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A SUMMARY REPORT ON THE GEOLOGY AND MINING DEVELOPMENT

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Énergie et Ressources
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Québec 

THE MINING INDUSTRY

in

CHIBOUGAMAU

A Summary Report

on the

GEOLOGY & MINING DEVELOPMENT

of the

CHIBOUGAMAU, QUEBEC, MINING DISTRICT

Prepared for the Chibougamau Branch, CIMM

by personnel of the

Producing Mines and of the

Quebec Department of Natural Resources

Chibougamau

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GEOLOGY & MINING DEVELOPMENT

CHIBOUGAMAU DISTRICT

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GEOLOGY & MINING DEVELOPMENT

CHIBOUGAMAU DISTRICT

INTRODUCTION

The Chibougamau District is now the largest copper producing area in Quebec and the second largest producing district in Canada, it being exceeded only by the Sudbury nickel-copper district of Ontario. As such, Chibougamau is now producing 38 per cent of Quebec's copper output or 13 per cent of Canada's total copper production. This production record has been achieved only eight years after the first mine went into production at the start of 1954.

Many persons concerned with the development of the mining industry in Chibougamau have felt that a summary report on the growth and present status of this district would be very useful for our own purposes and of interest to the mining industry in general. In answer to this need, the local branch of the Canadian Institute of Mining and Metallurgy has compiled the following report which treats of production and mining operations, general technical information and, briefly, of the economic and social development of our mining community. The proposed visit to our district of the National President of the C.I.M.M., Dr. J.B. Mawdsley, offered a timely occasion for the presentation of this report.

The Chibougamau Branch of the C.I.M.M. wishes to thank the mining companies of this district and the Quebec Department of Natural Resources for their help and cooperation in the preparation of this report.

HISTORICAL BACKGROUND

Interest in the mineral possibilities of the Chibougamau area dates back to the beginning of this century when Peter McKenzie and J. Kokko discovered occurrences of asbestos, gold and copper. By 1910, this wave of interest, and requests for a road and railroad, prompted the Quebec Government to seek an authoritative opinion concerning the possibilities of the area. A "Chibougamau Commission" was appointed to carry out the investigation and it concluded that none of the mineral occurrences then known were of economic interest.

However, by the late 1920's, the area witnessed a renewal of interest which resulted in the discovery of additional mineral occurrences and also the underground testing of the Cedar Bay showing by the Consolidated Mining and Smelting Co. in 1934, the Opemiska Copper Mines property in 1936 and the Obalski Ltd. property in 1939 and 1945.

The main period of development followed the completion of the Mines Department road to the area in 1950. Campbell Chibougamau Mines diamond-drilled their lake holding in 1950-51, commenced shaft sinking late in 1951 and started production in 1955 upon the arrival of hydro-electric power to the area. Opemiska Copper Mines resumed work in 1951 and started production early in 1954. The discovery and evaluation of the Chibougamau Explorers Ltd. gold find in 1950-51 lead to production late in 1955. Merrill Island started shaft sinking in 1952 and went into production early in 1958. Copper Rand Chibougamau Mines started underground development in 1956 and became a producer at the beginning of 1960.

The C.N.R. branch line linking Chibougamau with the Val d'Or-Noranda area was completed in 1957. Prior to this, all concentrates were trucked to the lake St-John area and then shipped to Noranda by rail - as such, Chibougamau was unique for it was the first camp to prove that an area located in the interior could become an important copper producer without railway facilities.

GROWTH and STATUS OF THE MINERAL INDUSTRY IN CHIBOUGAMAU

Chibougamau is presently producing copper at a rate of 115 million pounds per year and the gross value of the production exceeds 37 million dollars annually. This production is gained from treating 181,000 tons of ore per month which requires the efforts of 2000 employees whose wages total over 3/4 of a million dollars monthly.

The two tables following this page contain various statistics concerning general mining operations and production for all the Chibougamau mines. Although these tables provide, in themselves, a good picture of the growth of the mineral industry in Chibougamau, the following notes are given so as to summarize, and to comment on, the contents of these tables.

STATISTICS ON MINING OPERATIONS IN THE CHIBOUGAMAU DISTRICT

MINES	Opemiska Copper Mines Ltd.	Campbell Chib. Mines Ltd.	Anacon Lead Mines Ltd.	Merrill Island Mng. Corp.	Copper Rand Chib. Mines	TOTALS:
Capital Expenditures \$	10,893,765	19,817,999	2,700,000	3,117,350	7,418,000	43,947,114
Pre-production and Deferred Development \$	6,603,700	20,536,589	3,200,000	2,820,000	13,737,000	46,897,289
Gross Value of Production \$	61,880,787	67,373,124	6,281,000	8,000,000	16,284,000	159,819,911
Total wages Paid \$	14,909,856	18,095,739	Approx. Total costs. 8,000,000	3,321,000	7,479,000	47,305,595
Total Value Equipment, Supplies Services \$	18,784,890			4,235,000		
Taxes Paid						
1) Federal	775,483	nil		nil	nil	775,483
2) Provincial	1,039,715	570,089		150,000		2,860,000
3) Municipal \$	436,054	396,509		85,000	167,140	>1,000,000
Total Drilling						
1) Surface	81,500	298,135	50,000		541,224	
2) Underground (feet)	411,200	797,022	95,000		259,842	
Total Tonnage Milled	2,920,700	4,400,010	625,867	637,210	1,150,000	9,733,787
Ore Reserves						
1) Proved	5,805,300	2,885,319		353,225	3,178,400	19,197,559
2) Probable (T)		6,651,315	324,000			
Present Monthly Tonnage	60,000	57,000		13,000	52,500	182,500
Present Monthly Wages \$	231,678	327,900	Closed since mid-1960	60,000	195,200	814,778
Present No. of Employees	560	750		155	497	1962
1) Fr. -Speaking	93%	83%		90%	90%	
2) Eng. -Speaking	7%	17%		10%	10%	
3) Married	77%	57%		80%	62%	

PRODUCTION OF CHIBOUGAMAU MINES

Year	Mine	Ore Treated (tons)	Copper (pounds)	Gold (ounces)
1954	Opemiska	134,879	14,047,210	6,260
1955	Opemiska	162,098	15,318,454	6,434
	Campbell ^x	632,810	34,872,905	54,483
1956	Opemiska	236,392	18,530,480	7,778
	Campbell	618,485	27,766,870	35,939
	Anacon	132,713	1,235,000	27,309
1957	Opemiska	240,422	17,110,530	7,684
	Campbell	591,944	22,966,581	30,668
	Anacon	170,668	1,882,000	38,056
1958	Opemiska	352,884	25,942,828	10,902
	Campbell	682,518	25,132,950	29,855
	Anacon	170,156	1,485,300	35,223
	Merrill ^x	77,875	2,746,472	432
1959	Opemiska	443,444	28,544,531	13,077
	Campbell	735,637	32,273,394	38,377
	Anacon	98,108	779,000	17,955
	Merrill	149,850	7,357,729	1,218
1960	Opemiska	751,453	43,433,983	17,812
	Campbell	796,637	37,487,176	34,415
	Anacon	114,223	764,000	19,043
	Merrill	157,220	6,486,000	1,182
	Copper Rand	550,568	27,745,308	18,297
1961	Opemiska	599,015	32,525,141	14,294
	July-Dec/61-Campbell	341,979	14,496,585	11,262
	July 60-Dec/61-Merrill	252,265	11,082,799	2,268
	Copper Rand	600,000	28,000,000	30,000
TOTAL:-		9,733,787	480,013,226	510,223

Gross Value \$159,818,911
(with silver)

Average grade 2.5% Cu 0.052 oz/Au/ton

Value per ton.....\$16.40

x The Campbell and Merrill figures are totals for their July 1 to June 30 financial year.

The total production to date is valued at 160 million-dollars, gained from treating over 9.7 million tons of ore. To achieve this total production, as well as the present ability to produce 37 million dollars of mineral wealth yearly, has required the investment of 44 million dollars in capital expenditures and 47 million dollars in pre-production and deferred development charges, or a total of some 90 million dollars.

The present 2000 employees of the mining industry earn an average of \$400 per month and total wages paid to date exceed 47 million dollars. These expenditures have been of prime importance in the development of this new district whose population presently totals some 9000 people.

The amount paid to date in direct taxes totals over 3.5 million dollars. It must be remembered, in this respect, that the 160 million dollars of new wealth produced by the Chibougamau mines has itself been a large source of tax revenue, for this gross amount has been disbursed in salaries, supplies, equipment and other, all of which are taxable in their own right.

A different note of progress is seen in the rate at which new mineable deposits have been found. An average of one deposit per year has been disclosed since the opening of the road in 1950, at which time no mineable deposits were fully indicated. Thus, within a period of eleven years, eleven deposits are being, or have been, mined.

Thus the progress of the mining industry in Chibougamau can, in the final analysis, be judged by the mounting productivity of the area, whereby a large amount of new wealth is being created, and also by the fact that it has given birth to, and is maintaining, an active and progressive mining community of some 9000 people.

A SURVEY OF MINING METHODS AND MILLING

IN CHIBOUGAMAU

Campbell Chibougamau Mines Ltd.

The original mining and milling plant was set up on Merrill Island at what is now known as the Main Mine Division. In later years the Cedar Bay, the Kokko Creek and the Henderson Divisions have been brought into production.

The Main Mine ore body has been mined to a depth of 1900 feet using standard sub-level, shrinkage and cut and fill methods. The largest amount of mining has been done by cut and fill methods initially using gravel back-fill, which was later replaced by hydraulic back-fill. The hydraulic back-fill, from which fine particles and sulphides have been removed, is delivered by gravity directly from the mill. The reduced mining cost, improved recovery and ground support resulting from the use of hydraulic fill proved to be so important that other mining methods are being largely discarded.

The Main Mine is presently being developed, through an internal shaft, to a depth of 3,800 feet. This is the greatest depth yet reached in the Chibougamau area. Conditions indicate that cut and fill mining methods will be the most suitable for this deep zone.

The Kokko Creek Division is located 4,400 feet across Doré Lake from the Main Mine. The two divisions are connected underground on the 400 foot level. The Division is serviced from the Main Mine and the ore is trammed underground to the Main Mine. In addition, there is a two-compartment shaft at Kokko Creek to service the four levels. Considering the problem of pumping hydraulic fill across on the 400 level and up into the stopes rendered it advisable, in view of the excellent ground conditions, to use shrinkage stope methods at the Kokko Creek mine.

The Cedar Bay Division, located on Doré Lake five miles by road from the Main Mine, has a separate mining plant with its own shops and service facilities. Ore from this division is trucked to the Main Mine mill and filtered hydraulic back-fill is taken back on the return trips of the trucks.

Initially, shrinkage stope methods were used exclusively at Cedar Bay. However, with the development of methods to filter, transport and repulp the hydraulic back-fill, it became possible to distribute this fill underground at Cedar Bay. The advantages of cut and fill mining could then be realized and the mine is being converted more and more to this method of mining. Plans are being made to deepen the shaft and continue mining below the present deepest working.

The Henderson Division has a complete mining plant and the ore and back-fill trucking system and the back-fill distribution systems underground are similar to those developed for the Cedar Bay Division.

At the Henderson mine all the ore is located under Lake Chibougamau and at a distance of 12.5 miles from the Main Mine by road. To locate the shaft closer to the ore zones, it was necessary to build a land area out from the shore of Portage Island.

Normal development procedures were undertaken from this shaft and the decision was taken to mine all the ore by cut and fill methods, using hydraulic back-fill. Some sections of the ore are being mined by standard cut and fill procedure, but the major portion mined to date has been done by a method called "Mechanized Cut and Fill". This system involves a radical departure in the methods and equipment used. Diesel powered, rubber tired, loading and transporting equipment is used to move the broken ore into steel-lined millholes, which are widely spaced at 300 foot intervals. Hydraulically controlled, three machine, track mounted "Jumbos" are used in the drilling operations. This is a unique application for this type of equipment and the system has resulted in improved mining costs.

Copper Rand Chibougamau Mines Ltd.

Ore feed for the mill at the main Copper Rand property comes from three producing mines - Copper Rand, Jaculet and Portage. Milling started in December 1959, when the Copper Rand and Jaculet mines were brought into production. Production from Portage mine started in the latter part of 1960.

The original milling rate was 1,500 tons per calendar day and it has increased to the present rate of 1,750, with supply of ore proportioned as follows:

Copper Rand mine	1,000 tons
Jaculet mine	220 tons
Portage mine	<u>530 tons</u>
	1,750 tons

The main Copper Rand mine is located on the Gouin peninsula, between Doré and Chibougamau lakes, five miles east of the town of Chibougamau. Jaculet mine is on Doré lake two miles to the north and Portage mine is on Chibougamau lake five miles to the northeast of Copper Rand mine. Ore is trucked from Jaculet and Portage to the Copper Rand mill.

The Copper Rand mine is equipped with a complete surface plant, at which major repair work and warehousing is done for all mines.

