit yielded, on analysis, 23.84 per cent sulphur, 22.19 per cent iron with about 30 per cent each of copper and zinc.

North Shore of Lake Superior

Rossport - Some of the ground originally staked for gold near Rossport, on the north shore of Lake Superior have been mentioned, at various times, as carrying fair amounts of pyrite. Veins and small pockety masses of mixed sulphides have been reported in the area.

Schrieber - Exploration, and some development, was carried out about the turn of the century on a number of pyrite showings near the north shore of Lake Superior, in the vicinity of Schreiber, a divisional point on the Canadian Pacific Railway.

Mudge (Otisse) Prospect: Mining Location 776X - Mining claims T.B. 1048 and T.B. 1049 constituted, respectively, the northwest and southeast quarters of old mining location 776X. This prospect lies about 1.5 miles north of Schreiber at the north end of Cook lake. A heavy mineralized zone strikes east and west for about a mile and some test pits were sunk through the gossan capping. The largest of these test pits was about 12 feet deep and 12 feet long across the strike of the band which, at this point, consists of a very fine grained mixture of pyrite, pyrrhotite and silica.

A sample selected from the dump and reported by Robinson yielded 28.6 per cent sulphur, 42.5 per cent iron and 1.40 per cent zinc. An average sample of the dump material taken by Fraleck, in 1906, yielded 32.26 per cent sulphur.

The Davis Sulphur Ore Company: Mining Location R. 606 - This prospect is about a mile and a half southeast of Schreiber. About 1905 the Davis Sulphur Ore Company shipped a car of pyrites from the property for test purposes. The old workings consist of a shallow trench

running north along the strike of the deposit for about 100 feet; a shaft near the north end of the trench; and a short tunnel driven into the hillside at the bottom of a gully below the shaft.

Pyrite and pyrrhotite, with considerable quartz, occur in the deposit with the width of the mineralized zone varying from 4 to 10 feet. The zone dips from 50 to 60 degrees to the east. A sample across 3 feet of the better looking pyrite on the east side of the trench gave, on analysis: 27.48 per cent sulphur, 41.54 per cent iron, and 1.52 per cent zinc.

The Morley Prospect - Fraleck and Wilson each describe, under this heading, a prospect "Situated about three miles southeast of Schreiber on the Canadian Pacific Railway and about two miles north of the shore of Lake Superior". According to Robinson, under advice from J.D. Mudge of Schreiber, the Morley prospect is identical with R.606, the Davis Sulphur Ore Company's claim just described.

Fraleck described the deposit as consisting of practically pure pyrite on the east side of the trench, becoming mixed with pyrrhotite toward the centre, and changing over almost entirely to pyrrhotite on the west side. The sulphide occurrence lies between trap on the east and quartz on the west. The 60 foot shaft is reported as having been put down in massive pyrite to its full depth.

Mining Location R.638 (Ansell's Claim T.B. 2381) - About a mile and a half east of Schreiber and 100 yards north of the C.P.R. track, a westward striking fahlband lies between trap on the north and quartzite on the south. Stripping and shallow trenching exposed pyrrhotite and small stringers of pyrite in the zone which dips northward into a hill. A sample of the better looking material gave, on analysis, 27.25 per cent sulphur, 40.06 per cent iron, with very low zinc content.

Mining Location R.425 - The fahlband that outcrops on Ansell's claim shows up again about a quarter of a mile to the east. A short incline into the side of the hill north of the track was driven in a bed of quartzite that is overlain by trap and underlain by greenstone. A thin layer of black graphite schist, carrying pyrite, lies between the trap and quartzite. Small pockets of pyrite are found in the quartzite near the graphitic schist.

Trenching and test pitting east of the incline showed only small stringers of pyrite.

Sulphur Lake - P.E. Hopkins in the O.B.M. report of 1915 mentions a narrow fahlband 14 miles north of Schreiber, about 2 miles in length, striking northeastward across Sulphur Lake. Pyrite veins up to 2 feet wide carrying low gold values, and pyrrhotite veins up to 3 feet wide, occur in the mineralized zone.

Various Locations on the North Shore of Lake Superior - Robinson mentions the occurrence of pyrite showings at or near Jackfish, Schist Harbour, and Port Coldwell on the north shore of Lake Superior.

In the vicinity of Jackfish station, on the C.P.R., mention is made of pyrite occurring on mining locations taken up for gold. These properties have been idle since the early 1900's and no information is available on the presence of pyrite bodies of appreciable size. It would appear that in early exploration, gold values were obtained in quartz veins in association with pyrite.

A mile and a half north of Schist Harbour, which lies a few miles east of Jackfish, a number of claims were staked on a mineralized zone in which narrow bands of fairly clean pyrite occurred. No bodies of any extent have been located.

It was reported that an iron pyrites prospect, held by S.D. Crenshaw, Richmond, Virginia, occurred near Port Coldwell, a fishing hamlet 25 miles east of Jackfish. Robinson reported that this property could not be located nor could any information concerning it be obtained.

Missinaibi Area

Smith-Travers-Laforest Prospect

The information obtained by Robinson and contained in his report was supplied by C.H. Hitchock to Smith and Travers, Sudbury.

The property consists of five mining claims, S.S.M.1846 to 1850, lying northwest of Lake Manitawick, in township 45, range XXV, Algoma district. The Algoma Central Railway passes 8 miles southwest of the group.

Heavy limonite gossan is found associated with a belt of siliceous, pyrite-bearing iron formation between acid and basic Keewatin schists. The upper part of the iron formation, next to the basic schists, consists of quartz with disseminated pyrites, and judging by the similarity of the geological conditions with those present at the Goudreau pyrites deposits, is probably the hanging wall of any large bodies of pyrites that may exist. It is a hard formation standing out on the surface and serving as an indicator.

The pyritous quartz formation extends from a small lake, called Pine lake, at the northwest corner of S.S.M. 1847 westward across S.S.M. 1846, and disappears into a swamp on S.S.M. 1849. It is about 1500 feet long with the width not being determined. A second gossan-bearing belt of siliceous iron formation occurs to the north, crossing S.S.M. 1848 and S.S.M. 1850.

The best indications of the occurrence of bodies of pyrites are found in a shallow valley that follows the iron formation westward from Pine lake. Four pits on S.S.M. 1846 show compact limonite but did not reach the underlying formation. A pit to the north, on S.S.M. 1848, shows siliceous iron formation, about half of which is pyrites.

Goudreau Lake Pyrite Deposits

North Range

Deposits A, C, and Bear Claim

South Range

Deposits B, D, and E

Other Deposits

Morrison No. 3 Property
Rand Consolidated Mines, Limited
Hamilton Pyrite Claims
Holdsworth Pyrite Claims

Second only to the pyrite reserves in the Noranda area of Western Quebec, the Goudreau pyrite deposits, collectively offer the largest known reserves of pyrite on this continent. There are several large orebodies, close to rail transportation, all within a radius of two or three miles. In addition to the known deposits there are several miles of iron formation, not yet explored, which could contain further bodies of pyrite. However, no base metal sulphides occur in association with the pyrite in the Goudreau deposits and, as an economic operation, the mining of pyrite for the production of sulphuric acid, iron oxide sinter and elemental sulphur would have to justify itself.

The Goudreau pyrite deposits lie just east of Goudreau station, at mileage 177, on the Algoma Central railway. During the First World War several hundred thousand tons of pyrite, mainly in lump form, were shipped from the deposits to acid manufacturers in Canada and the United States. After 1918 production and shipments from the mines decreased rapidly and no further shipments were reported after 1921. The mines have remained idle since then.

The ranges, for convenience, may be roughly described as the North Range, comprising deposits A, C, and the Bear Claim; and the South Range comprising B, D, and E. deposits. A.W.G. Wilson describes the occurrences and the early work performed on them. The following information is taken from his report and one by A.L. Parsons, O.B.M., 1915, on the Productive Area of the Michipicoten Iron Ranges.

North Range

"A" deposit lies a short distance to the north and slightly east of "C" deposit in the vicinity of the hill on which the camps were situated. The depressions are all underlain with limonite. A section across the low hill near its west end shows green schist to the south; then limestone with some pyritous schist; 30 feet of pyrite; 12 feet of green schist; 9 feet of pyrite; and green schist to the north. Continuity over the length of the structure is not apparent and sections across the structure vary greatly. Pyrite or gossan extends about 400 feet from east to west, with a width of about 150 feet but

the pyritous zone contains large amounts of other materials, especially schist and limestone. The deposit was explored by trenching and diamond drilling. One hole is reported to have cut pyrite to a depth of 169 feet averaging about 35 per cent sulphur. No shipments are on record as having come from the "A" claim.

"C" Deposit was operated, under lease, by the Nichols Chemical Company and provided a major portion of the pyrite shipped from the Goudreau area. It lies south and west of "A" deposit, strikes east-west and is bounded on the north by green schist. Early surface trenching across a low ridge disclosed a 50-foot width of fairly high grade pyrite. The pyrite on the side of the ridge was covered with a thin scale of gossan which deepened toward the depressions at the extremities. The length of "C" deposit, as disclosed by early trenching, was about 600 feet. The deposit was stripped in 1918-19. Shipments of pyrite in 1919 were obtained from open pit operations. The O.B.M. report for 1919 states that about 150 men were employed.

The "Bear" claim is the most easterly deposit of the Goudreau lake group and has the largest extent of any of the outcrop areas with an east-west length of 1,200 feet an overall width of nearly 300 feet. To the west of the deposit there lies low peaty ground with small pools containing a foot or more of ochre or bog ore which has probably been leached from the deposit. Original test pitting, near the middle of the 1,200-foot length, across the outcrop showed gossan of pyrite at several points over a 150-foot width with the walls of the deposit not reached. Towards the east, walls of green schist rise on both sides of the ore zone. The pyrite in this deposit seems more mixed with rock matter than that of "B" or "C".

The Madoc Mining Company, controlled by the General Chemical Company of New York (Nichols Chemical Company is the Canadian operating subsidiary), operated the Goudreau Pyrite mine and reported large shipments over a period of several years.

South Range

"B" deposit lies on the northern flank of a rocky ridge striking east and west and forming the southern shore of a small lake. Along the side of the hill, trenching revealed a length of 900 feet of either pyrite or gossan, and the lake bottom on that side appears to consist of limonite. The pyrite here, although interbanded with green schist, is of fair grade. On the side of the hill the capping is very thin but becomes a considerable body of limonite in the lake and in a depression on the eastern extension. No production is reported from this deposit.

"D" deposit, lying along the south end of a hill, is a short distance north of "B" deposit and from surface indications appears to be the smallest and lowest grade deposit of the series. In one diamond drill hole on "D" deposit a considerable amount of garnet associated with pyrrhotite was encountered at a depth of about 170 feet.

"E" deposit, striking east-west, lies a short distance west of "D" across a small muskeg. Coleman (O.B.M. 1906) described the cross section of the 100-foot long exposure from south to north as follows,-

Pyrite with some green schist	8	paces
Limestone	6	"
Pyrite	4	"
Green schist	33	"
Pyrite with some cellular silica	29	"
Very rusty banded silica	19	"
Width of section	98	"

The Nichols Chemical Company Limited obtained the "Bear" deposit on lease and stripped it for open pit mining in 1918. However, the property was again idle in 1919 and there is no record of production from it. A crushing plant was built between the "C" and "Bear" deposits and a narrow gange tramline was built from the crushing plant to the "Bear" deposit about one mile to the east and on to the adjoining Morrison No. 2 deposit which was also operated under lease by Nichols Chemical Company.

A.L. Parsons in describing these deposits under "The Productive Area of the Michipicoten Iron Ranges" in the O.B.M. report for 1915 listed seven prominent outcrops with an estimated total outcrop area of 283,500 square feet, divided as follows,-

Bear Claims	200	x 1,200	ft.
"A" deposit	50	x 75	"
"B" "	50	x 200	"
"C" "	50	x 300	"
"D" "	50	x 75	"
"E" "	50	x 150	"
"F" "	20	x 200	"

From the exploratory and development work done to date on the Goudreau Lake pyrite deposits with their past record of production, it can be surmised that large tonnages of good grade pyrite, grading from 25 to 40 per cent sulphur, still exist. The closing down of operations, about 1920, was a result of the increasing amounts of cheap, elemental Frasch-mined sulphur of Texas and Louisiana available to the manufacturers of sulphuric acid.