A total of six shafts has been sunk, the deepest of which is the circular, concrete-lined main production shaft at Copper Rand mine which extends to a depth of 2,130 feet. The lowest production level at Jaculet mine is the 600-foot and at Portage the 700-foot level. Shaft compartments and all mine equipment are standardized so that equipment can be moved from mine to mine.

The ore generally occurs in sheared and altered anorthosite. Dip of the ore bodies varies from 45° to vertical and they vary in width from a few feet to over 100 feet. Mining methods at the three mines are either conventional cut-and-fill or shrinkage, and hydraulically placed, classified mill tailings is used for back-fill at Copper Rand and Portage. The crushing plant, installed in the mill building, handles the ore from all mines.

Merrill Island Mining Corp.

Excepting one shrinkage stope, all mining at Merrill is done by standard flat-back cut and fill stoping. This method was originally chosen so as to obtain 100 per cent extraction from ore occurrences that are irregular, especially the "B" zone with its numerous flats extending into the hanging wall. Both the ore and adjoining anorthosite and dykes are strong and require only occasional rock-bolting.

In mining upward through levels, all the ore was extracted and a timbered drift was established on the fill.

The fill consists of deslimed tailings. Stoping is carried out on eight-foot lifts and scraping is done with Pinkrose electric slushers. Tramping is carried on by one-man crews, each using 1½ ton battery locomotives and three 60 cu. ft. Granby type cars.

Extensive use has been made of tailings cement in the flooring of stopes, a method pioneered by Merrill in the Chibougamau area. In this technique the tailings fill is poured and levelled to some 4 inches below the final level. For the flooring, a measured quantity of fill is mixed in the mill with a measured amount of cement slurry so as to produce a 5 : 1 mix which is pumped underground and distributed in the stope with standard bull hoses. This quickly hardens into a rugged flooring which is quicker to install, cheaper and more satisfactory than wood. It may be blasted on one hour after having been poured and scrapping can be carried out after two or three days with no ill effects.

Opemiska Copper Mines (Que.) Ltd.

The property of Opemiska Copper Mines (Quebec) Limited is in Levy Township, Chibougamau district, and is about thirty miles west of the town of Chibougamau on the railroad from Senneterre to Chibougamau.

The mine has three operating shafts, - known as Springer #1, which is 2240 feet deep; Springer #2, at 2400 feet in depth, and the Perry shaft that is 2000 feet deep.

Springer #2 is the production shaft and is equipped with a modern friction hoist.

Springer #1 is the service shaft. The Perry shaft is about 3,000 feet East of Springer #1, and was put down to develop and service the Perry ore body.

The 2000-foot or 13th level is the deepest level developed at this time.

The underground crusher is located on the 2150-foot or 14th level.

Three methods of stoping are used at Opemiska. The sub-level method of stoping is used in the wide ore zones and supplies 40% of the tonnage; shrinkage stoping produces 10%, and the balance of the production is from cut and fill stopes. The fill material used is mill tailings.

The production rate is 2,000 T.P.D. with a grade of 2.9% copper, .03 ounces gold and .40 ounces silver.

Milling in Chibougamau

The recovery of copper from the ores of the district is carried on at four mines, being Merrill Island Mining Corporation, Copper Rand Chibougamau Mines, Opemiska Copper Mines and Campbell Chibougamau Mines. Total capacity of the four concentrators involved is approximately 7,500 tons per day, with an annual production of 115,000,000 pounds of copper, 79,000 ounces of gold and 840,000 ounces of silver. The precious metals are recovered by flotation in a copper concentrate averaging about 25% copper which is shipped to Noranda for further processing. Recoveries of metals for the district are better than 95% for the copper, 80% for the gold and 75% for silver.

Primary crushing is done by jaw crushers underground or on surface, depending on circumstances. Secondary crushing circuits all employ Nordberg Cone Crushers of varying sizes with one concentrator using an open circuit system and the others operating in closed circuit. Three concentrators use only ball mills on a fine feed for grinding, whereas the fourth uses a rod mill and ball mill combination and a relatively coarse feed. The flotation process is standard, varying mainly in the equipment used.

The ore mineralization consists of chalcopyrite, pyrite and pyrrhotite; the amounts of the last two vary between very wide limits. Essentially, the precious metals are associated with the chalcopyrite but at two of the mines a large portion of the gold is associated with the pyrite as fine inclusions of gold in the pyrite crystals. This posed a special problem that was solved by floating a pyrite concentrate for regrinding in a small regrind mill. This mill is operated in closed circuit with a cyclone classifier operating at a relatively high pressure to take advantage of the high specific gravity of the gold. The gold is freed at a size considerably smaller than the remaining material and is very amenable to flotation. Gold content of the tailings averages about 0.006 to 0.008 ounces per ton.

Back-fill for ground support in the mines is produced at all the concentrators. Recovery of fill is between 40 and 50% of feed tonnage and percolation rates are set at about four inches per hour as a minimum requirement. All fill is deposited hydraulically direct from the mill or it is filtered and trucked to other mines where it is repulped and pumped to the required location underground.

Tailings are impounded in ponds of varying sizes and every effort is made to keep the effluent clean. This is quite a problem due to the fineness of material discarded and requires pumping of tailings across distances of up to 4,500 feet to the best area available.

GEOLOGIC PORTRAITS OF THE PRODUCING MINES

The Campbell Chibougamau Deposits

1) Main Mine at Merrill Island

History

A portion of the main Campbell Chibougamau - Merrill Island deposit was discovered in 1920 by a prospector named Blake. Subsequently, surface trenching by the Blake interests disclosed a mineralized shear zone 30 feet wide having a length of 250 feet. In the winter of 1928-29, Chibougamau Prospectors Ltd. put down ten diamond drill holes to test the northwestward extension of the main showing. These holes were drilled from the ice on lake claims which are presently held by Campbell Chibougamau Mines Ltd.

In 1934, Consolidated Chibougamau Goldfields Ltd. acquired the Chibougamau Prospectors holdings and the Northern Investment and Mining Co. bought out the Blake interests. More surface drilling was done in 1934-35-36.

In 1950, following the completion of the highway, the property held by Northern Investment and Mining Co. was acquired by Merrill Island Co. Almost simultaneously, on a share transfer basis, Campbell Chibougamau acquired title to the claims held by Consolidated Chibougamau Goldfields.

By mid-August 1950, a detailed diamond drilling program was initiated to explore the extension of the original Blake showing on Merrill Island. Forty thousand feet of drilling was done and magnetometer and drill hole resistivity surveys were run, with the result that one million tons of ore grading 3.56% copper and .15 Oz/Ton gold were blocked out to the 750-foot horizon.

The company secured a contract with the United States Government Defense Materials Procurement Agency, which agreed to purchase 63.2 million pounds of copper at prevailing prices, with a floor price of \$.245 per pound. Campbell Chibougamau rented a mill site from the adjacent Merrill Island Mining Co. and obtained a lease on that company's west ore body. Campbell agreed to mine a daily minimum of 425 tons from this property, and Merrill was guaranteed 50 per cent of the net profits from these operations. These transactions concluded, Campbell began underground operations with the collaring of a four-compartment shaft in November, 1951.

General Geology and Structure

The host rock in the immediate mine area is a highly altered feldspar-rich rock, containing 70-80% feldspar, called anorthosite. Regional alteration appears to have caused a breakdown of the feldspar to acid albite

and zoisite and the matrix is altered to chlorite and epidote. Where the original feldspar-rich habit is still apparent, the rock has been described as "tombstone" anorthosite.

Alteration associated with shearing has frequently obliterated the "tombstone" habit, leaving light-coloured ghost-like phenocrysts in a highly chloritized matrix. This change can be traced also to a reserve condition where the original light-coloured feldspars are completely obliterated by a dark chlorite and the original dark matrix changed to a light colour.

Dykes are a common feature throughout the anorthosite mass. They appear to be concentrated along the main shear zone area where they comprise approximately 30% of the rock in the area of the mine workings.

Dyke types identified to date include granite dykes, quartz feldspar porphyries, feldspar porphyry and diorite dykes and occur in widths of up to 40 feet. They strike subparallel to the shear with dips varying from 55 to 70° to the south and the north.

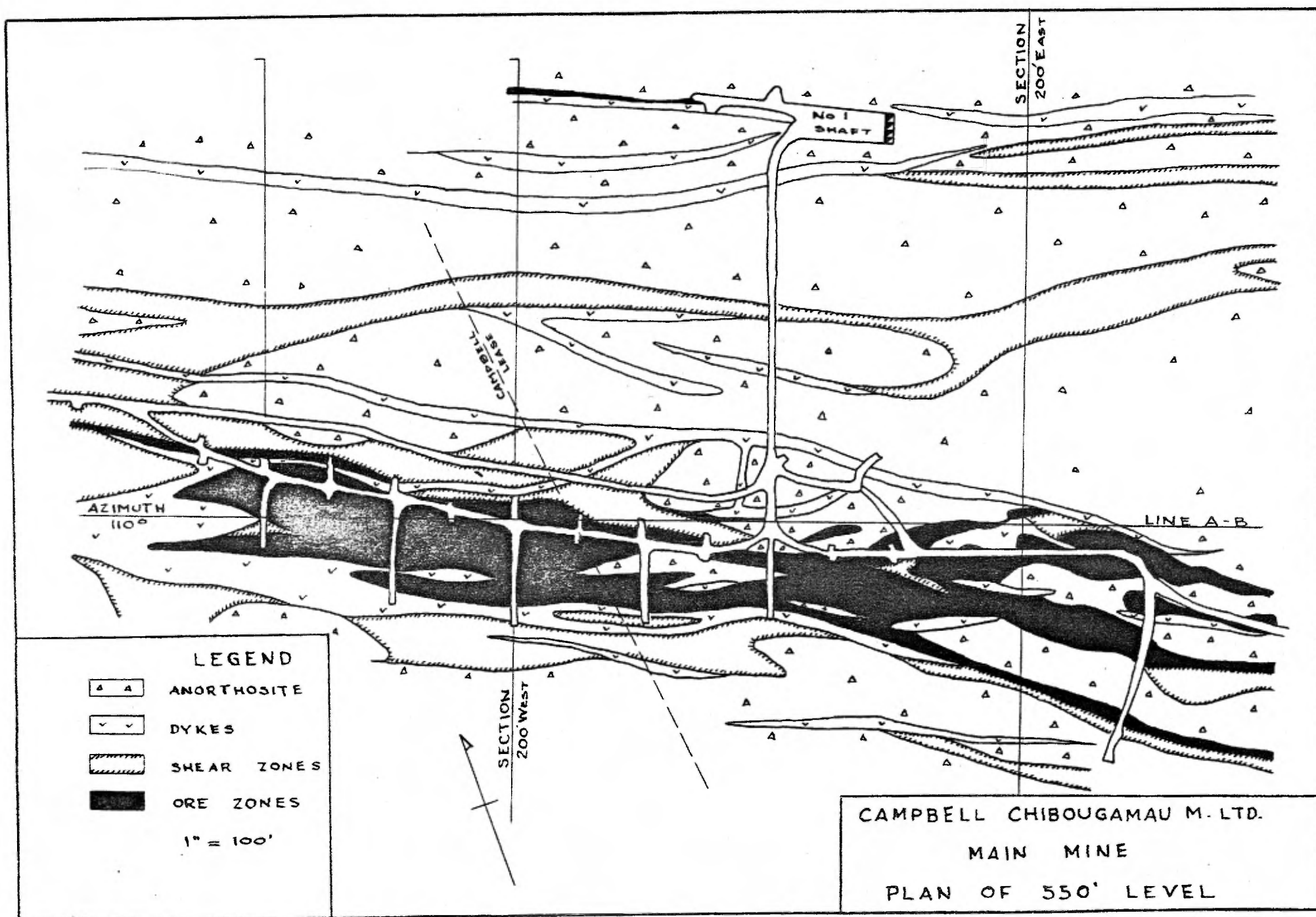
All dyke types are pre-final shearing and pre-ore. They appear to have played a considerable part in the ore localization.

Development above the 1900-foot level has been concentrated along a shear zone ranging in width from 10 to 150 feet. Values are not confined to this major sheared band, however, for a number of other mineralized minor shears have been indicated.

The average strike of the Campbell Chibougamau ore zones has been N 70° W with a tendency to a N 45° W strike showing up in current east and west developments. The zone has been detailed for a length of 900 feet having an average width of 36 feet to date.

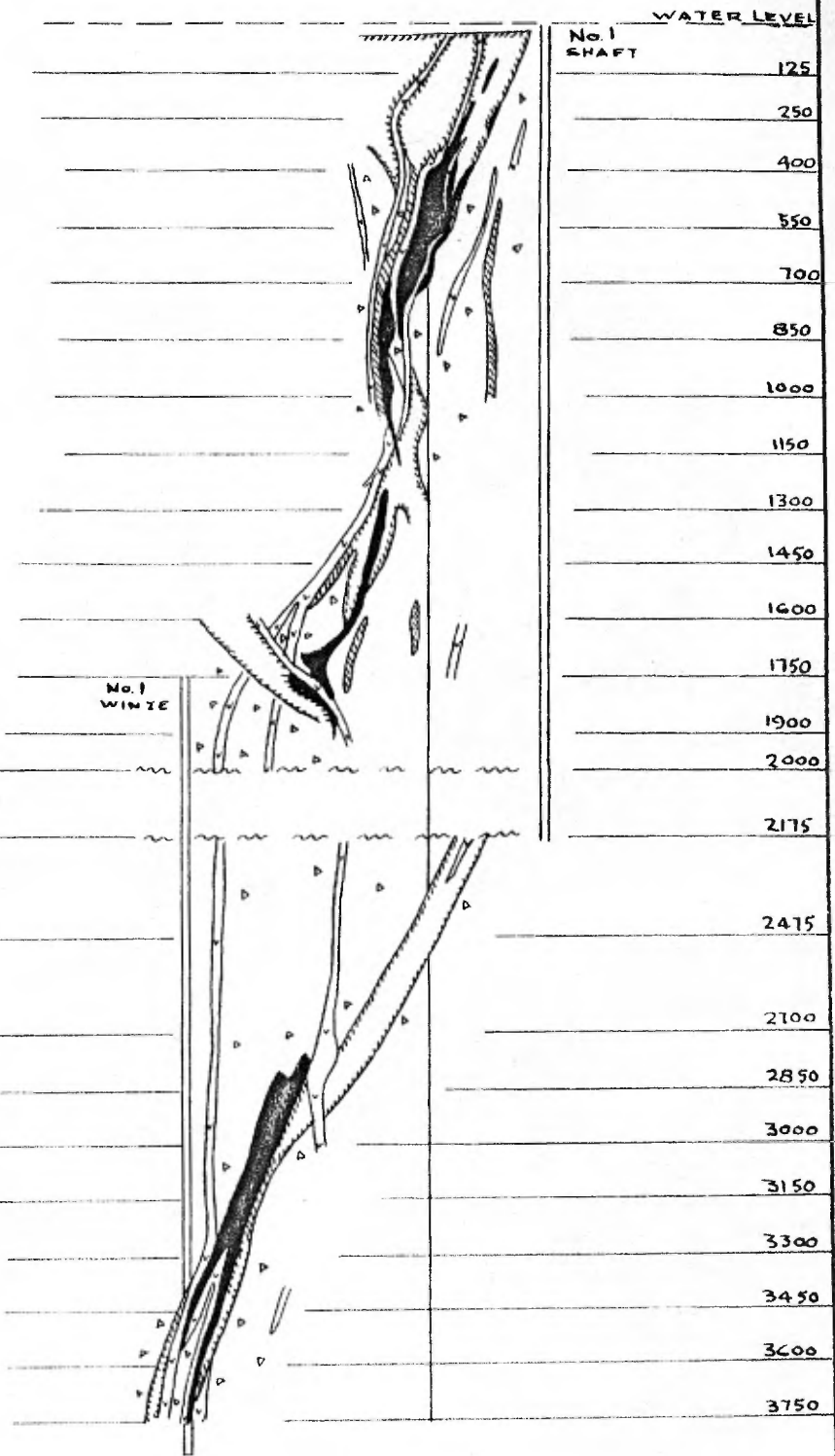
Dip changes are sudden and range from 60° south to 80° north with a net dip of 70° southward. The better values appear to be localized in areas where the shear strike is north 70° west and the dip approaches vertical.





Minor ore-bearing shears are observed in the hanging and the footwall of the main shear. Many of these are sub-parallel to the main shear but have north dips in the order of 65 - 75° north.



SECTION
400 W

SECTION
900 W



-  ANORTHOSITE
-  DYKES
-  SHEAR ZONES
-  ORE ZONES

1" = 500'

CAMPBELL CHIBOUGAMAU MINES LTD.

MAIN MINE

TYPICAL CROSS SECTION

LOOKING WEST

North to N 20° W shears with flat westerly dips are observed. These are early structures and are offset by the steep-dipping ore-bearing shears.

Mud seams and evidence of late movement are a rarity. The faults along the hanging and footwall of the ore are tight and not too apparent in development work. They show up clearly, however, by careful selective mining.

Mineralization

The main zone occurrence at the Campbell Chibougamau - Merrill Island property has a length of 900 feet and an average width of 36 feet. It is a sulphide replacement deposit of the copper-gold type.

The sulphide content is in the order of 50% with 33% pyrrhotite, 10% chalcopyrite, 5% pyrite, 2% sphalerite and a cobalt content of two pounds to the ton.

Gold accompanies the sulphide mineralization in the free state. It is extremely fine in grain size and is rarely seen. It appears to be concentrated in the western portion of the ore zone where the dyke habit is best developed. There appears to be no megascopic characteristics to facilitate the identification of gold rich ore.

The chalcopyrite occurs both as a coarse and fine mineralization. The pyrrhotite is only slightly magnetic and it is generally non-nickelferous. The spalerite is iron-rich and varies in colour from black to reddish brown. The sphalerite content in the ore varies considerably and is concentrated in the central portion of the zone.

Gangue minerals consist of irregular patches of quartz, chlorite, sericite, talc and a series of pink to grey carbonates. Crude rosettes of actinolite are quite common, particularly where the pyrrhotite content is high. Siderite is found in places but mainly in the upper portion of the workings.

The main ore body gradually decreased in size below the 1450-foot level and finally pinched out at the 2000-foot elevation.

However, another ore body was found below the 2700-foot elevation by deep drilling from the 1750 and

1900-foot levels. This new ore occurrence is similar to the main ore body except for a slightly lower copper content and it is presently being developed from an internal shaft and a series of levels at 150-foot intervals.

2) Kokko Creek Mine

History

The ore occurrence at Kokko Creek was one of the first to be found in Chibougamau. In 1906, John Kokko made the discovery of a mineralized showing along a small creek (now bearing his name) north of Merrill Island. Results of the original trenching were disappointing. However, in 1951, a series of surface drill holes completed by Merrill Island Mining Co., partially outlined the ore zone from surface. In 1952, the property was leased for 99 years by Campbell Chibougamau Mines Ltd. An additional 10,203 feet of surface drilling was done in 1956 to outline the ore zone to an average depth of 406 feet.

In 1958, it was decided to sink a 593-foot shaft and to develop the ore zone on four levels. At the same time, a long cross-cut was driven on the 400-foot level to connect the Kokko Creek mine with the main production shaft on Merrill Island.

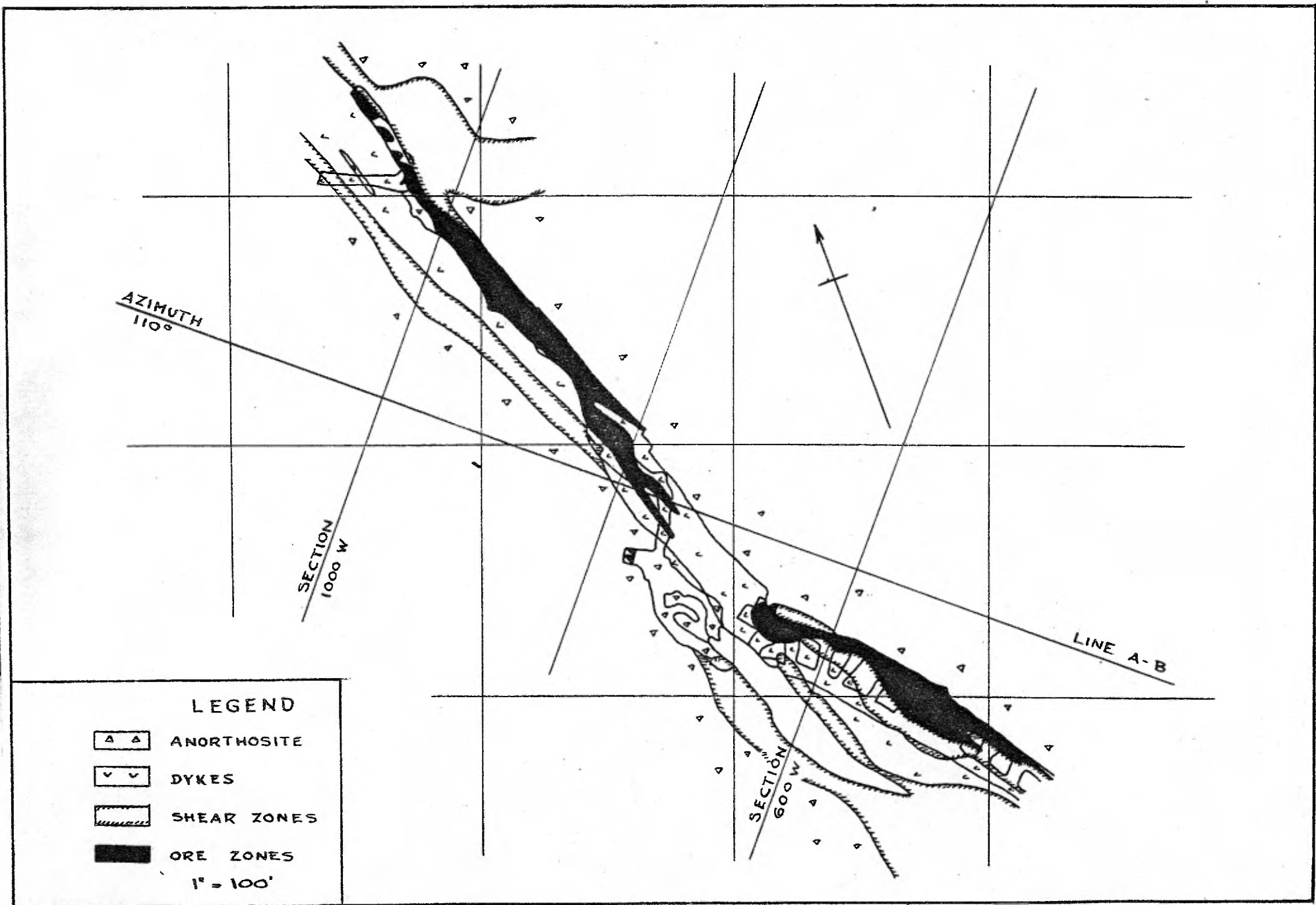
General Geology and Structure

The ore body at Kokko Creek occurs in the anorthosite of the Chibougamau intrusive complex. The anorthosite is found in various stages of alteration, and is similar in texture, composition and appearance to the anorthosite found at Merrill Island and Cedar Bay.





The ore is found in an altered and fractured zone that is generally in contact with massive quartz feldspar porphyry dykes which, in places, may attain as much as 40 feet in width. The ore zone strikes approximately N 45° W, and dips steeply to the north. Schistosity in the rock of the ore zone is not obvious. Strike faults and northeasterly cross-faults with mud seams are common. The dykes are pre-ore.

Mineralization

At the southeasterly limit of the ore zone, the predominant mineral is chalcopyrite with lesser amounts of pyrrhotite, pyrite, and quartz. At the northwesterly end of the ore zone, pyrrhotite and quartz are more abundant



LEGEND

	ANORTHOSITE
	DYKES
	SHEAR ZONES
	ORE ZONES

1" = 100'

KOKKO CREEK 240' LEVEL PLAN

whereas chalcopyrite occurs in lesser amounts. The silver content is about three times higher than the average for other mines in Chibougamau, but gold is only present in small quantities.

The ore zone appears to pinch out approximately 100 feet below the 560-foot level. However, the dyke structure persists and additional ore may be found at a greater depth.

3) Cedar Bay Mine

History

The Cedar Bay ore occurrence was discovered by Peter MacKenzie in 1922. Results of the first surface exploration were encouraging and, in 1934, Consolidated Chibougamau Goldfields Ltd. took control of the property. A shaft was sunk to 522 feet, and lateral development on the 250-foot and 500-foot levels totalled 4,732 feet. Insufficient ore was indicated at that time to justify production.

Campbell Chibougamau Mines Ltd. acquired the Cedar Bay property in 1950. More surface drilling was done in 1951, and in 1956 the old underground workings were de-watered. A thorough development program outlined sufficient ore to justify the sinking of a new shaft and production started in 1958.

General Geology and Structure

The ore bodies at Cedar Bay are found in the anorthosite of the Chibougamau intrusive complex.

The significant structures in the mine are east-west strike faults and northeast striking cross-faults. Minor faults and shears associated with these large structures are common and are often the loci of ore shoots.

The faults and shears are zones of weakness along which repeated movement took place and they have been divided into pre-ore and post-ore types, depending on the time of major movement. The pre-ore strike faults and shears contain ore shoots. The strike faults trend east-west and dip 60-70° south. The shear zones generally strike N 45° W and dip steeply to the south or the north.

A major cross-fault, striking northeast and dipping 35° northwest, offsets the dykes substantially but does not apparently offset the ore zone.

The post-ore faults are transverse faults which have a small strike slip. The offsets on the veins never exceed 10 feet.