The pyrite of the deposits is free from deleterious elements such as zinc and can be concentrated quite readily to a marketable grade of 48 per cent sulphur. Several million tons have been indicated by diamond drilling in the deposits described above and in the others outlined below.

Other Pyrite Deposits in the Goudreau Area

Morrison No. 3 Property

This property consists of a group of six claims, A.C 38 to 42

inclusive, totalling about 140 acres. It is located in the north central part of township 27, range 26, about three and a quarter miles east of the Algoma Central Railway and northeast of the Goudreau mine deposits (described above).

A band of iron formation from 300 to 500 feet in thickness crosses the property and outcrops at several points. An extensive body of pyrite has been disclosed by trenching, diamond drilling and underground development on the south side of the formation. Twenty-two diamond drill holes put down to 250-foot depths in 1918-19 indicated pyrite for a length of 1250 feet with a maximum width of 115 feet at the east end. Both ends of the east-west deposit are open so additional tonnages can be expected above the estimated 700,000 tons per vertical 100-foot depth. The dip of the orebody varies from 40° to 70° to the north. The Nichols Chemical Company, on a leasing arrangement, conducted the exploration and development of the property which is now owned by Algoma Ore Properties Limited of Sault Ste. Marie.

A three compartment, 47-degree inclined shaft was sunk on the footwall side of the pyrite body to a depth of 230 feet and two levels were established at the 100 and 210-foot horizons. Limited lateral work was carried out on each level. All work was stopped on the various properties held by Nichols Chemical Company (Bear claim, "C" deposit, Morrison No. 3) early in 1920.

Rand Consolidated Mines Limited
(Morrison No. 2 and No. 4 properties).

Rand Consolidated Mines, Limited, worked under lease, the Morrison No. 2 and Morrison No. 4 near Goudreau station from 1918 until in 1920.

Some pyrite was shipped in the spring of 1919 from Morrison No. 4 property east of Goudreau. It was opened as a quarry and in the fall of 1919 employed about 60 men. The erection of a crushing plant was begun in 1919. In December of that year all work stopped in the quarry of Morrison No. 4 property and preparations were made to develop the Morrison No. 2 property, one and a quarter miles south of Goudreau station and west of the track, by means of an adit. On the latter property both pyrite and siderite were found associated with iron formation. The adit was to have been started about 1200 feet west of the track at mileage 175.75 on the Algoma Central. No mention is made in O.B.M. reports of further work on either of the properties.

Hamilton Pyrite Claims

These deposits are on and near the shore of Smith Lake, about five miles east at mileage 171 of the main line of the Algoma Central railway. The best showing is reported on the shore of the lake where there is an exposure of apparently massive pyrite about fifteen feet wide. The wall rock dip varies from 42 to 58 degrees and possible vein extensions are drift covered. It is possible that further work might uncover large bodies of pyrite.

In addition to the massive pyrite showing there are two occurrences of highly pyritic schists that were trenched and test pitted about 1913-14. No further results on the limited amount of of work performed is on record.

Holdsworth Pyrite Claims

Near mileage 24 on the Michipicoten branch of the Algoma Central railway, there are two claims originally prospected by John Holdsworth. Some large masses of pyrite, up to twelve feet in diameter, were found along the shore of a small lake. Smaller boulders of pyrite are abundant. Subsequently, Algoma Steel Corporation put down 22 diamond drill holes and according to the O.B.M. report for 1919 it is understood that 900,000 tons of pyrite were indicated.

Holdsworth also did some prospecting on claims near the south end of Loonskin lake where a small patch of iron formation was mapped by Coleman and Willmott. A small body of pyrrhotite carrying some chalcopyrite was uncovered.

Vermilion Lake

Vermilion lake is about 5 miles west of the town of Graham which lies a short distance west of Sioux Lookout on the Canadian National Railway. The discovery, on claims HW 715 and HW 716 on the northeast shore of the lake, of the large body of pyrite that was later developed into the General Chemical Company's Northpines Mine, led to considerable prospecting and exploration in the area for similar bodies. Other pyrite bodies were uncovered but none compared in size, or grade, with the Northpines Mine. These deposits have been described by E.S. Moore in the 20th Annual Report of the Ontario Bureau of Mines, 1911, pages 204 to 207. Later information on the activities in the area has been obtained from subsequent annual reports of the Ontario Bureau of Mines.

Northpines Mine (Nichols Chemical Company Limited)

This mine has been known at various times as the Michnie mine, the Northern Pyrites mine and the Vermilion Pyrite mine. It was operated by the Nichols Chemical Company which also controlled several other pyrite mines in Ontario including the Goudreau, Sulphide, and Caldwell operations. The company supplied pyrite for its sulphuric acid plants in Canada and to plants of its parent company, the General Chemical Company, in the United States.

The main body of the deposit, on which mining operations were begun, is nearly pure pyrite with some pyrrhotite. It occurs in a pyritic schist band that strikes a little north of east and can be followed cross country for about twelve miles. The original discovery lay in the lake and was found by a prospector who observed the red gossan capping on an outcrop of pyrite and pyrrhotite at the shore of the lake.

The sulphide body lies between a clear-cut footwall of old diabase, which is fairly regular in outline, and a hanging wall of schist composed chiefly of a brecciated basalt. Narrow bands of schist, in some cases, are interbanded with the pyrite, but on the footwall there is little pyrite in the country rock. Some quartz occurs with the pyrite.

The No. 1, 2-compartment vertical shaft was 337 feet deep and connected with No. 2 shaft on the fourth level. The No. 2, 3-compartment shaft, was sunk on a 55-degree incline to 320 feet from which horizon it continued to 624 feet slope depth at 59 degrees. Early in 1921 the fifth and sixth level stations were being cut at the No. 2 shaft but operations were suspended a short time later and the property has been inactive since. For most of its producing years, 150 to 200 men were employed at the mines. It supplied a large portion of the pyrite output of the province with shipments averaging around 40 per cent sulphur.

Tindall Claims

On the east end of an island in Vermilion lake, about eight miles west of Northpines (Vermilion) mine, there is a deposit of pyrite on what was known as Tindall's claims. On this island there is a pit on a hill, a few rods from the shore in which a 2 1/2 foot vein of nearly solid pyrite was exposed in the bottom. In a stripping at the shore of the lake the pyrite vein varies from three to four feet in width but the grade does not appear as good. The vein strikes a little north of east and its projection is evidenced on a small island to the east by iron stained schist and pyrite float. Further projection eastward would carry it somewhere near the Northpines mine.

The Fanning Prospect

E.L. Fraleck and A.W.G. Wilson describe, in their reports, an occurrence of pyrites on the shore of Big Vermilion lake, eight miles west of the Michie (now Northpines) mine. The description reads: "some trenching through a blanket of boulder clay about 4 feet in thickness has been done at the extreme end of a point. High grade pyrite, in seams from 2 to 6 feet in thickness, is interbanded with graphite shale. The deposit strikes east and west, and dips towards the shore to the north".

The Tindall claims and the Fanning prospect are probably one and the same.

Schmidt Claims: H.W. 778 and H.W. 779

These claims are about 4 miles northeastward from Northpines mine, close to the railway southwest of Pelican lake.

E.S. Moore, in the O.B.M. report for 1911, says of them: "On claims H.W. 778 and 779 there are some pits and trenches. The pit on H.W. 778 is about eight feet deep and runs into the side of a hill. The sulphide consists chiefly of pyrite, with a little pyrrhotite. In spots the pyrite is almost solid, but in other places it is much mixed with rock, either greenstone, or altered quartz porphyry, and an altered granite dike about one foot wide is associated with the deposit".

"The pit on H.W. 779 is situated, with reference to the last pit described, in a line along the strike of the rocks. The pit is 3 feet deep by five in diameter and located on a mass of pyrite in schistose quartz-porphyry."

Some diamond drilling is said to have been done on these claims since Moore's report was written but there is no record of any drilling results. Only limited work has been done on these claims.

Minnitaki Lake

Minnitaki lake lies east of Vermilion lake and south of Graham. The Fort William branch of the Canadian National Railways run about 4 miles from the east shore on which the pyrites deposits have been found.

Cross and Whelan Prospect

The Cross and Whelan property consists of seven mining claims on the east side of Minnitaki lake, not far from the mouth of Minnikan river. It includes a point of land projecting westward into the lake from the east shore, the north part of Cranberry island, and the land under the waters of the lake adjacent to both point and island. The property is accessible by water from Graham, 10 miles to the northwest.

A.H.A. Robinson reports on the property as follows:- "The outcrop of the deposit, on the lake bottom close to the north shore near the end of the point, is entirely covered with water; a knob of pyrites projecting through the ice at a time of low water led to its discovery. The rock on the shore adjacent to the outcrop is a grey, sericitic schist, through which a little pyrites is disseminated. South of the sericitic schist is green chlorite schist. The rock dips north, toward the lake, at an angle between 60 and 70 degrees; the strike is westerly. Development work shows that the dip of the pyrites is parallel to that of the schist.

A shaft, which is now full of water, has been sunk close to the shore - on mining claim K. 608 - directly opposite the outcrop in the lake. According to W.A. Cross, the shaft is 75 feet deep, and a cross-cut 80 feet long has been driven north from the bottom. At a point 50 feet from the shaft, the cross-cut entered mixed pyrites and rock, and after passing through 10 feet of this mixed material, penetrated clean massive pyrites for 20 feet. The face of the crosscut was still in clean pyrites when it was stopped, at a point 80 feet from the shaft, in November, 1917. There are about 100 tons of clean pyrite that should run over 40 per cent of sulphur on the dump at the shaft mouth.

Four shallow drill holes, spaced at intervals for about a mile along the strike, have also been put down to test the deposit. One, put down beside the shaft on K. 608, at an angle of 45 degrees, is said to have cut 80 feet of pyrites. Assuming the dip of the deposit to be 65 degrees, this 80 feet would correspond to a thickness of about 35 feet, measured at right angles to the walls.

A second hole, on K.628, the next claim east, also pointing north at an angle of 45 degrees, is said to have passed through 18 feet of pyrites.

The third hole, still farther east, on K.627, cut soft pyritous, graphitic schist; but no solid pyrites.

The fourth hole was put down on K.629, west of the shaft, on the northwest shore of Cranberry island. It is said to have cut four feet of pyrites.

Much more development work would appear to be well warranted on this prospect. That more has not been done appears to be almost entirely due to its somewhat unfavourable location with respect to transportation facilities.

Sturgeon Lake Area

Hornick Prospect

Three mining claims (T.B. 2201, 2356, and 2357) were staked by R.S. Hornick on a band of pyritous rocks that strikes northward along the west shore of Loch Gordon, a small, narrow lake whose northern end touches the Canadian National Railway.

The best exposures of the pyritous band are at the south end of Loch Gordon on mining claim T.B. 2201. Here, heavy gossan outcropping along the west shore can be traced north into a swamp on T.B. 2357, and south into T.B. 2356. Numerous trenches were dug in the iron-stained drift and honeycombed quartz that cover the deposit, but in few of them could unaltered formations be seen. Pyrite, pyrrhotite, and quartz occur on the dumps. The rock structure dips from vertical to 40 degrees west.

At the bottom of one pit, about 10 feet deep, there is 5 feet of pyrite mixed with a little quartz against the hanging wall and about 8 feet of a poorer mixture of pyrite, quartz, and rock on the footwall. A sample, reported by Robinson, taken across the 5 feet of pyrite on the hanging wall gave, on analysis, 43.21 per cent sulphur, 40.10 per cent iron, 0.31 per cent zinc, and 0.63 per cent copper.