Rock Types and Alteration

The most abundant rock in the mine area is the meta-anorthosite consisting of small to very large grains of sodic plagioclase, in various stages of alteration, with interstitial chlorite, quartz, or epidote.

The meta-anorthosite is cut by dykes, which at the time of intrusion were diorite porphyry and quartz diorite porphyry. The more severely metamorphosed equivalents of the dykes are called simply grey dykes and black dykes. The dykes strike in a general northwest direction and parallel the shears that contain the richest ore bodies. The dykes are pre-ore and, because of their competence, helped to maintain dilatational openings in which the ore was deposited.

A study of the alteration minerals has shown that it is possible to distinguish alteration zones which generally envelop ore shoots.

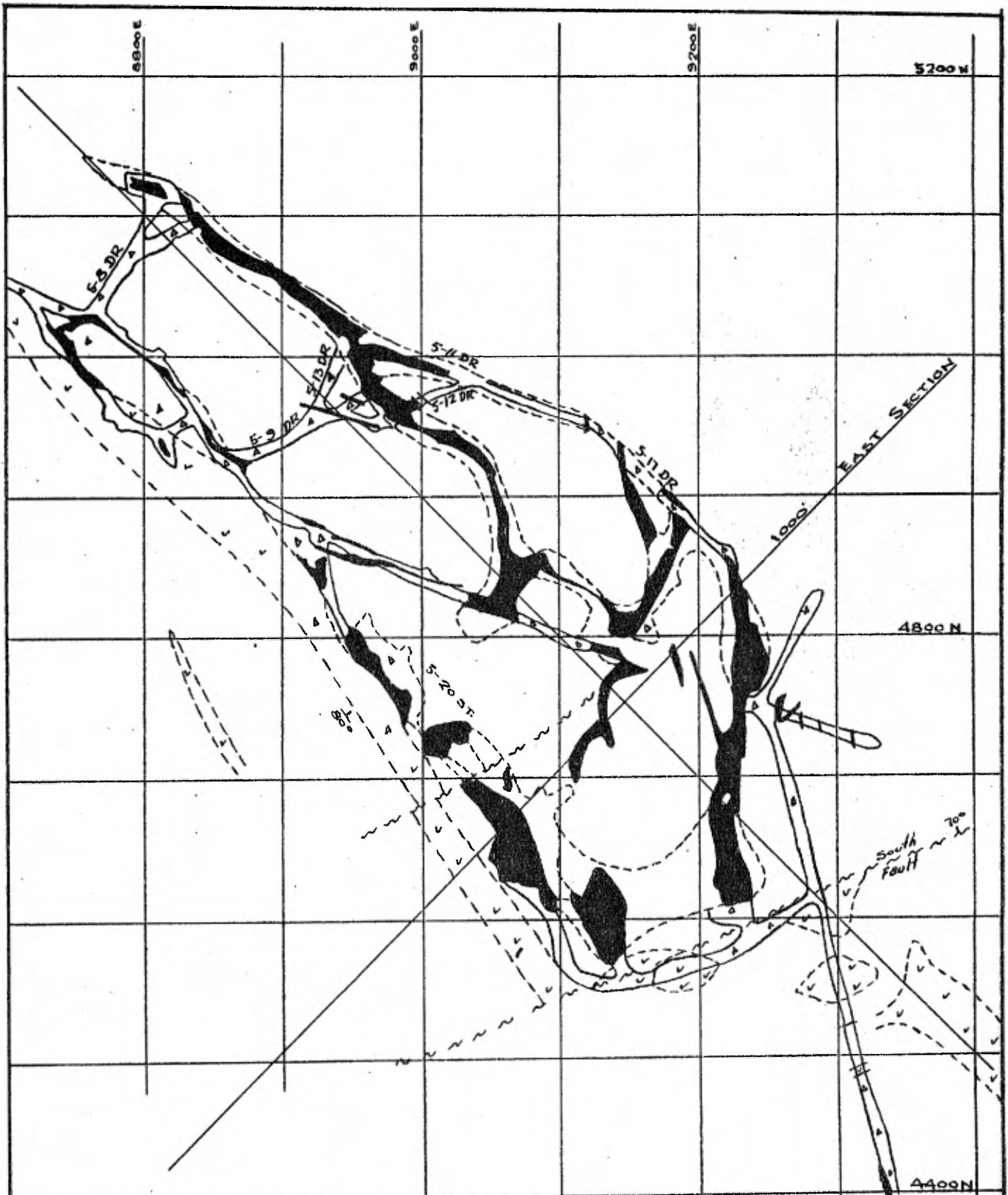
The minerals of the outer zones are metamorphic in origin and include sodic feldspar, clinozoisite, epidote, magnesium-rich chlorite and quartz. The inner zones, considered to be predominantly metasomatic, are composed of iron-rich chlorite, mica, muscovite, sericite, quartz, carbonate, apatite, actinolite and ore minerals.

The inner zone of metasomatic minerals is found only in the immediate vicinity of the veins and its use as an indicator in prospecting for new veins is limited.

Mineralization

The veins are definitely hydrothermal and may be classified into two main types:-

- a) East-west veins in which pyrite predominates over chalcopyrite; these contain gold, silver, and some sphalerite, arsenopyrite, and a cobalt mineral



△ ANORTHOSITE

v DYKES

□ ALTERATION

■ ORE ZONE

CAMPBELL CHIBOUGAMAU M. LTD.
 CEDAR BAY LEVEL 500
 GEOLOGY
 1" = 100'

LINE A-B

NORTH

SHAFT ELEV. 1231.5'

WATER LEVEL

BEDROCK

125' L

250' L


375' L

500' L

650' L

LEGEND.

 ANORTHOSITE

 DYKES

 ALTERATION

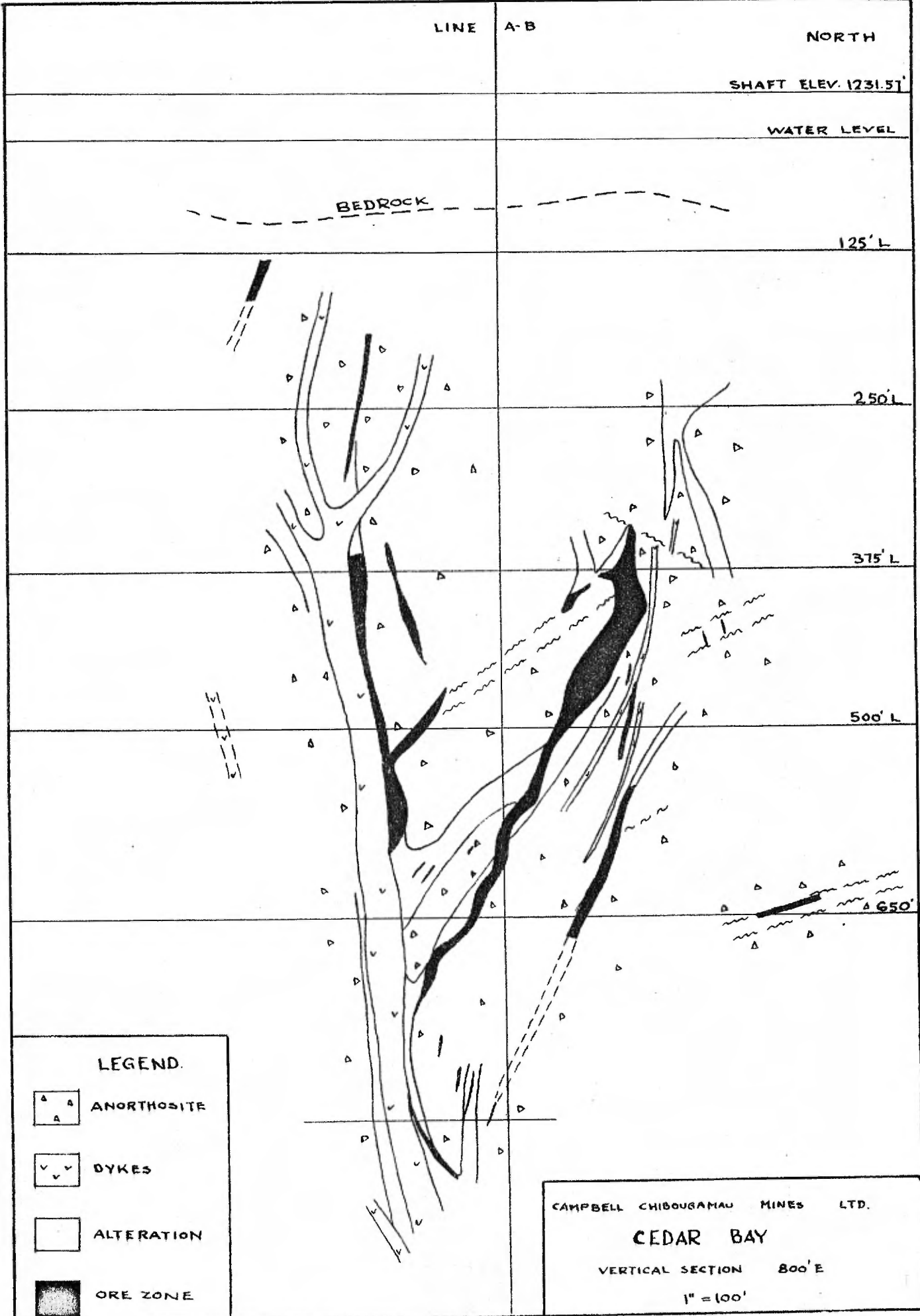
 ORE ZONE

CAMPBELL CHIBOUGAMAU MINES LTD.

CEDAR BAY

VERTICAL SECTION 800' E

1" = 100'



- b) Northwest and north-south veins which contain more chalcopyrite than pyrite; these have a lower gold content than the first type, contain only minor arsenopyrite and cobalt, but carry rare pyrrhotite.

The veins occurring in the northwest shears are lenticular and the thickest parts occur along the junction with the east-west veins.

The width and length of the veins is quite variable. Some of the veins are less than two feet wide and fifty feet long, whereas others are more than thirty feet wide at places, and have been followed for a length of nine hundred feet. The average width of the veins is ten feet.

All production to date has come from working places above the 800-foot level. It is now planned to sink the main shaft to at least 1600 feet, and possibly 2000 feet, in order to explore the ore possibilities at depth.

4) Henderson Mine

History

The Henderson ore bodies are located entirely under the waters of Chibougamau Lake. They were discovered in 1956 after ground electromagnetic follow up of airborne conductors indicated in a survey flown in 1955. During the years 1956 to 1959 approximately 133,600 feet of drilling was carried out on the ice of Chibougamau Lake along a strike length of just over one mile. This was followed by the construction of a causeway 600 feet out in the lake from which a shaft was sunk to an initial depth of 730 feet. Levels were established at 125, 275, 525 and 650 feet below the collar and mine production started in the summer of 1960 at the southwest end of the occurrence.

Geology and Structure

The ore bodies lie in the anorthosite member of the Chibougamau intrusive complex. The anorthosite has been more or less completely saussuritized and is termed meta-anorthosite. With the exception of a few dykes, this is the only rock type encountered in the mine. Unlike the other mines in the camp, dykes are structurally unimportant in ore control. One persistent pyroxenite dyke cuts across the mine area in a northwest direction and has been traced for over two miles.

The dominant structural control of the Henderson ore bodies is a strong northeasterly striking shear zone measuring 50 to 200 feet width and having a strike varying from N 20° E to N 45° E and an easterly dip of 25° to 45°. The magnitude of the movement along the shear is not known.

Two different types of ore shoots have been outlined. Both are hydrothermal replacements but quite different in character. The "B" and "G" ore bodies occur within the strong northeast shear whereas the "A" ore bodies occur in a broad fracture zone subsidiary to the shear zone.