A second, parallel belt of iron-stained rock occurs on the west side of T.B. 2201.

Kowkash Gold Area

In a report on "The Kowkash Gold Area" published in the Twenty-sixth Annual Report of the Ontario Bureau of Mines, 1917, P.E. Hopkins describes a number of occurrences of pyrite and pyrrhotite in that district.

The following extracts are taken from that report:-

Whitefish Lake

> "A prospector, Phillip Gagnon, discovered a pyrite deposit, five miles to the southwest of Paska station, on the south shore of the extreme northeast end of Whitefish lake. The pyrite occurs about 300 yards south of a

syenite hill, in black slates of the iron formation type, which strike southwest and northeast. Under three feet of water, and about fifteen feet from the shore, are two places which show massive pyrite, apparently of good quality and over a width of four feet. It grades, at the sides, into black slates covered by gossan in places and containing much disseminated pyrite, often in the form of rounded nodules. Some magnetite and pyrrhotite and a little chalcopyrite are also present in parts of the formation. The deposit warrants further exploration."

Lake Ste. Marie

"A wide iron formation band of varying strike and dip occurs in the rhyolites around lake Ste. Marie, which is two miles to the southeast of Redmond station. The rocks have been greatly brecciated, permitting the circulation of sulphide solutions .... Within 100 yards of the northeast shore of the lake, trenching has revealed a pyrite band 3 feet in width. A chipped sample across three feet yielded, on assay, 31.3 per cent of sulphur and $2.40 of gold to the ton. There was not enough work done to disclose the extent of the deposit."

Coleman Deposits

"D. Coleman, a prospector, has located a pyrite deposit one-quarter of a mile north of mileage 55.7 on the railway. At this locality on the side of a large hill of cherty-looking rhyolite, is a vein-like deposit five feet in width containing considerable pyrite .... About 100 yards west of the pyrite showing, and on the south shore of a pond is a massive pyrrhotite body, five feet or more in width, from which samples gave, on assay, no values in gold, platinum or nickel."

McCann Claims

These claims, T.B. 2808, 2809, 3,060 and K.115, owned by J.C. McCann, of Kowkash, are 3 miles north of Paska station.

Hopkins says: "Mr. McCann has done several hundred feet of trenching near the III-mile post of Code's meridian line to Howard falls, in an endeavour to locate a pyrite deposit. The stripping has revealed gossan in the form of rusty sand and limonite below which is considerable pyrite and a mixture of pyrite and pyrrhotite, somewhat interbanded, in a cherty quartz-porphyry and altered iron formation. The deposit across 50 feet would run about 20 per cent of sulphur, there being a much larger amount of lower grade material. A sample of the massive sulphides contained no gold or nickel."

Willet Lake

"Pyrite was discovered by the writer on the small pond four chains east of the east end of Willet lake ... The pyrite occurs disseminated through a "sugary" quartz-schist which strikes N. 70° W. and dips vertically. Ten feet of the deposit would run about 25 per cent of sulphur; a sample showed gold to be absent. If some trenching were done in this vicinity a workable pyrite deposit might be located."

Pyrrhotite Deposits

Several large bodies of massive pyrrhotite occur in different parts of the district. In so far as they are known, they carry neither gold, nickel nor platinum, and are of no commercial importance.

"The largest body seen lies on the south central shore of Marshall lake, where an open-cut through shallow gossan reveals fifteen feet or more of pyrrhotite which contains a small amount of pyrite and quartz ... A mile and three-quarters northeast of Marshall lake, near Lower Meta lake, considerable work has been done on a rusty hornblende-mica schist containing much disseminated pyrrhotite.

A sample from a pit eight feet deep, three-quarters of a mile east of the eighty-fourth mile post on the east boundary of the Nipigon Forest Reserve, consists 'largely of pyrrhotite with some pyrite and magnetite, an altered iron formation'.

A pyrrhotite mass has been found also at Rupert falls, on the Kawashkagama (Kowkash) river."

North of the Hudson Bay Watershed

A.W.G. Wilson in his report on "Pyrites in Canada" describes the occurrences of pyrites north of the Hudson Bay watershed as follows:

Island Portage on Mattagami River

On an island portage on the Mattagami river, between its junction with the Kakozhish and Kapuskasing rivers, is an iron pyrite deposit that was noted both by A.G. Burrows and E.L. Fraleck in 1900.

The former writer mentions the occurrence of a vein of quartz impregnated with pyrite and garnets. This vein is about 30' wide and showed for 40' along its length. A sample of the vein material, nearly all pyrites, showed a gold assay of $1.50 per ton. No trenching has been done and the quantity and quality of the ore is not known.

Big River Deposit

In the Report of the Bureau of Mines, for 1895, E.B. Borron quotes John Driver's description of a large pyrite deposit on Big River, a tributary of the Opasatika river. John Driver, who started out from Brunswick Post, states: 'We followed the Missinabit down to the Opasatika portage, which is a straight line, northeast 40 miles, and thence crossed over to Opasatika lake, which is 3.5 miles south of Missinaibi river. From the west end of Opasatika lake to the junction of the southwest end of Missinaibi lake is 91 miles, including 5.5 miles up the Big river to the pyrites bed or vein. Having looked over the vein, which I had no trouble to find, the next work was to cut out a path or road on the south bank down to the camp, a distance of 1.5 miles ... We uncovered the rock along the south bank the full width of the bed of pyrites, which is 35' from wall to wall. I put in shots, which broke up the vein rock 2' deep, from which I got specimens. I then uncovered the rock 100' back from the bank, and found the vein covered over with a foot of sandy loam. My men uncovered the vein from wall to wall, and I found it to be 35' wide. The course is northwest 2° west, and (the rock dips) at an angle of 65° east. In tracing the vein south, I found it to be deeply covered with soil. The rock gradually rises in going back from the river and at 300 yards is about 20' above water level of the river.

When Mr. Borron explored Big River in 1886, he thought that the rock in the river was a boulder from which he got his specimen, but I found it to be part of the vein, 15' wide and 2' above the water. It crosses one third of the river on the south side about 200 yards up stream. The river here takes a bend to the south, and comes back on itself, so that in following the course of the vein on the north side, it cuts across this point of land, which is a drift soil... However, in following up the course, I found the vein to crop out at the foot of the rapid on the scuth side of the west branch of the forks of the river, half a mile northwest from the place where I had been working. Here the rock is deeply covered with stiff clay. I got the men to clean off the part of the vein, and took what specimens I could break off with my pick hammer. From the surface, the pyrites at this place do not look as good as at the Lower place, although I am quite sure it is the same vein. The rock is so deeply covered with a clay soil that I could not follow it any farther, but no doubt it continues on for a much farther distance northward. In following up some 300 to 400 yards, I found that the country rock took a change, being on the west side of the first rapid, it is a slate, what I take to be Huronian."

Lower Island Portage, Mattagami River

E.L. Fraleck states that at this portage there is every indication of a considerable body of iron pyrites ore.

Deposits Accessible from the Ontario Northland Railway

Timagami Area
O'Connor Prospect
Mandy Claim
Northland Pyrites Mine: James Lake

Timagami Area

In a report on "Iron Ores of Nipissing District", W.G. Miller, in the 10th Annual Report of the Ontario Bureau of Mines, 1901, draws attention to the possible value, as sources of sulphur, of certain belts of pyrite-bearing rock that roughly parallel the iron ranges in the vicinity of Lake Timagami. The distance separating the pyritous belt from its accompanying band of iron formation is usually less than half a mile.

Some of the localities in which Miller reports such pyrite-bearing belts to occur are: Snake Lake, Turtle Lake, Matagama point, Vermilion Lake, O'Connor Lake, Net Lake, Heart Lake, Kokoko Lake, Austin Bay, Cross Lake, and Emerald Lake.

A sample of the pyrites in a pyritous band south of O'Connor lake yielded, on analysis, 35.91 per cent sulphur and $1.20 in gold per ton; another, from the south shore of Vermilion lake, 30.31 per cent sulphur and $2 in gold per ton. A third sample of mixed pyrites and rock, from the south shore near the eastern extremity of the northeast arm of lake Timagami gave 26.2 per cent sulphur, 0.48 per cent copper, 0.27 per cent nickel, and $1.40 in gold per ton.

O'Connor Prospect

A.H.A. Robinson reports on this prospect as follows:-

"Mining claim W.D. 357, in the township of Strathcona, owned by J.T. O'Connor, of Sudbury, has been located on one of these pyritous bands, as a copper prospect. This prospect is on the south shore of the northeast arm of Timagami lake, about 2 1/2 miles from Timagami station.

The pyritous band, which also carried pyrrhotite and a little chalcopyrite, can be traced northeastward across this claim and the next two claims to the east W.D. 402 and W.D. 401; it parallels a band of iron

formation that runs through Turtle lake, north of the northeast arm. The country rock is greenstone and green schists. In many places a felsitic looking rock-possibly rhyolite-occurs on the footwall side of the pyritous zone. The dip is northwestward at varying, but usually low, angles.

Not far from the lake shore, on W.D. 357, there are seven or eight pits and open cuts, from which some 1,000 tons of ore are said to have been taken; 542 tons are said to have been shipped to Grasselli Chemical Company's works at Hamilton in 1916. As seen in the pits, pyrites and rock are irregularly intermixed, widths of from four to six feet of fairly pure looking pyrites being accompanied by rock matter heavily charged with pyrites. Judging by its appearance, most of the material would require considerable culling to make a merchantable grade of pyrites.

A sample of the best looking ore taken from one of the piles yielded:-

	Per Cent
Sulphur	39.40
Iron	43.55
Insoluble	11.55
Copper	1.17
Zinc	1.57
Arsenic	0.009

Analyses furnished by Mr. J.T. O'Connor, the owner, show: sulphur 20.12 to 39.4 per cent, copper 0.78 to 5.4 per cent, and 0.03 to 0.05 oz. gold per ton.

In the winter of 1916-17 eight diamond drill holes, aggregating 1,000 feet of drilling were put down in the vicinity of the pits. Six of these are said to have passed through pyrites five to thirty feet thick. The drill cores were not analysed.

Test pits along the strike of the fahlband, on the east side of W.D. 357 and on W.D. 402, also show some fairly clean pyrites mixed with rock heavily charged with pyrites. A sample from one of these pits near the east boundary of W.D. 357 yielded:-"

	Per Cent
Sulphur	28.21
Iron	32.26
Insoluble	8.12
Copper	1.20
Zinc	1.47
Arsenic	0.007

Mandy Claim

A deposit of pyrites occurs in the township of Cassels, a short distance inland from the east shore of Outlet bay of Net lake, on what is known locally as the Mandy claim. This seems to be identical with mining claim T.R. 1229.

Shallow pits and trenches, scattered over an area about 100 feet in diameter, disclose an irregular deposit, of undetermined extent, of mixed pyrites and quartz in greenstone country rock. Some of the pyrites are fine-grained, massive, and appear to be clean, though most of them are mixed with considerable quartz. The unaltered pyrites are overlain by a thin capping of gossan and cellular leached quartz.

A sample of some of the better looking pyrites from one of the pits yielded, on analysis:-

	Per Cent
Sulphur	44.58
Iron	42.64
Insoluble	9.45
Arsenic	Traced
Zinc	0.49

Northland Pyrites Mine: James Lake

The Northland Pyrites mine, also known as the Rib lake, James lake, or Harris mine, is situated on the shore of James lake, about 10 miles north of Timagami station. A spur line, half a mile long, formerly connected the mine with the Ontario Northland Railway.

The deposit, discovered in 1903, was not developed until 1906, when shipment of pyrites commenced, and continued with few interruptions until July, 1910, when the mine was abandoned. The plant was removed afterwards. No work has been done since 1910. For two months, before closing down, the mine was operated under lease from the owners - The Northland Mining Company of London, Ontario - by C.B. Stranahan of New York.

At the time of its abandonment the shaft had reached a depth of 300 feet, and levels had been driven at 100, 175, and 275 feet. On the first level, drifts had been carried 150 feet north and 250 feet south of the shaft; on the second level, 165 feet north and 200 feet south. Stoping had been done above all three levels. The stopes between the first and second levels were from 10 to 20 feet wide. In addition to ore won from the underground workings, considerable pyrites was also mined from open cuts southeast of the shaft. Most of the output went to Buffalo, New York.

The deposit in which the main shaft was sunk was a lens-shaped body enclosed - in a rusty belt, or fahlband - in soft green schist, about 100 feet east of its contact with a grey hornblende granite. The dip of the deposit, and of the enclosing schist,

is west, at an angle of about 70 degrees. The only impurities in the pyrites were some small veinlets of quartz, and, in places, finely disseminated pyrrhotite. Massive pyrrhotite occurred on both walls of the lens.

Other lenses of pyrites have been found in the same pyritous zone, or fahlband, which is fairly strong and traceable for a quarter of a mile or more.

Other Northern Ontario Locations

Whelan Prospect, Boston Township
Hearst Township
    Mining Claim H.S. 904
    Mining Claim H.S. 913
Feick Prospect, Eby Township
Maisonville Township
Porcupine Area
    Bob's Lake Prospect
    Moyer Veteran Claim
    Dan O'Connor's Claim

Other Northern Ontario pyrite locations are described by A.H.A. Robinson in the summary report of the Mines Branch, 1919. As no changes are on record concerning these occurrences, his descriptions are quoted as follows:

Whelan Prospect, Boston Township

Mr. P. Kirkengaard, Sun Life Building, Toronto, did some work during the summer of 1918 on a pyrites prospect, known as the Whelan claims, situated $2\frac{3}{4}$ miles east of Dane station on the Ontario Northland Railway. The workings are about 600 feet south of the road from Dane to Larder Lake, on mining claim L.7069, the northwest quarter of the south half of mining location M.R. 14, Boston township.

Here, the trees and brush have been cleared from an area about 150 or 200 feet square; the rock surface partly stripped and several test pits sunk. The pyrites, mixed with much quartz, is found associated with a black cherty, pyritous banded rock resembling iron formation, and greenstone, both of which are cut by small trap dikes. Acid eruptives also occur in the immediate vicinity; and the rocks appear to have been much disturbed and altered. There are some pyrrhotite and magnetite in places. The mixed pyrites and quartz, as seen in the exposures, is in seemingly discontinuous bodies scattered without apparent order over the cleared area. Bands, or probably pockets, of pyrites, from a few inches to seven or eight feet thick, were measured in the various openings. Some small spherical nodules of pyrites, as well as disseminated crystals, are to be seen in the black chert.

The material in the ore piles is pyrites mixed with considerable quartz and some pyrrhotite. A general sample from one of the piles yielded, on analysis:-

	Per Cent
Sulphur	41.02
Iron	37.39
Insoluble	19.60
Arsenic	0.01
Zinc	0.20

About 100 feet north of the clearing, beside the trail leading to the Dane-Larder Lake road, a pit 10 by 20 feet has been dug about 14 inches deep in drift stained a deep red by iron oxides which may either have been washed down from the rocks exposed in the clearing, or have been derived from sulphides in place.

Hearst Township

Two pyrites prospects in the township of Hearst are described by P.E. Hopkins, of the Ontario Bureau of Mines, in "The Canadian Mining Journal" for February 5th, 1919, p. 71, as follows:-

Mining Claim H.S. 904 - A promising pyrite prospect occurs on Claim H.S. 904, or No. 2717 on Sharp creek, one-half mile from the southwest bay of Larder Lake, in Hearst township. This is one patented claim of a group owned by the Combined Larder Mines, Limited.... The claims were extensively prospected near the surface for gold several years ago, but apparently with little success. In October, 1918, the writer, while examining some of the old workings, noticed that a mineral dump on the above claim, H.S. 904, consisted almost entirely of massive iron pyrites with some gossan. The shaft was full of water, but the owners reported the shaft to be 25 feet deep, with a 25-foot cross-cut at that depth, all of which were in pyrite. The dump consists mainly of fine-grained, massive, pyrite with occasional quartz and dolomite stringers carrying a little pyrrhotite and magnetite. An eight pound sample, fairly representative of the dump, yielded on analysis 43.00 per cent of sulphur and 40 cents of gold to the ton. About 100 yards northwesterly from the dump, with intervening drift covered surface, is a deposit of "sugary" quartz, and 100 yards farther along the same strike is a 30-foot shaft in a banded formation of "sugary" quartz with much pyrite and pyrrhotite. The rocks in the vicinity are dominantly green chlorite schists and pillow lavas. The deposit is apparently worthy of further development. It lies 12 miles distant from the Ontario Northland Railway, and 1 1/2 miles from the Associated Goldfields hydro-electric transmission line.

Mining Claim H.S. 913 - Massive iron pyrite several feet wide was also seen in a 6-foot pit on Claim H.S. 913 in the southeast part of Hearst township.

Feick Prospect, Eby township

The Feick pyrites prospect is on the southwest quarter of the north half of lot 2, concession III of the township of Eby,

3 1/2 miles due south of Kenogami station on the Ontario Northland Railway. It can be reached from Swastika, 5 miles distant by bush trail.

Harry O. Feick, of Kitchener, Ontario, is the owner.

The rusty, weather surface of a fahlband striking northward has been uncovered over a length of 1,000 feet or more, and a number of trenches and test pits dug in the altered rock. One pit, 10 feet deep, in a gossan of limonite and cellular quartz, shows in the bottom a width of 10 feet of massive pyrites with some intermixed quartz. A sample taken from analysis yielded:-

	Per Cent
Sulphur	40.91
Iron	36.82
Insoluble	20.41
Arsenic	0.015
Zinc	0.20

The rocks in which the fahlband occurs are Keewatin: greenstones, schists, and iron formation. Intrusive syenite occurs a short distance to the east.

Maisonville Township

In the Twenty-third Annual Report of the Ontario Bureau of Mines, Part II, p. 34, A.G. Burrows says:-

"On lot 7, in the third concession of Maisonville the iron formation is much fractured and impregnated with iron pyrites, pyrrhotite and a little copper pyrites. A sample of pyrrhotite, on analysis, showed a trace of nickel. The rock in the vicinity is greatly oxidized, and this locality is worthy of prospecting for iron pyrites."

Porcupine Area

Bob's Lake Prospect - "A pyrites deposit of such extent as to have attracted attention to its possible economic value, outcrops on the south shore at the east end of Bob's lake, on lot 7, in concessions III and IV, Whitney township. It lies about three-quarters of a mile east of South Porcupine station on the Porcupine branch of the Ontario Northland Railway.

The pyrites occurs in a band of siliceous iron formation traceable from the lake shore southwestward for a quarter of a mile. Associated with the iron formation are green schists interlaminated with acid eruptives, of which some of the latter are porphyritic. Diabase dikes cut all these rocks, pyritous iron formation included. On the lake shore, the dip of the pyritous band is to the northwest at an angle between 40 to 50 degrees; farther inland the dip becomes steeper.

In part the pyrites is massive and tolerably pure-looking, but most of it is finely disseminated through quartz. Pyrrhotite occurs with it in places. The best exposures are to be seen in three shallow pits, or open-cuts, on the lake shore; other pits farther inland along the strike show, for the most part, only gossan or lean iron formation. The width of the pyritous band could not be determined with certainty, but fourteen feet of the mixed pyrites and quartz are exposed at one place on the shore.

Of the following analyses (1) represents a sample of the purer portions of the band, (2) a general average of the exposure.

	(1) Per Cent	(2) Per Cent
Sulphur	44.33	29.68
Iron	43.78	34.88
Insoluble residue	7.84	20.30
Zinc	0.10	0.54
Arsenic	0.007	0.009

In the winter of 1916-17 three diamond drill holes were put down through the ice, to explore for the deposit under the east end of the lake - on lot 6, concession IV. The two westerly holes are said to have penetrated pyrites, but no authoritative information is available as to the results obtained.

Moyer Veteran Claim - "About a mile southwestward along the general line of strike of the Bobs lake deposit, pyrites have been found also in a small low outcrop barely rising above the soil at the northeast corner of the south half of lot 9, concession III, on the Moyer Veteran claim. ...

The deposit here occurs in the form of a band of highly pyritous schist. The schist strikes northeastward and the dip is nearly vertical. Drift covers the north side of the pyritous band, but parallel with it on the south side is a band of acidic eruptive rock, and, south of that again, green chloritic schist. A width of 18 feet of interlaminated pyrites and schist is exposed.

An average sample taken across this width yielded:-"

	Per Cent
Sulphur	26.10
Iron	42.07
Insoluble residue	5.62
Zinc	0.24
Arsenic	0.009

Dan O'Connor's Claim - McCart township - "In 1916, Mr. Dan O'Connor, of Connaught, Ont., uncovered a showing of pyrites while prospecting for nickel on the south half of lot 7, concession V, of the township of McCart. The occurrence is about 3 1/2 miles west of Nellie Lake siding on the Ontario Northland Railway.

The pyrites were found in some pits and trenches dug through the drift covering the bottom of a shallow valley, or longitudinal depression, in the rocks. These workings were full of water when the property was visited and consequently not in a condition to afford much information. A large part of the material that had been blasted out was piled up alongside of them, however, and could be examined. This material is a black, cherty-looking, schistose rock through which spherical nodules of pyrites are rather sparingly scattered. In addition to the scattered nodules of pyrites, there are also, intercalated in the black schist, thin, pinching and swelling layers made up partly of nodular pyrites, and partly of quartz. The greatest thickness of pyrites seen in any of these layers was six inches; generally it was under three inches. Considerably less than one-half the volume of the material in the pile would be pyrites.

M.B. Baker, who inspected the deposit when it could still be seen in the pits and trenches, says: 'Scattered through arkose rock or tuff (black carbonaceous schist) are small, round, ball-like concretions of iron pyrites. They vary in size from that of peas to balls two inches in diameter. In places there is a layer six feet or more in thickness, where these ball-like concretions are so packed together as to be almost touching each other.'

A similar occurrence of nodular pyrites associated with quartz in graphitic schist, or slate, is that on the Nicuso Syndicate's pyrites claims, 14 miles southwest of English River station; others, on the Lake of the Woods, have been described by A.C. Lawson and A.L. Parsons."

Pyrites in British Columbia

Britannia Mining and Smelting Company Limited
The Consolidated Mining and Smelting Company of Canada Limited
Northern Pyrites Limited (Ecstall River Deposit)
Hidden Creek Deposit

Many occurrences of pyrites are mentioned in the annual reports of the British Columbia Department of Mines. Generally these occurrences are associated with gold or base metal deposits and the pyrites content is, or would be, of secondary importance to that of associated metals.

Britannia Mining and Smelting Company Limited

Britannia Mining and Smelting Company Limited has been for many years a regular shipper of by-product pyrite from its copper-gold-silver operations at Britannia Beach. The property is on the

coast about 27 miles north of Vancouver and is developed by adits, 6 shafts, and many miles of underground lateral workings. Recently it was announced that Columbia Cellulose Company, a subsidiary of Celanese Corporation of America, which built a $27,000,000 dissolving pulp mill near Prince Rupert, has entered into an agreement with Britannia (a subsidiary of Howe Sound Company of New York) whereby it will process pyrite accumulated at the mine. Britannia, primarily a copper producer, has more than 200,000 tons of pyrite in its stockpile and this store is being increased at the rate of 200 tons a day. Columbia Cellulose proposes to install facilities for converting this pyrite for use in its plant near Prince Rupert. In recent years Britannia has supplied pyrite to the Nichols Chemical Company acid plant at Barnet, B.C., and has shipped pyrite to Japan and Mexico.