1) The "A" Zone

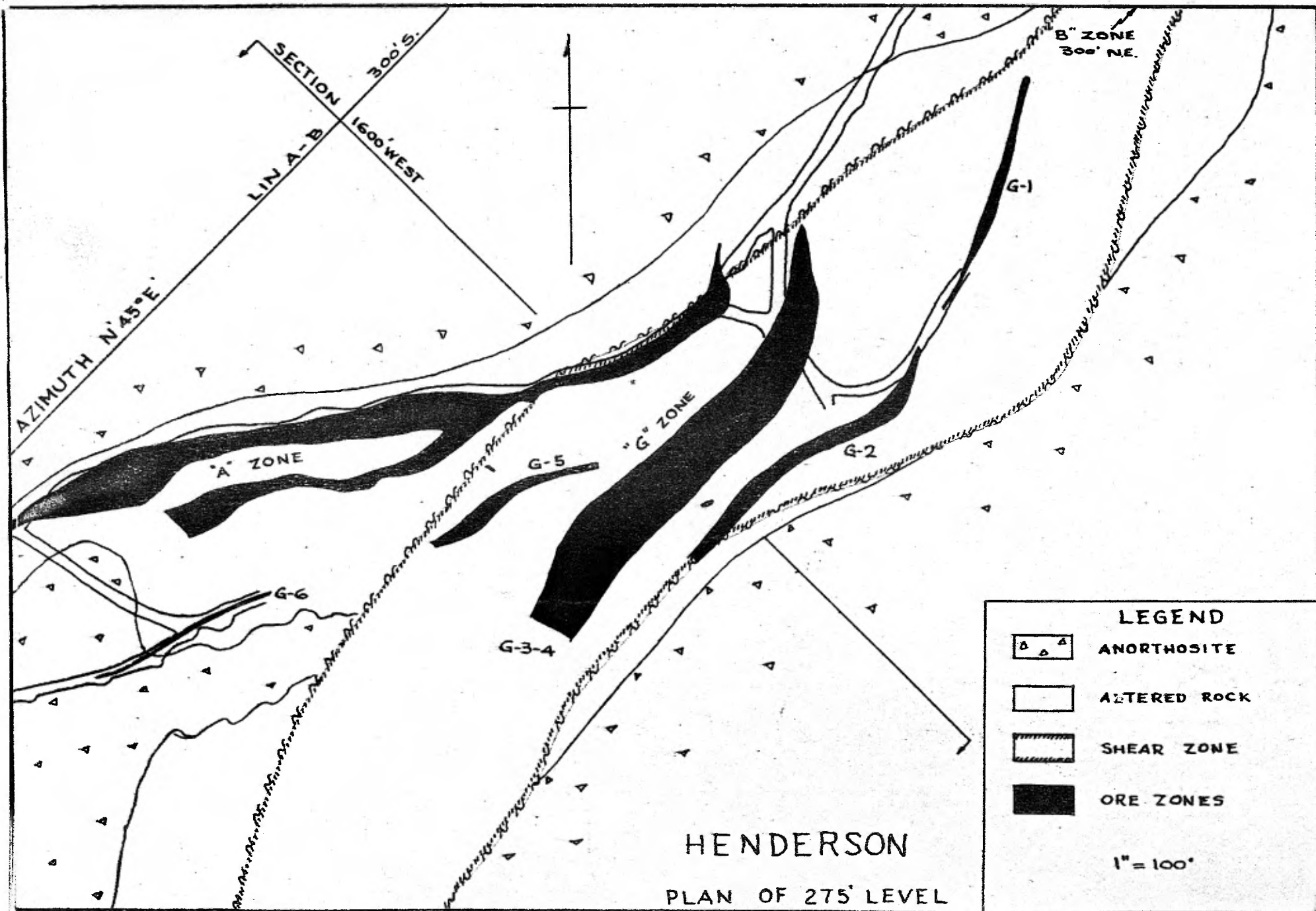
The "A" zone diverges from the strong northeast shear at a point where the shear rolls or changes strike from N 45° E to N 20° E. It is a fracture zone with an intense brecciation along the footwall that grades into weak shattering along the hanging wall. At lake bottom, the zone strikes N 70° E with dips 45° to 70° south and has a strike length of 1600 feet. At the west end it curves sharply southward where it is still untested. Just above the bottom level, the zone flattens to dips of from 5° to 45°. The change in dip occurs along a line plunging about 15° east.

Within the "A" zone there is one main ore body of massive sulphides measuring in excess of 20 feet in width; associated with it are several hanging wall zones of ore grade.





Alteration is most intense at the footwall of the zone and it extends for distances up to 200 feet into the hanging wall, but in the footwall it passes into meta-anorthosite within ten feet of the ore. The sequence of alteration going from hanging wall to footwall is as follows:

- meta-anorthosite
- sericite-carbonate alteration
- sericite-chlorite alteration
- chlorite-sericite alteration
- chlorite-actinolite alteration
- massive sulphides
- chlorite-sericite alteration
- sericite-carbonate alteration
- meta-anorthosite

In the chlorite-actinolite zone all evidence of an original anorthosite texture has disappeared and the rock is homogeneously dark green. In the other zones the original rock texture is discernible in varying degrees.



LEGEND

-  ANORTHOSITE
-  ALTERED ROCK
-  SHEAR ZONE
-  ORE ZONES

1" = 100'

HENDERSON
PLAN OF 275' LEVEL

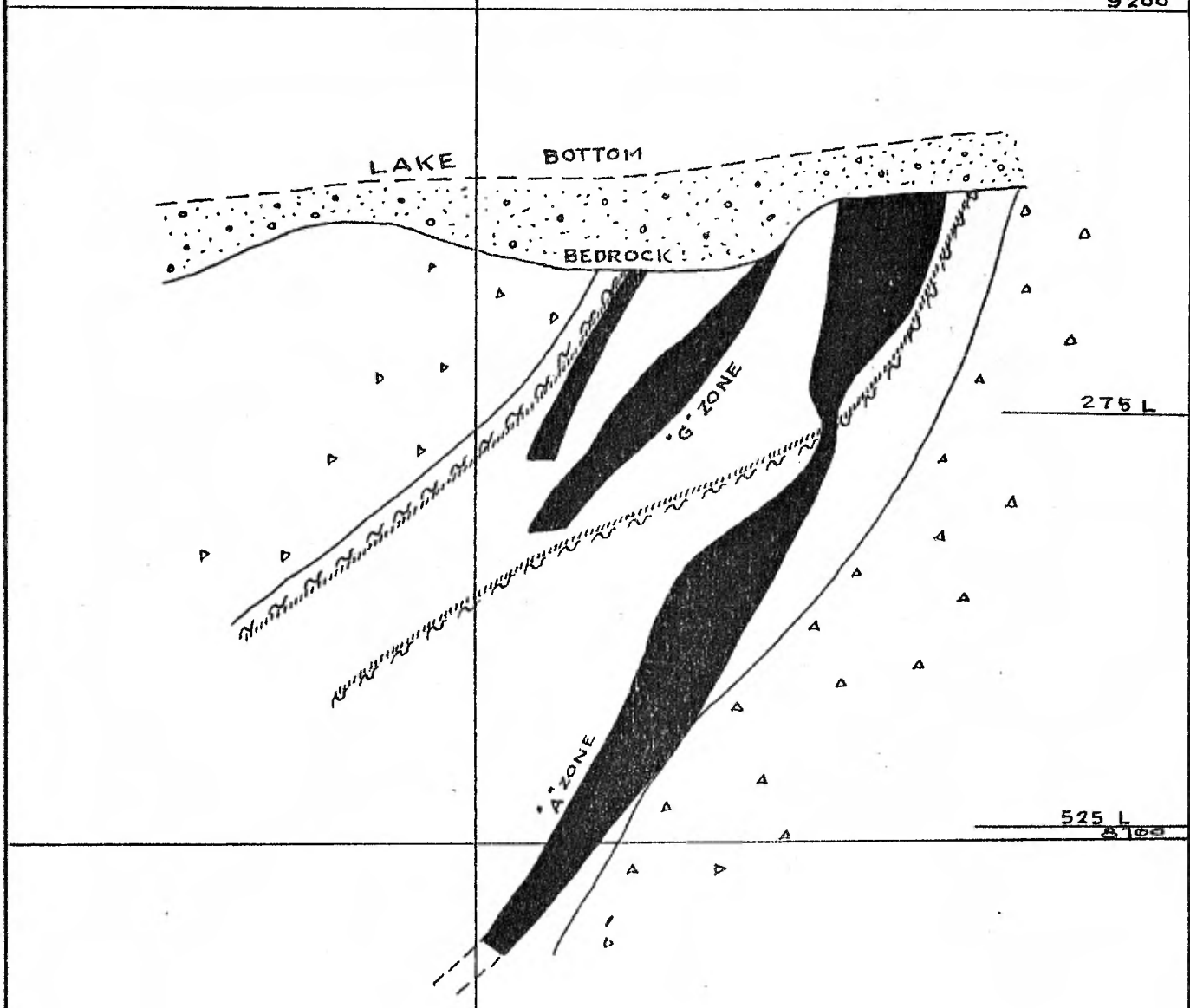
SOUTH

LINE A-B 800' SOUTH

NORTH

WATER ELEV. LAKE CHIBOUGAMAU

9200



LEGEND



ANORTHOSITE



ALTERED ROCK



SHEAR ZONE



ORE ZONES

HENDERSON

1" = 100'

VERTICAL X-SECTION

1600' WEST

2) The "G" and "B" Zones

The "G" and "B" ore bodies are massive replacements within the northeast shear zone. The "G" is located at the junction of the shear zone and the "A" zone; the "B" zone is found approximately 400 feet to the northeast along the same shear zone. Three distinct zones of alteration may be recognized symmetrically arranged with regard to the ore; an outer sericite-calcite zone, an intermediate black sericite-chlorite zone and an inner chlorite-chloritoid zone, each zone being gradational into the other. The core of the shear zone contains one or more quartz-ankerite veins which in places contains ore grade sulphides and magnetite.

Mineralization

The "A" and "G-B" zones differ in their mineralogy and metal content. In general the "A" zone is considered a copper zone while the "G-B" zones are copper-gold zones with appreciable cobalt.

1) "A" Zone

Chalcopyrite and pyrrhotite are the predominant metallic minerals and pyrite is fairly abundant. Relatively sparse associated minerals are pentlandite, sphalerite, cobaltite, siegenite, willyamite, magnetite, arsenopyrite and ilmenite. The chief gangue minerals are quartz, green chlorite, apatite, antinolite and calcite.

2) "G-B" Zones

Pyrite is the most abundant metallic mineral and contains gold, cobalt and nickel in appreciable amounts. This is followed by chalcopyrite and pyrrhotite, cobaltite and spotty magnetite. Ankerite is the most abundant gangue mineral. Several ages of quartz are present and also chlorite.

To-date most of the production has come from the "A" zone at the southwest end of the mine and above the 525 level. Development is underway on the southwest end of the "G" zones near the junction with the "A" zone and the main shear zone. Over half of the strike length explored from the surface has yet to be tested underground. Drives are now in progress on the 275 and 525 levels to open up the "B" zone in the northeast part of the mine.

The Merrill Island ore bodies lie along the same complex shear and dyke structure that contains the main Campbell Chibougamau deposit. Nodular-textured meta-anorthosite underlies all of the mine area, but a granite mass extends to within 2000 feet of the shaft area. The localization of ore is dependant on relations between dykes and shear or fault zones.

Dyke Characteristics

Acid and basic dykes are recognized. The acid dykes include quartz-feldspar porphyry, and rhyolite porphyry. Quartz-feldspar porphyry dykes are largest, some having widths of up to 400 feet. They are a similar rock to the main porphyritic granite mass that lies in the southeast part of the property, the main difference being a smaller grain size and an absence of mica. It is probable that they are, or once were, connected to the main granite mass. They are known to extend further to the southeast, towards the granite, at depth than they do in the upper horizon. The feldspar-porphyry and rhyolite porphyry dykes are smaller and probably are branches of the main quartz-feldspar-porphyry dykes, the textures and colouring depending on the rate of cooling and alteration during ore forming period.

These dykes were once thought to be all pre-ore in age. However, small horizontal dykes in the east end of the "B" zone cut across the ore and are not mineralized with chalcopyrite or pyrrhotite. Again, the flatly dipping branches of the "B" zone (see section) extend on either side of a feldspar porphyry dyke, yet no continuity of ore through the dyke has been found. It is possible that at least some of the dykes are post-ore.

The basic dykes are of two types, grey and diorite dykes. The grey dykes are usually irregular in form and often sheared and well mineralized and, under the proper conditions, are of ore grade. It is possible that the higher grade parts of the "A" zone are actually mineralized grey dykes. The deeper ore found at the 1,825 level also seems to be in a grey dyke, almost entirely replaced by quartz and sulfides.

The diorite dykes vary from a dark green, coarse grained rock with chilled contacts to fine grained, light grey types. The large diorite dyke, shown on the plan, is of the dark and coarse variety. It appears to be later than the quartz-feldspar-porphyry dykes because it is deflected on approaching the large northerly dyke; also small diorite

dykes are found to cut the large southern dyke. The fine grained diorite dykes are often flat lying, with dips of about 30° to the west. This is seen at the 925 level and above the 300 level where they are usually chloritized.

The general synclinal form of some ore shoots and dykes (see "B" zone in section) is probably the result of shearing having been deflected along flat-lying dyke structures and thereby creating openings for ore deposition. It may be significant that the two rolls in the most northerly dyke occur at horizons at which these flat-lying structures have been noted - i.e. above the 300 and at the 925 level.

Faulting and Shearing

Three directions of faulting are recognized on the property. One direction strikes $S 65^{\circ} E$ and parallels the direction of the main Merrill-Campbell shear. The best example of this faulting is shown on the plan; the north side of this structure moved east in relation to the south side. This fault structure is oblique to the ore shoots and passes through the "A" and "B" zones on the upper levels and through the "C" and "D" zones at depth. That this fault had some effect on ore deposition is shown by the fact that some ore shoots extend along this structure beyond the normal ore limits.

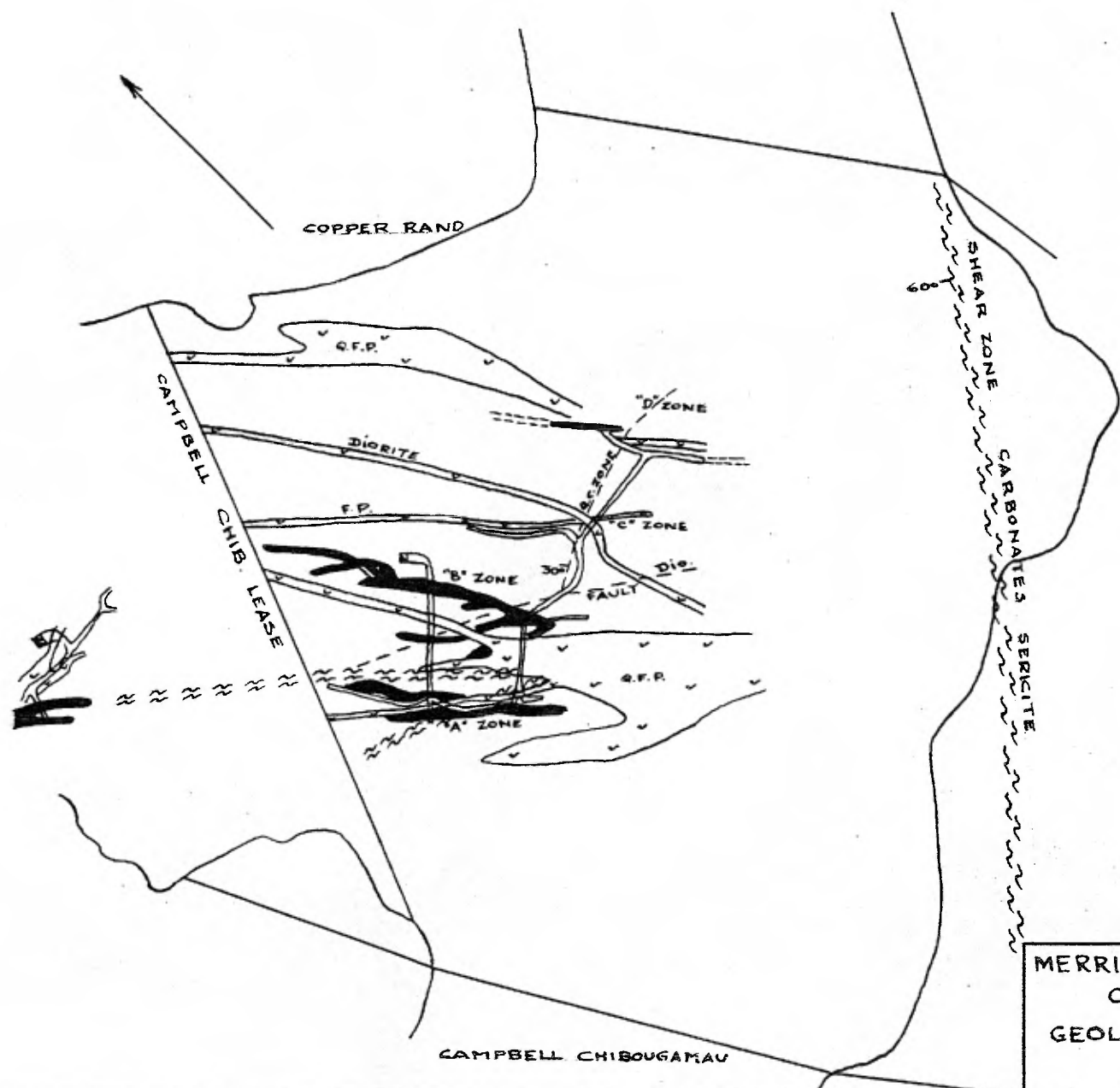
The second direction of faulting strikes nearly east-west and dips 30° to the northwest. The best known of these is the "Quartz Crumple Zone", a fault zone containing an altered and mineralized diorite dyke. Movements of from 5 to 30 feet are indicated along this structure, with the hanging wall having moved to the north.

The third direction of faulting is at right angles to the long axis of the ore bodies. They are vertical, calcite-bearing, and show movements of from 5 to 15 feet with east side up relative to the west.

All these structures are subject to forking and change of strike along their length, especially where contrasting rocks are present. The steep structures often change attitude suddenly for short distances along flat structures before resuming their normal attitude.

Ore Zones

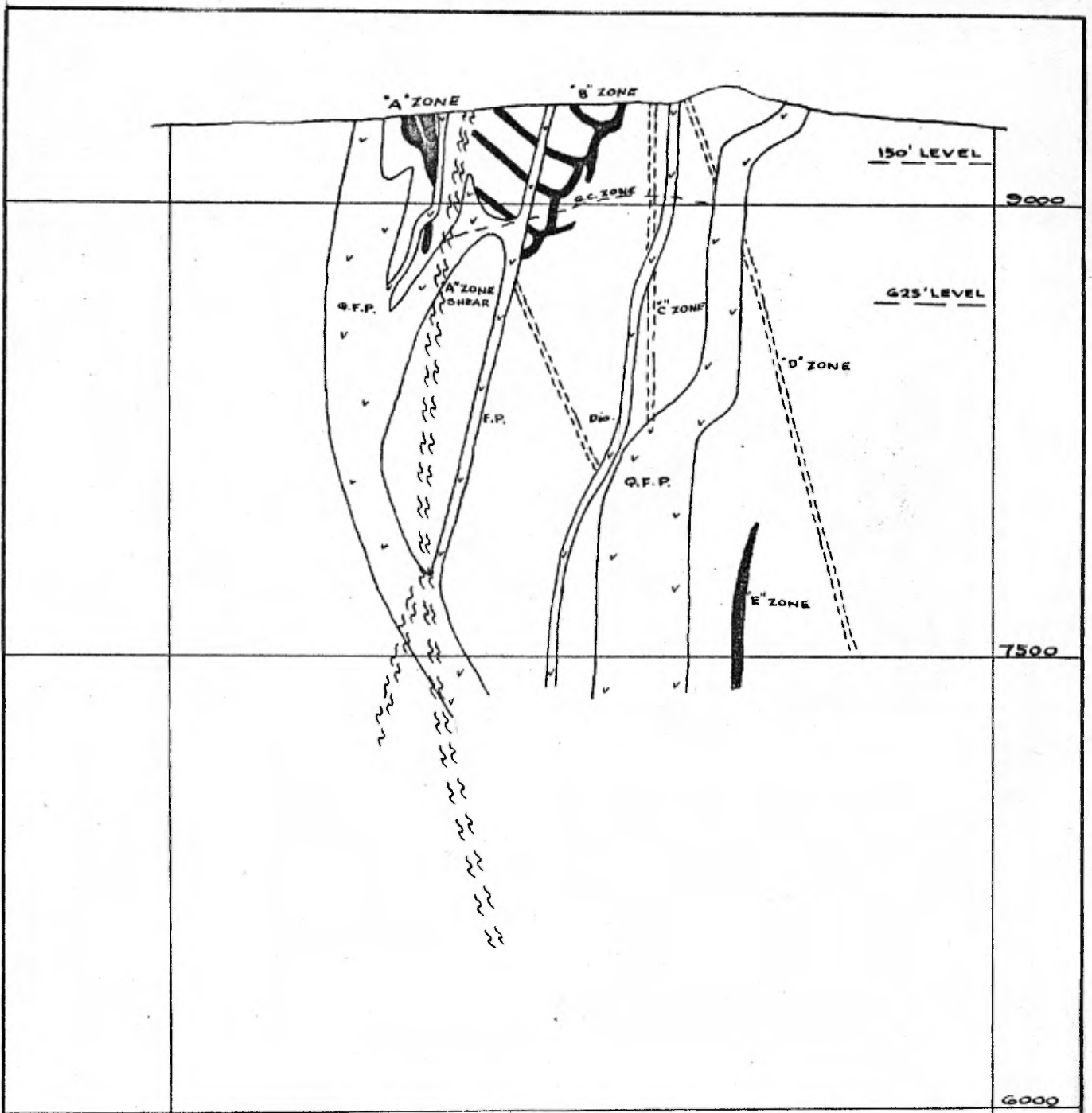
The "A" zone occurs at the junction of a feldspar



LEGEND


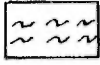


-  DYKE
-  SHEAR ZONE
-  SULFIDE ORE
-  FAULT

MERRILL ISLAND MINING CORP. LTD.
 CHIBOUGAMAU QUEBEC
 GEOLOGICAL PLAN 150' LEVEL
 1" = 500'



MERRILL ISLAND MINING CORP. LTD.
 CHIBOUGAMAU QUEBEC
 GENERALIZED CROSS SECTION
 1" = 500' 20-2-62

LEGEND

-  DYKE
-  SHEAR ZONE
-  SULFIDE ORE
-  FAULT

porphyry dyke and a shear zone within an embayment in a large mass of quartz-feldspar porphyry. The ore is composed of heavy sulfides, chlorite and quartz, with values extending, in places, into lightly chloritized anorthosite. The sulfides present, in order of abundance, are pyrrhotite, chalcopyrite and pyrite; occasional sphalerite is present. The copper content varies from 2.5 to 3.5 per cent.

The grade of ore increases to the east as the large dyke is approached. The northwest branch of this zone is of lower grade and consists of irregular and narrow, upright to flat stringers and veinlets, a characteristic of the "B" zone. Except for a small ore shoot above the 475 level, the "A" zone bottoms just above the 300 level; however, low values extend along the "A" shear zone to below the 925 level. The "B" zone is a more irregular and lower grade zone. It is characterized by steep sections followed by flat rolls - a north dipping ore shoot coincides with each flat roll. These shallow dipping shoots are found only between the "B" and "A" zones and they are narrow and discontinuous on the southwest side of the feldspar porphyry dyke.

As with the "A" zone, the grade and widths of the "B" ore increase towards the east. In general, the "B" zone is less altered and mineralized than the "A" and carries lower values (1.5 to 2.7 per cent) in copper.

The "C" and "D" ore shoots are located along feldspar porphyry dykes where shear zones meet dyke structures obliquely, that is at angles of from 10 to 20°. The "C" is usually well developed where it intersects a diorite dyke. The "D" ore nearly always occurs along the footwall side of the controlling dyke structure. Some of these ore shoots extend into the large quartz porphyry dyke that divides the "D" zone into an upper and lower segment.

The Copper Rand Deposits

1) Main Mine

The Copper Rand ore body lies in a wide shear and alteration zone, between 1,700 and 2,000 feet in width, striking N 30° W, straddling the Gouin Peninsula and crossing Eaton Bay. The contact to the south is sharp and distinct where the zone abuts against massive anorthosite; to the north, the contact tends to be transitional with a gradual decrease in intensity of alteration and shearing and an increase in basicity of the anorthosite. The north contact is described partly as basic anorthosite, and partly as gabbro.

A series of dykes, generally parallel to shearing, occurs over a width of 400 feet in the central part of the shear zone. The ore occurs within this zone on the flanks of the dykes.