The Consolidated Mining and Smelting Company of Canada Limited

The Consolidated Mining and Smelting Company of Canada, Limited, consumes all acid produced from the SO_2 in the stack gases at its Trail smelter. The acid is used in the manufacture of fertilizer in its plant at Warfield (near Trail). Sulphur dioxide recovery was first undertaken here in 1916. In 1932 sulphur recovery facilities were greatly expanded and a by-product plant was built to use the sulphur dioxide in the production of sulphuric acid as part of an integrated programme to manufacture fertilizers (ammonium phosphate) for the Prairie provinces. With the depressed market conditions of the early 1930's the consumer market could not absorb the fertilizers output and in 1934 a process was developed to reduce concentrated SO_2 to elemental sulphur for sale to pulp and paper mills. The SO_2 was reduced by passing the gas, with oxygen, over incandescent coke in a gas producer. This process was in commercial operation from 1936 to 1943 at which time the fertilizer market had recovered. It was then more profitable to revert to the manufacture of sulphuric acid for fertilizer production.

Sulphur dioxide, present in the furnace gases in small amounts, is concentrated by a modification of the Guggenheim process. The concentrated gases are passed through Cotrell precipitators to remove dust and then to large scrubbing towers through which circulates ammonium bisulphite. The reaction of the bisulphite with sulphuric acid releases concentrated sulphur dioxide which can be converted to either elemental sulphur or sulphuric acid. The amount of production is limited only by the amount of SO_2 present in the waste gases from the roasting of the lead and zinc concentrates. This would amount to a maximum of 165,000 tons of equivalent sulphur a year at the present milling rate.

Early in 1951 the Consolidated Mining & Smelting Company announced the planned construction of another fertilizer plant at Kimberley which would use pyrrhotite tailings from the concentrator as a source of sulphur dioxide for the manufacture of sulphuric acid. Large accumulated stocks of pyrrhotite tailings are on hand. Some of these have been used to augment the production of acid from stack gases at Trail. It is planned to treat approximately 300 tons

of pyrrhotite tailings a day which would produce from 275 to 300 tons of sulphuric acid. This would be equivalent to 100 tons of elemental sulphur per day. No decision has been announced on the disposal of 300 tons of iron oxide sinter resulting from the roasting of pyrrhotite.

Northern Pyrites Limited (Ecstall River Deposits)

This Vancouver company holds 21 mining claims 45 miles south of Port Essington. The property has been idle since 1948 but during the war years diamond drilling is reported to have indicated 5,000,000 tons of material averaging 49.35 per cent sulphur, 42.75 per cent iron, 0.80 per cent copper, and 2.30 per cent zinc. Possible tonnage of ore reserves is probably much higher. The Ecstall River deposit, as it is known, is located in the Skeena mining division on Red Gulch Creek, a tributary of the Ecstall river. In early work a prospect tunnel was driven a few feet above Red Gulch Creek about 2,400 feet from the Ecstall river. A body of pure pyrite, about 15 feet in width, was cut and stoped for 40 feet about 50 feet from the portal.

It has been reported that negotiations are in progress between Northern Pyrites Limited and Orkla Mining Joint Stock Company of Norway for the use of the latter's process for the recovery of elemental sulphur from pyrites deposits. The Orkla process is an old established one on which the first commercial unit was built in Norway about 1928. Subsequent plants were built in Portugal and Spain. As used to date it is essentially a copper smelting elemental sulphur recovery process by which about 55 per cent of the sulphur in the pyrites is recovered as elemental sulphur. About 105,000 tons of elemental sulphur was produced by this process in 1948 in Norway, Spain and Portugal.

In this process, developed by Lenander, pyrite is smelted with coke, limestone, and quartz in a furnace similar to a water-jacketed blast furnace at a temperature of abcut 1,600°C. Copper and the precious metals form a matte with sulphur, and iron is slagged off. About half the sulphur is removed by distillation of the labile atom of sulphur. Air blown in the base reacts with iron sulphide to provide much of the heat required. The coke feed is so regulated that some SO_2 is not reduced in the furnace, but is left to react with carbon-sulphur compounds in the upper part of the furnace, and in subsequent catalytic reduction chambers. Sulphur is recovered by condensation followed by electrostatic precipitation. The exit gases are finally scrubbed in a battery of limestone towers. The recovery of sulphur (as elemental sulphur and SO_2 gas) and copper is reported to be from 85-90 per cent.

An iron-stained band, on the west side of the Red Gulch Creek, is reported to have been traced for several thousand feet with widths varying from 12 to 200 feet. Outcroppings showing pyrite have been reported as occurring further up the creek on the sides of the valley. Only limited exploratory work has been carried out along the band of iron-stained rocks. More detailed work might locate further sulphide bodies containing pyrite from which, on weathering, the gossan band was probably formed.

Hidden Creek Deposit

The Hidden Creek group of 14 claims on Goose Bay at the head of Observatory Inlet in the Portland Canal mining division comprises the property on which the Anyox Mine of The Granby Consolidated Mining, Smelting and Power Company, Limited, was situated. This mine, during its period operation beginning about 1910, was one of the largest producers of copper in the Commonwealth. Shipments of copper concentrate from Anyox were suspended in 1935 and the property was sold to Consolidated Mining and Smelting Company late in that year along with supplies on hand. The property has been dormant since that time. The ore, composed of pyrite, pyrrhotite, and chalcopyrite, occurred in irregular replacement shoots, roughly elliptical in section, in dark argillites close to granite. Widths of shoots ranged from 50 to 240 feet with lengths from 800 to 1,600 feet. During the period of operations large tonnages of high grade pyrite were encountered.

III. SULPHURIC ACID AND LIQUID SULPHUR DIOXIDE IN CANADA

The production of sulphuric acid in Canada began in 1867 when a plant was built in London, Ontario. It manufactured acid from brimstone to supply the needs of the infant oil refining industry in southwestern Ontario. The second plant to manufacture sulphuric acid was built in Brockville, Ontario, in 1869 and burned pyrite from eastern Ontario mines as the source of sulphur. Since 1867 about twenty acid plants have been built and operated in Canada with 11 of them burning brimstone and the remainder burning pyrite or making use of the SO_2 content of smelter stack gas as the source material.

In Canada, at present, there are nine plants manufacturing sulphuric acid of which four use brimstone as the sulphur source, three use pyrite obtained as a flotation concentrate from the milling of base metal ores, and two use sulphur dioxide contained in the stack gases from the smelting of base metal ores or concentrates. The list of these companies, with plant locations, is as follows:

Name of Company	Plant Location	Source of Material
Aluminum Company of Canada, Limited*	Arvida, P.Q.	Brimstone
Canadian Industries Limited	Copper Cliff, Ont.	Stack gas
" " "	Hamilton, Ont.	Brimstone
The Consol. M. & S. Company of Canada Ltd.*	Trail, B.C.	Stack gas
Dominion Steel & Coal Corp., Ltd.*	Sydney, N.S.	Brimstone
Nichols Chemical Company, Limited	Valleyfield, P.Q.	Pyrite
" " " "	Sulphide, Ont.	Pyrite
" " " "	Barnet, B.C.	Pyrite
North American Cyanamid, Limited*	Welland, Ont.	Brimstone

* Manufacture sulphuric acid wholly for their own use.

In addition to the plants currently manufacturing sulphuric acid several other plants are either in the construction stage or are being contemplated. All of these projects will use material from Canadian sources, as outlined in the following table:

	Company	Plant Location	Source of Material
1.	Columbia Cellulose Company	Prince Rupert, B.C.	Pyrite (Britannia)
2.	The Consolidated Mining and Smelting Company of Canada, Limited	Kimberley, B.C.	Pyrrhotite (Kimberley)
3.	Noranda Mines, Limited	?	Pyrite (Co's mines)
4.	Aluminum Company of Canada, Limited	Arvida, P.Q.	Zinc Concentrates (Barvue)
5.	Canadian Industries Limited	Copper Cliff, Ont.	Stack gas (Inco)
6.	Nichols Chemical Company Limited	Valleyfield, P.Q.	By-product pyrite

The details concerning the plans of Columbia Cellulose Company, the Consolidated Mining and Smelting Company and Noranda Mines are discussed elsewhere. Briefly, all six may be summed up as follows:

(1) Columbia Cellulose Company, a subsidiary of Celanese Corporation of America, constructed a $27,000,000 dissolving pulp mill near Prince Rupert, B.C., and entered into an agreement with Britannia Mining and Smelting Company for the purchase of pyrite. Britannia has accumulated about 200,000 tons of pyrite as a by-product from its copper operations at Britannia Beach and is adding to this store at the rate of 200 tons a day. Columbia Cellulose will convert the pyrite into sulphuric acid which will be used in its own works.

(2) The Consolidated Mining and Smelting Company Limited announced, early in 1951, plans for the construction of a third fertilizer plant (others at Trail, B.C., and Calgary, Alta.) at Kimberley, B.C., adjoining the concentrator. This new plant will use, as a source of sulphur for acid manufacture, about 300 tons of pyrrhotite tailings daily in the production of an equivalent amount of sulphuric acid. The latter will be used in the manufacture of ammonium phosphate fertilizer. Iron oxide sinter, from the roasting of the pyrrhotite tailings, will be stockpiled and may, in the future, be a source of iron. Some pyrrhotite is currently being burned at Trail to augment the production of sulphuric acid from smelter stack gases there. Acid produced at Trail is consumed in the fertilizer plant nearby. Ammonium nitrate fertilizer is made at Calgary, Alta., and no sulphuric acid is needed in its manufacture.

(3) Noranda Mines Limited developed on a laboratory scale and, latterly, on a 25-ton-per-day pilot plant operation, a process for recovering brimstone and sulphur dioxide from a typical, finely ground, flotation concentrate. It is essentially a process that volatilizes most of the 'loosely-held' atom of sulphur in the pyrite with subsequent sintering of the residue remaining from the first step to produce a high quality iron-oxide sinter, and sulphur dioxide from which sulphuric acid could be made. By processing 300 tons of pyrite concentrate a day, assuming 50 per cent sulphur content, a recovery of about 18,000 tons of brimstone a year can

be expected, along with a sulphur equivalent of about 35,000 tons as sulphuric acid. No announcement has been made to mid-1951, by company officials of a decision to build a commercial plant for treatment of pyrite concentrates. Such a plant would have to be located where large sulphuric acid consuming plants are located. Acid cannot be transported great distances to consumers and be competitive with existing acid plants. However, a ready market exists for all brimstone that might be produced.

(4) Aluminum Company of Canada, Limited, at Arvida, in Quebec, have concluded arrangements with Barvue Mines Limited to roast the latter's zinc concentrates. Alcan will use the sulphur dioxide in the roaster gases to manufacture from 40,000 to 50,000 tons of acid a year which will be consumed within the company's works. The zinc concentrates in calcine form are to be shipped to the United States where the sale of 175,000 tons of concentrates have been contracted with American Zinc Lead and Smelting Company of Illinois. Production of ore from open pit operations at Barvue's mine near Amos, Quebec, is expected to reach 4,000 tons per day late in 1952. Original production plans called for the shipment of 200 tons of 60 per cent zinc concentrate daily.

The orebody as outlined by diamond drilling is about 2,600 feet long, with an average width of 106 feet. This has been drilled systematically to a depth of 300 feet and contains an estimated 7,650,000 tons of ore averaging 3.3 per cent zinc and 1.2 ounces of silver to the ton to this depth. The company has reported that up to 300 tons of pyrite concentrate per day might be available when operations reach the proposed 4000 tons per day.

(5) Canadian Industries Limited announced, early in 1951, that it will erect a plant at Copper Cliff, Ontario, to produce 90,000 tons of liquid SO_2 annually from stack gases produced in the operation of the oxygen flash smelting units recently developed by International Nickel Company Limited. Many years of research, resulted in the discovery of the oxygen flash smelting process with subsequent recovery of the SO_2 in the gases as liquid sulphur dioxide. Since 1928 Canadian Industries Limited has been producing H_2SO_4 from stack gases. The output is expected to reach a rate of 80,000 tons of acid per year by the end of 1951. This is equivalent to about 20,000 tons of brimstone a year and represents an increase of about 90 per cent over the output of recent years.