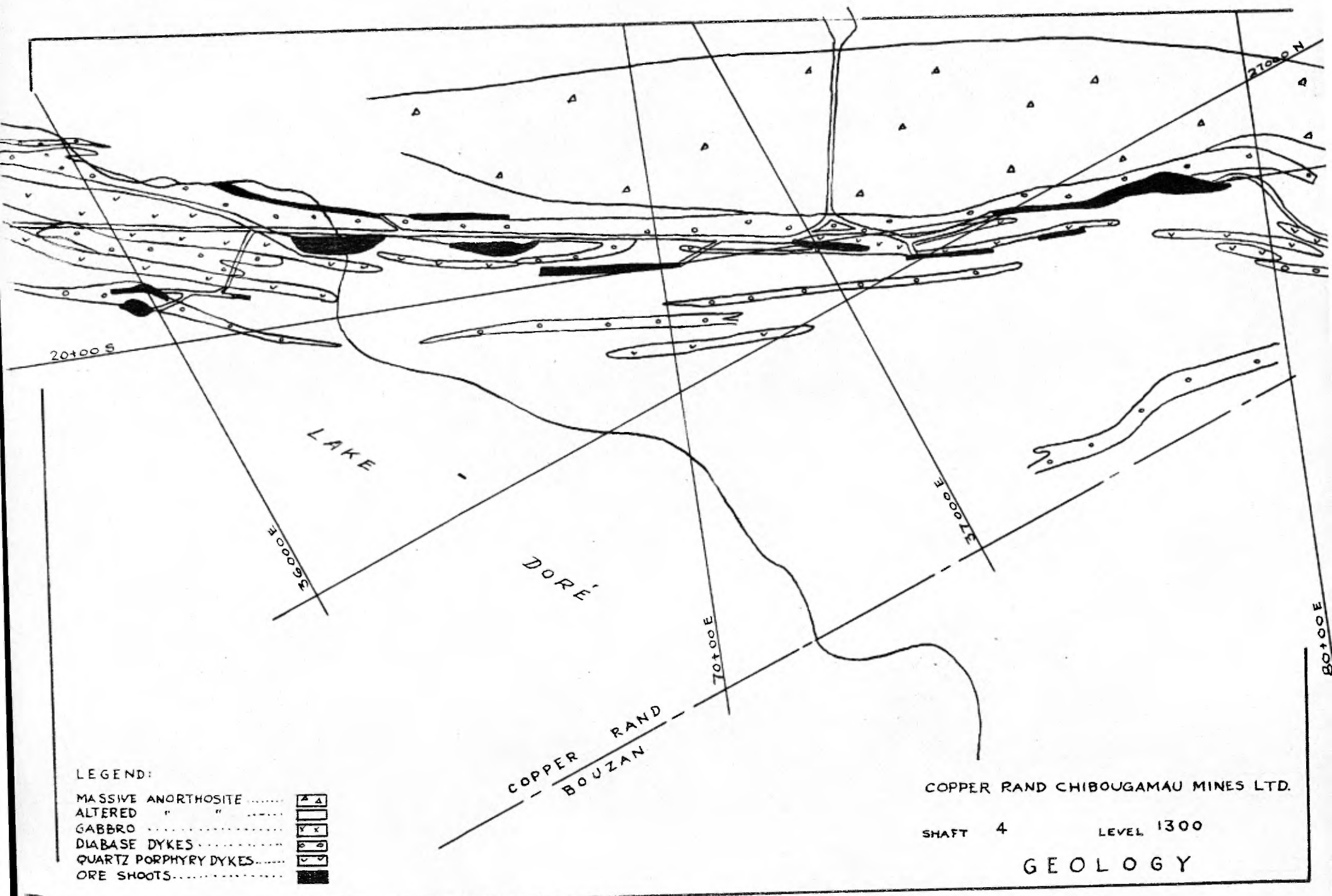
The alteration consists of a development of sericite, carbonate, chlorite and chloritoid and the complete breakdown or masking of the original rock texture. The most abundant alteration type is a sericite-carbonate facies producing a fine-grained, grey, featureless rock. The carbonate type is calcitic but increasing in iron content as the ore lenses are approached. A sericite-carbonate-chloritoid facies occurs in the vicinity of the dykes. The groundmass is again typically featureless but variable in colour from light grey to white with 1/10 inch phenocrysts of dark green chloritoid. Chlorite is confined to the proximity of the sulphide lenses; it first occurs as streaks in either of the previous alteration types and increases until at the margin of the ore it forms 90% of the mineral content.

Two main dyke types are known, both of which have been subject to alteration. The diabase dykes have all been carbonatized and often show pinpoints or 1/16 inch rhombs of carbonate set in the fine-grained matrix. Where the dyke forms a wall of an ore lens, chloritization is frequent, often masking the contact. The texture of these dykes remains distinct as opposed to the heterogeneity of the anorthositic schist.

The quartz porphyry dykes are highly deformed and altered, and are strongly foliated. Alteration in these dykes is mainly sericitic with occasional fine chloritoid. Quartz eyes are abundant in some sections but elsewhere are absent, probably due to interaction with carbonate.

The ore at the mine consists of chalcopyrite, pyrite and magnetite; chalcopyrite is by far the most abundant of these minerals. In the east and west limits of the mine it occurs as stringers or in massive form in a chloritic host. In the central part of the mine it is either massive or occurs as a fine dissemination in a sideritic gangue.

The ore lenses of the Main Eaton Bay zone occur in the altered anorthosite between dykes; the dykes frequently form the foot or hanging walls or both. The dykes themselves are generally unmineralized. The shoots dip southwards between 60° and 85° and have good vertical continuity. A strong westerly rake of 65° occurs in all shoots. The majority of shoots occur within a strike length of 2,500 feet.



LEGEND:

- MASSIVE ANORTHOSITE ▲
- ALTERED " " ■
- GABBRO ⊠
- DIABASE DYKES ◻
- QUARTZ PORPHYRY DYKES..... ◻
- ORE SHOOTS..... ■

COPPER RAND CHIBOUGAMAU MINES LTD.

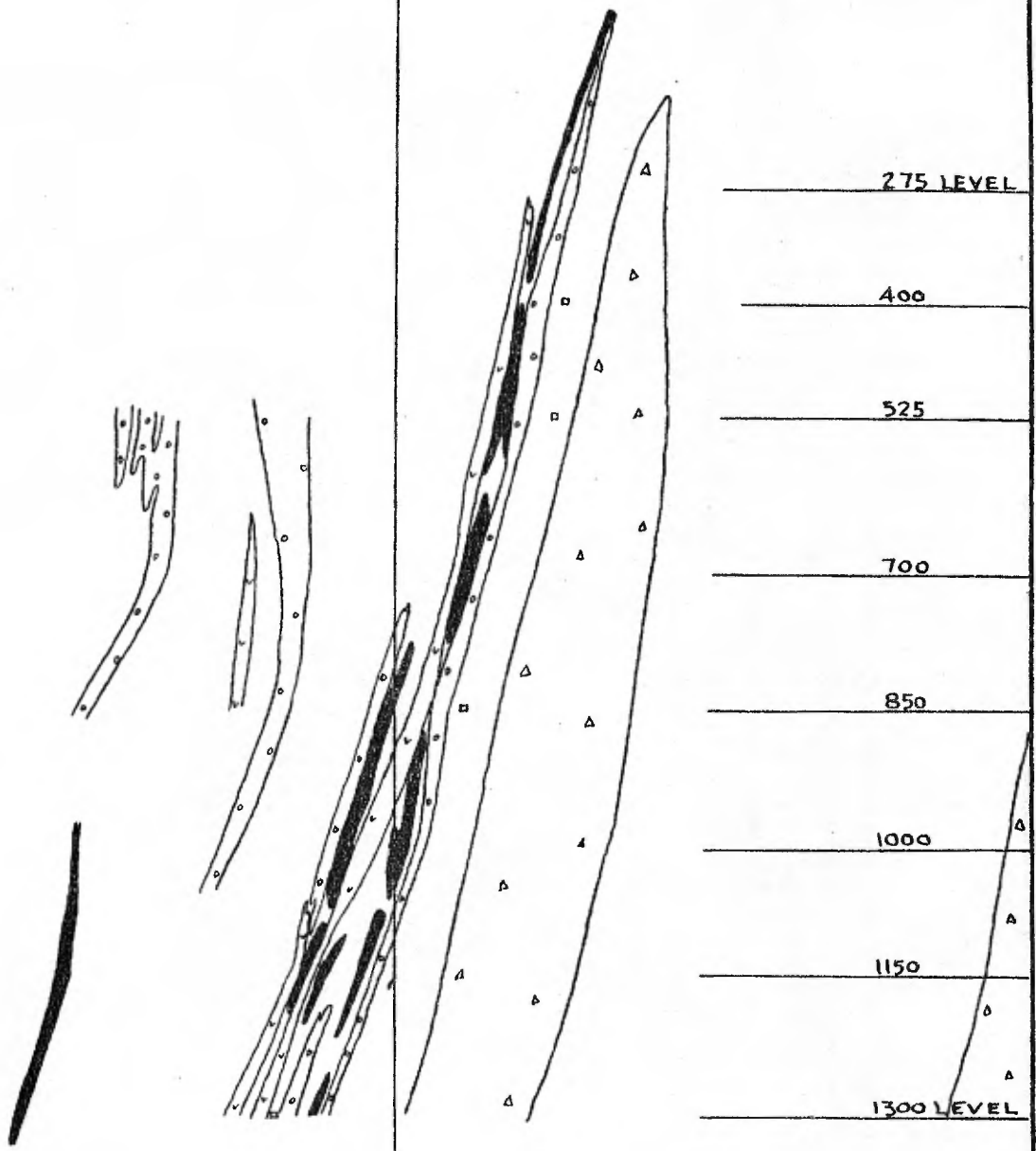
SHAFT 4

LEVEL 1300

GEOLOGY

20+00 S

10000 DATUM



LEGEND:

- MASSIVE ANORTHOSITE..... △ △
- ALTERED " ".....
- GABBRO..... x x
- DIABASE DYKES..... o o
- QUARTZ PORPHYRY DYKES..... v v
- ORE SHOOTS.....

1" = 200'

COPPER RAND CHIBOUGAMAU MINES LTD.

SHAFT 4 LEVEL

CROSS SECTION AT 81+50 E

The location of the shoots is controlled by fluctuations in strike and dip of the dykes. A southerly swing of 35° in the strike at the east end of the mine controls the largest and richest section of the orebody. A roll and steepening of dip from 55° to 72° in the west section controls the Machin No. 2 zone.

A second ore zone with a length at surface of 720 feet occurs 200 feet to the south of the Main Eaton Bay zone. This zone straddles the Bouzan - Copper Rand boundary.

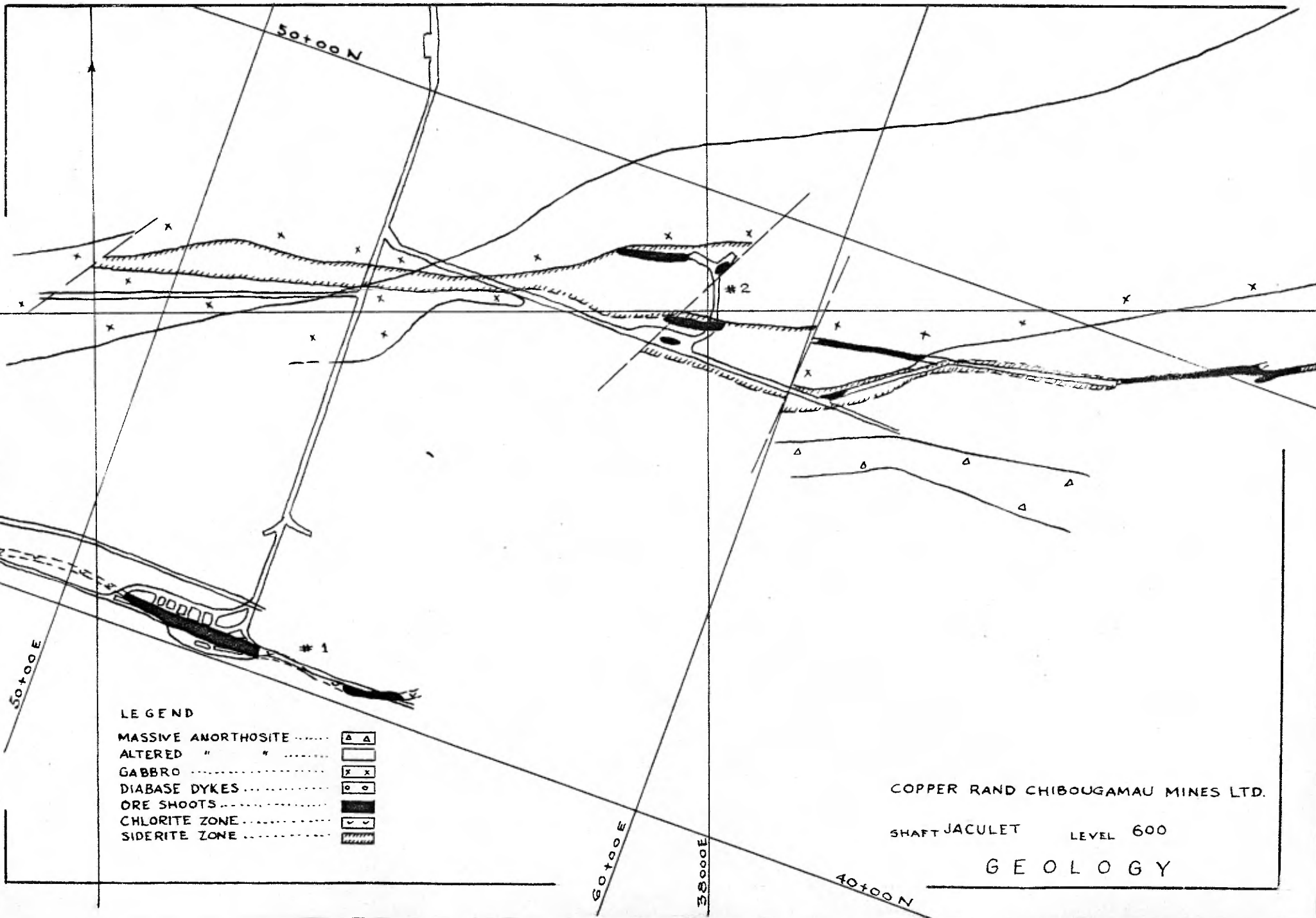
A zone of sulphides extends for 2,000 feet along the hanging wall of the shear but this zone only rarely attains ore grade.

2) Jaculet Mine

Jaculet mine is located on the west side of Doré Lake, one mile north of Copper Rand mine, on the western contact of the anorthosite and gabbro. Some 350 feet of gabbro are exposed in the main crosscut and it appears as a medium to fine-grained rock with occasional erratic aggregates of coarse feldspar. This gabbro is in contact with a sheared siderite zone containing chalcopyrite mineralization which forms the No. 2 ore zone. More gabbro occurs to the south of the No. 2 zone which is gradational to anorthosite. Approximately 600 feet south of the No. 2 zone, there occurs a narrow chloritic and sericitic shear in anorthosite striking $S 70^{\circ} E$ which forms the No. 1 ore zone.