Liquid SO_2 is not made in Canada at the present time although the company produced it in relatively small quantities from 1932 to 1945. However, the costs were too high then to permit the product to compete with elemental sulphur. The development of the oxygen flash smelting process opened up the possibility of economically converting the high content SO_2 gas into liquid SO_2. Operations of a pilot plant by the company at its Copper Cliff plant proved the technical and economic feasibility of large scale production. In 1947 test runs, using this liquid SO_2 in place of brimstone, were made at the Abitibi Power and Paper Company's 'Mission Mill' at Fort William in which its adaptability was proven.

This development will place liquid SO_2 in the category of a tonnage chemical available to consumers at a fraction of its present cost. The output from this operation will provide more liquid SO_2 than is being produced in all the Free World. Large potential consumers include sulphide pulp, newsprint, and acid manufacturers who now depend almost entirely on brimstone imported from the United States.

(6) The Nichols Chemical Company, Limited, began, in mid 1951, a $2,500,000 expansion project to double the capacity of the acid facilities at its Valleyfield works, Valleyfield, Quebec. Initial production, resulting from the expansion, is expected by the spring of 1952. As in the past, Canadian by-product pyrite will be used in the company's three acid plants at Valleyfield, Quebec, Sulphide, Ontario, and Barnet, B.C.

IV. RECOVERY OF SULPHUR FROM OIL REFINERY GAS STREAMS

Studies have been made, by several firms, of the possibility of recovering the sulphur dioxide or hydrogen sulphide content of the gas streams of oil refineries in Canada. The largest concentration of refining facilities in Canada is located in Montreal East where Imperial Oil, British American Oil, Shell Oil, and Texaco Oil companies have a combined throughput of about 150,000 barrels a day. Most of the crude refined in these plants comes from Venezuela via pipeline from Portland, Maine, and has a very low sulphur content (under 1 per cent). Minor amounts of Middle East crudes are consumed. They contain up to 5 per cent sulphur.

Total content of sulphur in the gas streams from the four refineries has been estimated at about 40 tons per day. Half of this is considered recoverable. However, several factors tend to prevent the treatment of gases from this group of refineries:

1. The gathering of gases from several sources, some distance apart, would be difficult.

2. The extreme climatic conditions in the area would make capital outlay, with respect to collection and transmission of gases, high.

3. The relatively low H_2S content of the gases would preclude the economical recovery of the sulphur content as brimstone.

4. In some cases, the refineries burn their waste gases for preheating the crude and would require payment for the H_2S, contained in the gas, on a B.T.U. basis.

5. The end product - sulphuric acid - must be marketed in a highly competitive area and the economics of producing and marketing a relatively small output of sulphuric acid (50-60 tons per day) would not be worthwhile.

Production of sulphur, or its equivalent, from any other refinery area in Canada, at present, appears even more remote than from the Montreal East area.

V. ELEMENTAL SULPHUR IN CANADA

The Consolidated Mining and Smelting Company of Canada Limited

Elemental sulphur, or brimstone, was produced, from 1936 until 1943, by the Consolidated Mining and Smelting Company at Trail, B.C. This operation was discontinued in 1943 when production facilities were switched back to production of sulphuric acid from the stack gases. The history of the manufacture of sulphuric acid and brimstone at Trail, B.C. is described in 'The Story of the Consolidated Mining and Smelting Company of Canada' by 'Cominco' in March, 1948, as follows:

> Roaster and sinter gases, containing up to 7 per cent sulphur dioxide are cleaned of dust by Cottrell electrostatic precipitations and water washing. If the sulphur dioxide content is sufficiently high, the gases go directly to five (5) standard contact sulphuric acids units. Otherwise sulphur dioxide is first absorbed and subsequently regenerated as pure sulphur dioxide. This pure gas is then made into sulphuric acid in a unit utilizing the usual cyclic process for acid manufacture.
>
> In the latter alternative, aqueous ammonia is used to absorb sulphur dioxide when gas concentrations are low. This yields an ammonium sulphite solution. The addition of sulphuric acid to this solution results in the liberation of almost pure sulphur dioxide and the formation of ammonium sulphate. The ammonium sulphate solution is pumped to a separate plant for crystallization of the fertilizer product. To make sulphuric acid from the regenerated gas, the pure sulphur dioxide and by-product oxygen are added continuously to a circulating load of inert gas, passed through a converter where the dioxide unites with oxygen to form sulphur trioxide in the presence of a vanadium catalyst. This gas is absorbed and combined with water to make sulphuric acid.
>
> In the five standard contact units for sulphuric acid manufacture, the process is standard and consists of sulphuric acid drying of the clean gas, oxidation of the dioxide to trioxide using a vanadium oxide catalyst, and absorption of the sulphur trioxide in 98.5 per cent sulphuric acid.
>
> The Trail elemental sulphur plant was run as part of an integrated fertilizer operation with ammonium sulphide, present in low concentrations in the smelter gases, was concentrated by a modification of the Guggenheim process whereby gases are sent through Cottrells to remove dust and fumes and then to large scrubbing towers through which

circulates ammonium bisulphite. The reaction of the bisulphite with sulphuric acid releases concentrated sulphur dioxide, which can be converted to either free sulphur or sulphuric acid. The elemental sulphur plant at Trail was started in 1936 at 60 tons a day. This was soon increased to 80 tons, and the final maximum annual output reached 40,000 tons. The stand-by capacity was probably close to 50,000 tons a year of elemental sulphur. The total output for the period 1936 to 1943 was in excess of 200,000 tons. The amount of sulphur that can be produced is limited by the amount present in the waste gases obtained from the roasting of the lead and zinc concentrates, and amounts to 400-500 tons of sulphur a day or a maximum of 165,000 tons a year.

Noranda Mines Limited

Noranda's proposed plant, in which 300 tons of pyrite would be roasted daily, would result in the annual recovery of about 18,000 tons of brimstone, and 35,000 tons of sulphur equivalent as sulphuric acid. This process has been described above under 'sulphuric acid'. However, plans for the construction of the plant are being held in abeyance and no official announcement has been made by company officials on the beginning of plant construction. A ready market exists for any brimstone produced but it would appear that the marketing of large tonnages of sulphuric acid presents a problem.

Sulphur From Sour Natural Gases

The recovery of sulphur, in elemental form, from 'sour' natural gases containing hydrogen sulphide is a development of recent years. The amount of H_2S in natural gases varies with the field but large volumes of proven reserves have been established in the Pincher Creek, Jumping Pound and Turner Valley fields of Alberta. These are estimated to contain 8, 4, and 2 per cent hydrogen sulphide gas respectively. One million cubic feet of H_2S gas contains approximately 44.6 tons of elemental sulphur. A recovery of 80 to 90 per cent is possible.

Shell Oil Company of Canada, in conjunction with Powell River Company of British Columbia, a large producer of newsprint, is building a $500,000 sulphur recovery plant in the Jumping Pound field of Alberta to recover brimstone from the scrubbing of sour natural gases. The gas scrubbing plant, officially opened in May 1951, cleans about 25,000,000 cubic feet of natural gas daily and upon completion of the sulphur recovery plant in 1952, about 30 tons of brimstone will be recovered each day. The H_2S in the natural gas is first extracted with amines and one third of it is oxidized to form SO_2. The SO_2 and H_2S gases react in the presence of an alumina catalyst to yield elemental sulphur. The Canadian Western Natural Gas Company distributes the scrubbed gas output to Calgary and Southern Alberta consumers.

Royalite Oil Company has announced that it will build a $350,000 sulphur recovery plant adjacent to its present gas scrubbing plant in the Turner Valley field of Alberta. The plant is scheduled to be in operation by mid 1952 and will have a daily capacity of 30 tons of brimstone. About 25,000,000 cubic feet of sour natural gas are scrubbed daily to remove the acid gases, containing CO_2, H_2S, hydrocarbons and moisture. These are absorbed in a Birbotol plant which uses an amine solution as a scrubbing agent. The amine solution is reactivated by heating and the H_2S and CO_2 gases are liberated. These gases comprise the feed to the sulphur recovery plant.

The H_2S and CO_2 are fed into the reactor furnace together with a controlled volume of air and a portion of the H_2S is burned resulting in the following reactions:

$$H_2S + 3/2\ O_2 = H_2O + SO_2$$

$$2H_2S + SO_2 = 3S + 2H_2O$$

From 70 to 80 per cent of the H_2S is converted to brimstone in the furnace. The combustion gases then pass through a waste heat boiler generating steam for plant requirements. From the waste heat boiler the reaction products pass through a feed water economizer into the wash tower in which sulphur, formed in the reactor furnace, is condensed by cooling to a temperature of about 275°F, and is collected in the run down tank.

The gases leave the wash tower containing the balance of the hydrogen sulphide, sulphur dioxide, carbon dioxide, nitrogen and water vapour. They pass through a direct fired tube and shell reheater where the temperature is raised to approximately 500°F. The gases then pass through a converter containing a bauxite catalyst where additional hydrogen sulphide and sulphur dioxide are converted to sulphur. The sulphur is then condensed in a second wash tower and is collected in the sulphur run down tank. The sulphur from the run down tank is transported through steam-traced lines to storage vats where it solidifies.

The overall recovery of sulphur in this type of plant is reported to be about 90 per cent and the sulphur produced is comparable in quality to that of Frasch-mined sulphur.

Naturally, the amount of elemental sulphur recoverable from sour natural gases depends entirely on the volume of gas consumed and its H_2S content. Within the next few years, possible some 50,000 tons of brimstone might be recovered annually but in the immediate future this will be considerably less. The cost of recovering a ton of sulphur from natural gases has been estimated to vary from $2 to $6 a short ton, excluding capital writeoffs and depreciation.

Export of Natural Gas from Alberta

The Alberta Government announced in June, 1951, that it had issued a permit allowing limited export of natural gas to the Anaconda Copper Mining Company, Montana, for five years. An application has been forwarded to the Board of Transport Commissioners at Ottawa to construct a pipeline to carry the gas from the Pakowki Lake gas field

in southeast Alberta to Montana. McColl-Frontenac Oil Company and Union Oil Company of California have bought most of the Pakowki Lake gas reserves.

This permit, Alberta's first covering major gas export, allows the two oil companies to supply a maximum of about 43 billion cubic feet of gas to the Montana Power Company over a period of five years for consumption in the mining, smelting, reduction, and refining operations of Anaconda. It was issued as a 'defense production emergency' because Montana Power was unable to meet all the needs of Anaconda from its failing supply. No announcement has been made on recovering the H_2S content of the gas as brimstone.

Several other gas pipeline companies have been formed and applications for permits have been made to the Alberta Government for natural gas transmission to the Pacific Northwest States and Vancouver area and to the eastern Canadian market of Ontario and Quebec.

Elemental Sulphur Deposits in Canada

There are no elemental sulphur deposits known to exist in Canada comparable to those of the Gulf Coast region of the United States. Fortune Oils Limited, while drilling for oil in 1949, noted 'sulphur chips' from cuttings of two wells north of Edmonton. Dominion Tar and Chemical completed negotiations with Fortune Oils Limited to give the company a controlling interest in Sunbeam Sulphur Limited, of Calgary. This company is currently core drilling two holes at the sites of the two 'discovery' wells to determine the extent and conditions under which the sulphur occurs. The drilling site is in the Chisholm area, on the Peace River railroad, about 100 miles north of Edmonton. In the Davies-Decalta Hondo No. 1 well, drilled in 1949, sulphur chips were reported as having come from a depth of 3040 feet. In the Fortune-Roxana-Chisholm No. 1 well flakes of sulphur were recovered from drilling mud from a depth of about 3,500 feet. The two wells are drilled about ten miles apart. It should be noted that the Frasch-mined sulphur of Texas and Louisiana occurs at depths less than 2,000 feet and that, to date, no sulphur has ever been extracted from formations lying at depths greater than 2,000 feet. Some new method of extraction of sulphur from formations lying below 2,000 feet might have to be developed if quantities of the element are discovered by current drilling.

VI. SULPHUR FROM BITUMINOUS SANDS

A huge potential source of sulphur in Canada exists in the extensive deposits of bituminous sands along the Athabaska river in northern Alberta. The deposits are about 230 to 200 air miles north of Edmonton. Several different processes for the extraction of the bitumen from the sand have been developed by the Alberta Government, the Fuels Division of the Department of Mines and Technical Surveys at Ottawa, and others.

Sidney M. Blair, consulting engineer, in his report to the Government of the Province of Alberta, on the Alberta Bituminous sands, dated December 1950, says:

> "The amount of sulphur in the raw bitumen varies appreciably throughout the area but in general may be considered as being between 4.5 and 5.5 per cent by weight of the dry bitumen. A few commercial crude oils have between 2 and 3 per cent sulphur, but the great bulk of even sour crudes have less than 1.75 per cent sulphur. The sulphur in the bitumen is in chemical combination with it.
>
> In view of the exceptionally high sulphur content in this bitumen and the effect on the value of the products derived, the refining studies of this survey have provided for the removing of sulphur to a sufficient extent to allow the products made to be evaluated on a normal oil market. 'The bitumen contains 5 per cent sulphur. The square mile studied contains 1,500,000 tons of sulphur. The distillate contains a 4 per cent, which must be reduced before marketing. The process used recovers 60 per cent of the original amount at a cost of about $8.50 per ton starting with hydrogen sulphide. The elemental sulphur recovered, about 140 tons per day, from a 20,000 barrel per day bitumen plant, corresponds to the total western Canada sulphur market."

VII. SULPHATES AS A SOURCE OF SULPHUR

Gypsum and Anhydrite

Natural sulphates - anhydrite and gypsum - are not considered important as sources of sulphur in North America at this time. However, processes are available and plants in Europe are using anhydrite for the production of sulphuric acid and ammonium sulphate. Natural sulphates can be described as almost inexhaustible in occurrence, yet high capital and operating costs preclude their widespread use in most countries as a source of sulphur.

Since the end products of the process - sulphuric acid and Portland cement - cannot be economically transported for long distances, the operation must be located close to markets.

Extensive deposits of anhydrite and gypsum, particularly in New Brunswick and Nova Scotia, constitute a huge potential source of sulphur and its compounds. Plants for the economic recovery of sulphur (as sulphuric acid) and output of Portland cement from anhydrite are in operation in England, Germany, and France.

The Billingham Process

Because of the possibility of the future importance of natural sulphates as a source of sulphur in Canada, the process being used at

Billingham, England, for the manufacture of sulphuric acid and Portland cement is described in some detail.

The plant was erected in the early 1930's and has operated continuously since then. A group of British industrialists, together with Imperial Chemical Industries Limited which operates the Billingham plant, are building a similar plant at Merseyside, costing about [illegible], $10,000,000. It will produce 150,000 tons of sulphuric acid annually within two years.

A description of the Billingham plant and process is contained in 'Chemical Engineering Journal', July 1951, from which the following is taken:

> "The Billingham plant produces 100,000 tons a year of 100 per cent sulphuric acid and a somewhat larger quantity of high grade cement clinker. Anhydrite (which occurs in many parts of Britain) comes from a deposit 600-700 ft. below the surface at the plant site. It is the only plant of its kind operating on a large scale at an economic rate. It has provided ICI engineers with over 15 years' experience to apply the new venture. They've learned, for instance, that an up-to-date converter system can improve upon the old plant's 89 per cent over-all conversion to sulphuric. But the general outlines of the process will be much the same.
>
> The process involves: heating together anhydrite, sand, coke and ashes containing alumina; evolution of sulphur dioxide and the formation of sulphur dioxide into sulphuric acid in a conventional contact plant.
>
> All raw materials except the anhydrite, which is dry, are first of all passed through rotary dryers heated by coke-oven gas. Next, separate storage bunkers discharge the raw materials to a common collector belt in proportions calculated to yield a satisfactory cement clinker. The belts feed two four-compartment ball mills and the mixed feed is ground to raw meal of required size and then elevated to storage bunkers. This insures a constant flow into two rotating kilns, 224 ft. long by 11 ft. in diameter, which are fired with pre-dried, pulverized coal blown into their hot end with the requisite primary and secondary air.
>
> The calcium sulphate evolves sulphur dioxide, leaving lime to combine with the alumina and silica in the other raw materials to give cement clinker. The final, carefully controlled temperature of the solid material in the kilns is in the order of 1,400 deg. C. - somewhat above that used in ordinary cement practice. The clinker passes through recuperators before discharge to recover some of the heat, and is subsequently transported by means of an aerial ropeway to the cement plant.

Before the kiln gases (9% sulphur dioxide) go to the converters they are passed through an elaborate purification system. They enter a cyclone to remove dust which is then recycled to the kiln. Partly cooled, they are subjected to a water wash to remove the remainder of the dust, then to a series of five parallel sets of two electrostatic precipitators to remove mist. Complete drying is accomplished in two packed towers working in series in which countercurrent washing with sulphuric acid is carried out.

The gases are circulated through the system by means of three centrifugal blowers, one of which is a standby. From the blowers, they enter the converter system through heat exchangers in counter flow to the outgoing gases. Two-stage conversion with platinum or vanadium catalysts is used. Sulphur trioxide formed is absorbed in the normal manner.

Exit gas from the plant is washed with ammonia in countercurrent giving a mixture of ammonium sulphite and bisulphite. This liquor is then treated with acid to release the sulphur dioxide which is returned to the plant.

Approximately 1.64 tons of anhydrite is consumed in the simultaneous production of 1 ton of acid and 1 ton of cement clinker. The fuel consumption is 0.266 tons of coal to a ton of acid.

In the kilns, the reaction goes practically to completion - all the sulphur in the anhydrite is evolved as sulphur dioxide. Not all of the sulphur dioxide appears as sulphuric acid, however, there are small losses in the washing of the gas and some sulphur passes out of the system as ammonium sulphate from the treatment of the gaseous effluent".

G.I. Higson, managing director of the Billingham plant, writing in the 'Chemical and Engineering News' of October 22, 1951 lists the plants which manufacture sulphuric acid from calcium sulphate as follows:

Plants for the Manufacture of Sulphuric Acid from Calcium Sulphate

Locality	Raw Material	Date of Installation	Capacity, etc.
Germany Leverkusen	Gypsum	1926	Original experimental plant. Projected capacity was 55,000 short tons of H_2SO_4 yearly, but it was never completed and is now dismantled.
Wolfen (Russian Zone)	Anhydrite	1938	165,000 short tons of H_2SO_4 per year was standing undamaged, but shut down in 1945. Alleged to have been removed by Russians, and now to be in progress of reconstruction for 100,000 tons by 1952, and 190,000 tons by 1955.
England Billingham	Anhydrite	1929	110,000 short tons of H_2SO_4 per year. Now being extended to 190,000 short tons.
Merseyside ?	Anhydrite	Under construction, due to start 1954.	165,000 short tons of H_2SO_4 per year. Is being installed to help to alleviate present shortages of sulphur in Britain.
France Miramas	Gypsum	1937	27,000 short tons of H_2SO_4 per year. Ran until 1940, and sporadically from 1940-5 during occupation. Now restarted and on full production.

He also draws a comparison of the costs to produce a short ton of sulphuric acid from cement-sulphuric, sulphur burning, and pyrites burning plants in the following table:

Comparison of Processes: Costs Per Short Ton of Sulphuric Acid

	Cement Sulphuric Plant	Sulphur Burning Plant	Pyrites Burning Plant
	$	$	$
Sulphur: 0.344 short tons at $31.36 per short ton	-	10.81	-
Anhydrite: 1.66 short tons at $2.52 per short ton	4.20	-	-
Pyrites: 0.77 short tons at $10.98 per short ton	-	-	8.46
Net cost of conversion, including fuel and other materials where necessary	8.23	0.87	4.20
Standing and other overhead charges	1.54	0.28	0.84
Interest and depreciation at 10% per annum	7.00	2.10	4.20
	20.97	14.06	17.70
Less: Clinker credit: 0.95 short tons at $4.34	4.12		
Net Cost	16.85	14.06	17.70
Capital costs per short ton year	70.00	21.00	42.00
Minimum economic size of plant, short tons per year	80,000		

These figures are quoted for British conditions and the British costs are converted from pounds sterling to dollars at the current rate of exchange $2.80 = £1.

In the 1943 Annual Report on Mines, Province of Nova Scotia, A.E. Flynn, Professor of Mining at Nova Scotia Technical College, describes some processes for using anhydrite in the production of sulphuric acid, liquid sulphur dioxide, and Portland cement. He says that by the calcination with coke (de John process), 'The gas produced is 9% SO_2 at an estimated cost of $6.50 per ton of SO_2. The SO_2 can be concentrated and liquified by the aluminum sulphate process for use in the paper industry in place of brimstone or pyrites. The cost of the liquified SO_2 would be about $15 per ton, delivered at the plant, which is equivalent to sulphur at $30 per ton. '

Sodium Sulphate in Saskatchewan and Alberta

The large deposits of sodium sulphate, which occur in southern Saskatchewan and Alberta, constitute a large potential source of sulphur. By using processes already known the sodium sulphate can be considered as an important possible source of soda ash and elemental sulphur.

One process consists of heating, by coal, gas, or oil the sulphate mixed with lignite coal in a rotary kiln to about 800 degrees centigrade. The sulphate is reduced to a liquid melt containing sodium carbonate and sulphide which is run directly into water. Carbon dioxide is bubbled through the solution and changes all the sodium into carbonate form from which it can be recovered as soda ash. The sulphuretted hydrogen (hydrogen sulphide) evolved can be converted by the Chance-Claus process to a high purity elemental sulphur. This conversion step is identical to that which will be used by Shell Oil Company and Royalite Oil Company to recover elemental sulphur from sour natural gases in Alberta. If such a process were established in the Canadian West to recover soda ash and sulphur it would provide outlets for sodium sulphate, oil or gas, and lignite coal and could go far to overcome the shortages of both soda ash and sulphur in Canada.

VIII. MISCELLANEOUS SOURCES OF SULPHUR

By-Product Sulphur from Industrial Gases

The recovery of by-product sulphur in industrial centres is closely linked with efforts to control and eliminate excessive atmospheric pollution. Particularly in recent years, following the smog disaster at Donora, Pennsylvania, in 1948, industrial cities such as Pittsburgh, Detroit, and Los Angeles, have instituted programs to cut down on 'smog'. Research into the whole field of air pollution, while primarily interested in lessening the pollution, may, by removing objectionable sulphur compounds from industrial gases, result in additional supplies of sulphur.

Sulphur in Coal 'Brasses'

The reserves of sulphur in coal, as coal 'brasses' is considerable because of the enormous reserves of coal in the world. The sulphur occurs usually as marcasite in the form of lenses, nodules and sheets, in both horizontal planes and vertical fissures in coal seams. Coal brasses have been recovered and used as a source of sulphur in relatively small amounts in central European countries, particularly in Germany. However, the small pyrites content of coal, ranging from 1 to 3 per cent, results in high recovery costs and places this material at a competitive disadvantage.

A. Graham Thomson, writing in the Mining Journal of July 6, 1951, on 'Sulphur Recovery in Germany' said:

> "By the end of 1944 the Germans had recovered 70% of the available sulphur in Ruhr coal. Considerable difficulties were reported to have been experienced in connection with the building of additional plants in coal-washeries to handle the separation of pyrites. In 1943, the Germans recovered 15,000 tons of pyrite from hard coal and an additional 20,000 tons from brown coal. By that time, ten plants had been installed in the Ruhr, about 50 per cent of the pyrites present being recovered as a product which met the required specification. Eight additional plants were planned, and it was estimated that about 20,000 tons a year could be produced from all Ruhr collieries.
>
> Two types of jig were used to treat colliery refuse smaller than 10 mm. in size. Pulsator jigs, operating at 150 pulsations a minute, treated raw materials up to 10 mm. Vibrating jigs, operating at 350 vibrations per minute, were used for material up to 1 mm. The vibrations were induced by means of a rubber diaphragm forming part of the bottom or side of the jig. For convenience, wash-boxes about 1 sq. metre in size were employed, the throughput being about two tons per hour. These wash-boxes might have an artificial bed composed of relatively large particles of pyrites. The fine material normally contains 5-10 per cent pyrites, up to 15 per cent being recoverable at a cost of RM 15-20 per ton. The specification for washed pyrites called for a sulphur content exceeding 40 per cent and a carbon content under 4 per cent. In practice, sulphur contents were up to 44 per cent and carbon down to 2 per cent."

Sulphur from Coke Oven Gases

Minor amounts of sulphur are being recovered from H_2S in coke oven gases in the United States and Europe. It is unlikely that large quantities will ever be obtained from this source for, in general, the concentration of sulphur values is low. Any sulphur produced from industrial stack gases is likely to be incidental to air pollution control. Larger thermal electric generating plants burning high sulphur coal will probably be among the first to recover sulphur from stack gases.

It has been estimated that the hydrogen sulphide now being evolved in United States coal carbonization plants could add about 200,000 tons annually to the sulphur supply. According to George P. Wilson of the U.S. Solid Fuels Administration, such hydrogen sulphide recovery is economical in coke plants which handle at least 4000 tons of coal a day. The gasification of coal in place, when it becomes a reality, could mean an additional source of sulphur.

Possible changes in metallurgical practices could have an important bearing on the amount of available by-product sulphur. There is, for example, a recent tendency in the iron and steel industry

to process ores before charging to the blast furnaces. As lower grade domestic ores become of increasing importance to the industry, the use of sintered raw materials will increase, particularly in the United States. Nodulizing of the taconite iron ores of the Minnesota ranges and the sintering of low grade magnetites in Canada and the United States could make available by-product sulphur. Continuation of the trend could result in an increase in the use of pyrites as the source of iron with a corresponding increase in the production of by-product sulphur.

IX. RECOVERY AND UTILIZATION OF SULPHURIC ACID FROM SPENT H_2SO_4

H_2SO_4 from Oil Refinery Sludge

The expansion of the oil refining industry during the past two decades has resulted in increased consumption of sulphuric acid. The acid sludge, formed during the treatment of petroleum, must be disposed of in some manner. The most economical practice formerly available involved the separation of the acid sludge into light acid oil, acid tar, and weak separated H_2SO_4. The latter was then concentrated for reuse. In recent years several processes have been developed for the direct production of contact H_2SO_4 from unseparated acid sludge and plants using these processes have been built in the United States. The minimum economic size for such a plant is estimated to be 25 tons per day.

H_2SO_4 from Spent Liquor

Sulphuric acid is also an important expense item in steel treatment, since large quantities are used in the pickling process. A great deal of effort has gone into trying to develop a method of economically recovering the acid from the spent liquor. Strip mill pickle liquor has a typical range of compositions such as 10-12 per cent free acid, 12-16 per cent ferrous sulphate, and 72-78 per cent water. The disposal of this waste solution presents a serious problem to many industrial plants. Little success was achieved until recently when the Chemical Construction Corporation, New York, operating under license in association with Nordac Limited of London, England, developed a process that not only eliminates the disposal problem, but economically converts spent liquor into strong H_2SO_4 suitable for further pickling operations.

From Digester and Evaporator Gases: the Ferralyst Process

In Canada the practise of converting the sulphides in the digester and evaporator gases in pulp and paper mills to elemental sulphur, or sulphur dioxide, has not been undertaken. In pulp and paper mills the calcium bisulphite used in the digester tanks is eventually wasted with loss of all elemental sulphur used originally. In 'The Chemical Age' of August 4, 1951, a new sulphur recovery

process is described - "The Ferralyst Process" - which might offer an economical means of recovering a good deal of this sulphur.

The process, developed in Australia during the war years and emerging from its pilot plant stages in the United States, is a catalytic oxidation process for the production of elemental sulphur from waste or natural gases. The Ferralyst process oxidizes organic and inorganic sulphur compounds, in one pass, through a non-fouling catalyst either to elemental sulphur or, depending on the conditions under which the process is operated, to sulphur dioxide. The article states that

> "The catalyst in no way changes the constituents of the gases or vapors, but has a selective action on all such sulphides as hydrogen sulphide, mercaptans, dimethyl sulphide, thiophene, carbonyl sulphide, carbon disulphide, and the like.
>
> The performance of the process is high over a wide variety of conditions. With hydrocarbon gases the process operates over a temperature range of 110-240°C. for the production of elemental sulphur, and between 110° and 400°C. for the production of sulphur dioxide. The operating pressure may be from 1-20 atmospheres and the space velocity (catalyst volume changes of gas per hour measured at S.T.P.) may vary from 10 to 10,000 the upper limit being governed by the total sulphur content of the feed gases and the means provided for removing the exermothermic heat of reaction in order to maintain the reaction temperature relatively constant.
>
> Being completely automatic in operation, the 'Ferralyst' plant is expected to operate at the cost of depreciation plus general maintenance and supervision, less the value of the sulphur and steam (6,000 lb. per ton of sulphur) recovered. Where sufficient sulphur is contained in the gas, the plant will desulphurise the gas at a corresponding profit.
>
> A plant 10 ft. high, 3 ft. wide and containing fifty-two 2 in. tubes, can desulphurise 100,000 cu. ft. of gas per hour. The reactor is made of ordinary boiler steel. If gases of low sulphur, say less than 36.9 grains/100 cu. ft. content have to be treated, heat must be supplied to maintain reaction temperature, and the catalyst is placed in a hollow reactor in one mass and heated preferably by means of closed steam coils situated in the fixed bed automatically controlled from the bed."

The process was applied to a paper industry to convert the sulphides in the digester and evaporator gases into elemental sulphur or SO_2. These gases had a sulphur content which varied from 5.43 per cent by volume, and the process effected a 98-99.99 per cent recovery of this sulphur either as elemental sulphur or SO_2, as

desired. Tests on a pilot-commercial scale, successfully treating all gases from a 150 ton-per-day mill, were conducted over a period of one year.

A series of pilot plant operations have been conducted in Australia and the United States on the desulphurizing of furnace atmospheres in the bright annealing of metals; on city gas; on coke-oven gas; on recovering the sulphur in pulp mill digester fumes; on waste gases from smelters; ore roasters, etc.; on oil refinery gases; and on natural gases. It is expected the first commercial plant using this process in the United States will be in operation early in 1952.

X. CONCLUSION

The most important world source of sulphur, at present, is the salt-dome deposits of the Gulf Coast region in the United States. Next in importance is pyrites - the all inclusive name for metallic sulphides which are found in practically every country. The remaining world sources are brimstone deposits not of salt-dome origin; hydrogen sulphide in sour natural gas and in oil refinery gas; sulphur dioxide in stack gases at base metal smelters; and sulphate minerals such as gypsum and anhydrite.

The problem of increasing domestic supplies in Canada is limited to the utilization of sulphur compounds for conversion into brimstone, liquid sulphur dioxide and sulphuric acid. Since practical processes exist for these conversions and since Canada has large resources of sulphur compounds, the problem resolves itself around economics and the availability of markets for the end-products.

The largest consumer of sulphur in Canada is the pulp and paper industry. It needs sulphur in a form which can be used in producing sulphur dioxide for its sulphite plants. With the exception of one mill which burns by-product pyrite, the needs of the industry are imported as brimstone from the United States. Capital costs of pyrite-burning plants are estimated to be three times those of sulphur-burning plants. Furthermore, elemental sulphur is preferred because of the convenience of handling, storage, disposal of waste and quality of the finished product. Due to the uncertainty of future supplies of brimstone, several pulp and paper companies in Canada are considering burning pyrite rather than brimstone as a source of sulphur dioxide gas.

The current contract price paid to producers of pyrite concentrate does not justify opening up long-dormant properties for the production of pyrite grading 48 per cent, or better, sulphur. A price of at least 10 to 12 cents per short ton unit of sulphur, f.o.b. mine, would be necessary to induce mining companies to

'go after' pyrite. Such a price, assured for a period of years, would result in greatly expanded pyrite mining and recovery processes.

Recovery of sulphur dioxide, as a liquid, by Canadian Industries Limited from stack gases at Copper Cliff will alleviate the sulphur problem of some pulp and paper mills. The production - about 45,000 tons equivalent sulphur - would supply about 15% of the total requirements of the industry. It will not be available until late 1952. Freight haulage distance will always be a limiting factor in the use of liquid sulphur dioxide by the pulp and paper industry.

The process developed by Noranda Mines Limited for the recovery of elemental sulphur from a typical, finely ground pyrite flotation concentrate, is not yet committed to commercial plant operation. It is estimated that 18,000 tons of elemental sulphur might be produced annually from a 300-ton per day plant if commercial operations are undertaken. Only a third of the sulphur content of the pyrite is recoverable as elemental sulphur with the remainder recoverable as sulphuric acid. The other product of the process is high-grade iron oxide sinter. Ready markets for sulphuric acid and iron oxide sinter would be necessary for economic operation of the process.

The amount of sulphur recoverable from sour natural gas is regulated by its hydrogen sulphide content and the volume of gas cleaned. As stated before, it is not likely that production from this source would reach even 50,000 tons of elemental sulphur annually, for several years.

Recovery of sulphur from oil refinery, coke-oven and other industrial gases is not likely, if ever, to enter very widely into the Canadian sulphur picture. Recovery of sulphuric acid and Portland cement from anhydrite or gypsum deposits in Canada appears to lie at some future date. Finally, the huge potential of sulphur which exists in the bituminous sands of Alberta will only be exploitable should oil extraction plants and refineries start operating.

No single, quick solution presents itself but rather a variety of programs will each contribute to the solution of the Canadian sulphur supply situation in years to come.

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The American Chemical Society during its annual meeting held at Houston, Texas, from March 26-30, held a symposium on "A Half Century of the American Sulphur Industry" during which the following papers were presented:-

1. Albert E. Marshall, "History of Sulfur and the Accomplishments of Herman Frasch."

2. E.R. Weidlein, "The Men Who Developed the Modern American Sulfur Industry."

*3. Will H. Shearon & J.H. Pollard, "Modern Sulfur Mining."

*4. James M. Todd, "Necessary Considerations for Frasch Process Mining in Gulf Offshore Operations."

*5. W.T. Lundy, "Known and Potential Sulfur Resources of the World."

*6. R.H. Espach, "Hydrogen Sulfide Scurces in Wyoming."

7. W.A. Cunningham, "Hydrogen Sulfide Reserves in the Permian Basin of West Texas and New Mexico."

*8. A.E. Sands and L.D. Schmidt, "The Recovery of Sulfur from Synthesis Gas."

*9. Morris Katz and R.J. Cole, "Recovery of Sulfur Compounds from Atmospheric Contaminants."

*10. E.P. Fleming and T.C. Fitt, "Production of Liquid Sulfur Dioxide from Lead Sinter Plant Gas by Use of Dimethylaniline."

*11. E.P. Fleming and T.C. Fitt, "Production of High Purity Sulfur from Copper Roaster and Converter Gas by Reduction of Sulfur Dioxide with Natural Gas."

*12. Robert M. Reed and Norman C. Updegraff, "Processes for Removal of Hydrogen Sulfide from Industrial Gases."

13. Howard Kehde and E.H. Chapin, "Removal of Sulfur Compounds from Gas Streams by Hypersorption."

*14. R.A. King. "The Economic Utilization of Sulfur Dioxide from Metallurgical Gases at Trail, B.C."

15. T.R. Harney and O.J. Weinkauff, "Review of Fifty Years of Contact Acid Plant Development."

*16. Edward M. Jones, "Review of the Developments in the Chamber Process Manufacture of Sulfuric Acid."

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*18. Alfred Lippman, Jr., "Improvements in the Rotary Sulfur Burner."

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