The No. 1 shear zone extends for a length of 1,700 feet and strikes between E-W and $S 70^{\circ} E$ with an almost vertical dip. Mineralization is intermittent and consists dominantly of chalcopyrite with minor pyrite, in lenses varying in length from 50 to 200 feet. Chlorite is strongly developed in the vicinity of the ore but elsewhere sericite and carbonate are the major alteration minerals. Vertical continuity of the lenses is good with one lens having a known vertical continuity in excess of 700 feet. Localization of the lenses seems to be random, with strike variations having no control on the ore.

The No. 2 zone extends for a known length of 2,200 feet. Its width varies from 10 to 150 feet. The zone is composed of siderite, sericite, carbonate, saussurite and some chloritoid with very erratic disseminations or bands of chalcopyrite. A dextral fault offsets the gabbro contact some 110 feet and it is close to this fault area that the No. 2 zone reaches its widest extent and has the greatest



LEGEND

- MASSIVE ANORTHOSITE △ △
- ALTERED " "
- GABBRO x x
- DIABASE DYKES ○ ○
- ORE SHOOTS
- CHLORITE ZONE ~ ~
- SIDERITE ZONE ▨ ▨

COPPER RAND CHIBOUGAMAU MINES LTD.

SHAFT JACULET LEVEL 600

GEOLOGY

COLLAR

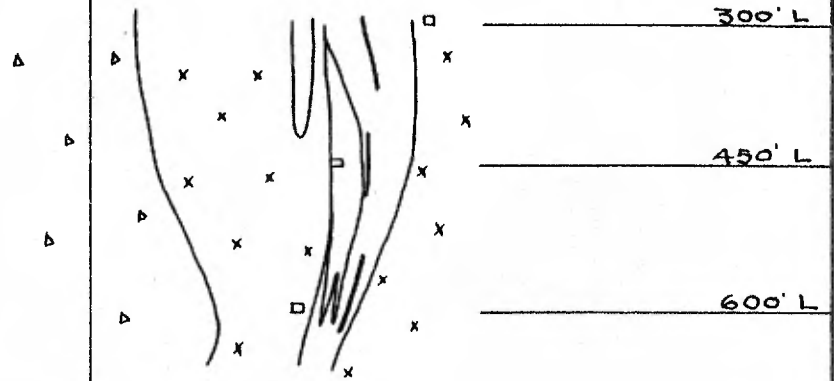
10 000 DATUM

No 1 ZONE










44+00S

No 2 ZONE



LEGEND:

- MASSIVE ANORTHOSITE..... 
- ALTERED " " 
- GABBRO 
- DIABASE DYKES 
- ORE SHOOTS 
- CHLORITE ZONE 
- SIDERITE ZONE..... 

LOOKING WEST

COPPER RAND CHIBOUGAMAU MINES LTD.

SHAFT JACULET LEVEL

CROSS SECTION AT 52+00 E

1" = 200'

content of chalcopyrite. The strike of the fault is S 50° W, with a westerly dip of 75°. Some ore occurs along the plane of this fault. The dip of the zone is 75° to the south with no apparent rake.

Some mineralization occurs in the gabbro, including one ore lens 180 feet in length.

Some dykes are present in the No. 2 zone and are best developed in the west end where both diabase and quartz porphyry dykes can be distinguished. In the eastern part of the zone, alteration is more intense and dykes are recognized only as remnants of pinkish saussuritized inclusions within the sideritic gangue.

3) Portage Island Mine

General

The Portage Island property of Copper Rand Chibougamau Mines Ltd. is situated in the southwest quarter of Roy Township and comprises five mining concession blocks covering the whole of Portage Island and twelve water claims.

The No. 2 Copper Point ore body, which is currently being mined, was discovered in early 1958 by drilling of an E. M. anomaly on the water claims to the east of the island and the shaft was collared in the spring of 1959, approximately 1700 feet west of Copper Point, the site of Mr. Peter McKenzie's original find in 1903.

Geology

A zone of intense alteration, varying in horizontal width from a minimum of 75 feet to more than 700 feet in places, is bounded by a footwall and hangingwall of normal meta-anorthosite; the alteration consists of an outer light green, sericite-chlorite-carbonate zone in which all the original feldspar outlines have been destroyed and a more extreme altered core of black chlorite alteration. Contacts are generally gradational between the types of alteration and also between the fresh and altered bands. This zone has an average strike of N 45° E and dips S 45° E at an average of 47°. Scattered occurrences of altered basic dykes are present but they bear no relation to the structure or ore occurrence.

The main structural feature is a strongly sheared zone with the same average dip and strike as the band of

20+00E

25+00E

35+00E






0+00

4+00S

8+00S

COPPER RAND CHIBOUGAMAU MINES LTD.
CAMPBELL CHIBOUGAMAU MINES LTD.

LEGEND

-  ORE
-  BLACK CHLORITE ALTERATION
-  ALTERED ANORTHOSITE
-  ANORTHOSITE
-  GABBRO

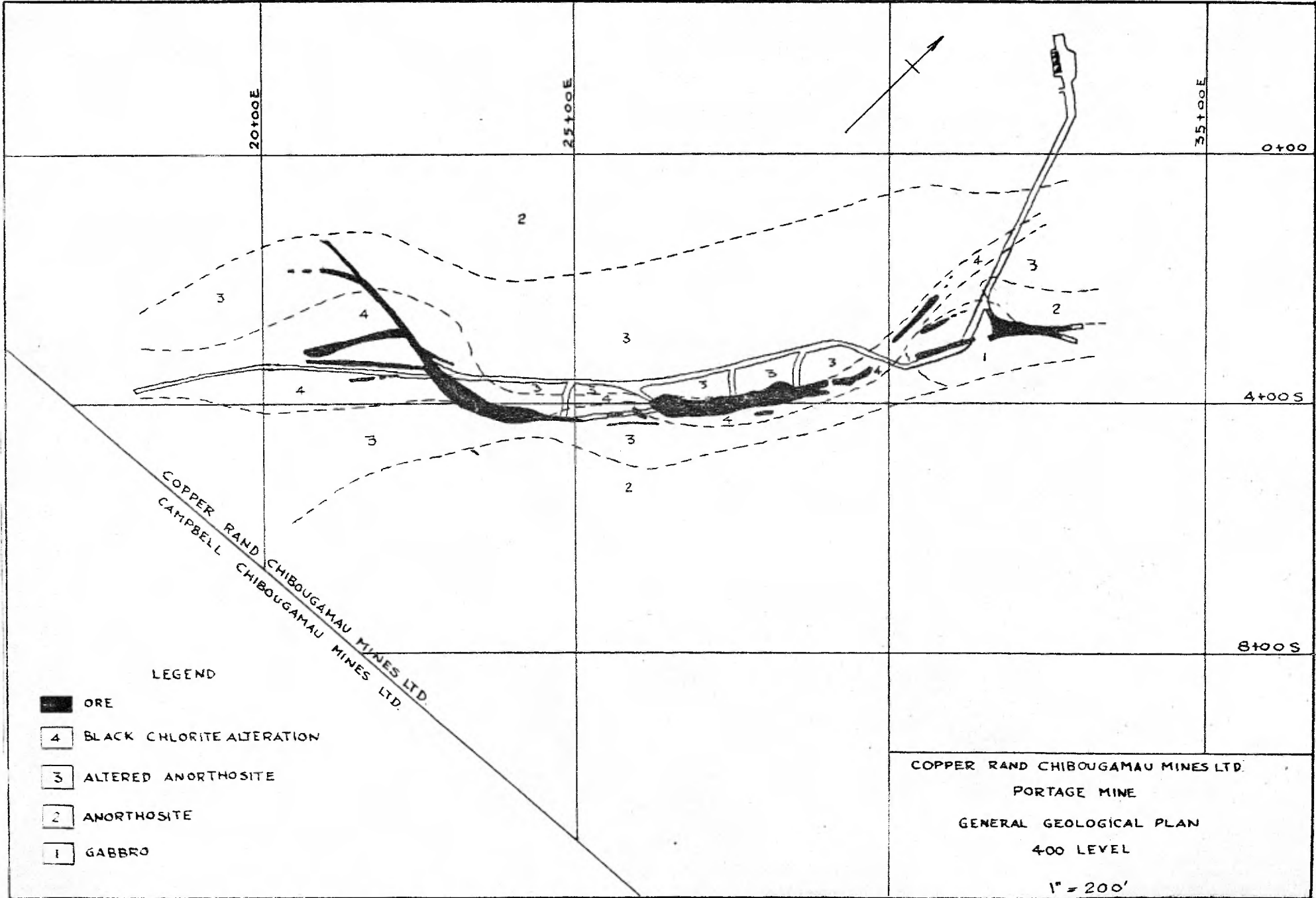
COPPER RAND CHIBOUGAMAU MINES LTD.

PORTAGE MINE

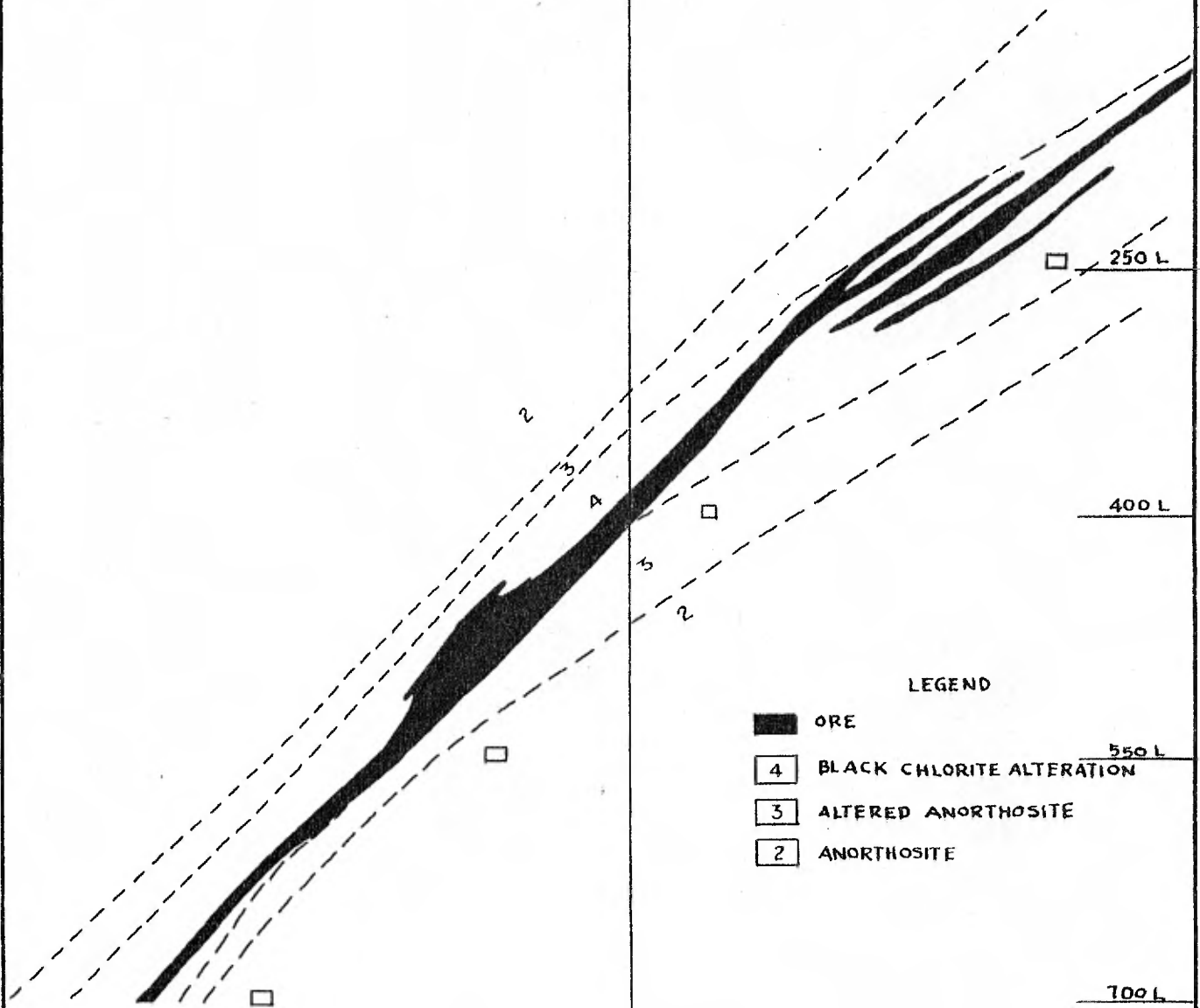
GENERAL GEOLOGICAL PLAN

400 LEVEL





1" = 200'



CHIBOUGAMAU LAKE LEVEL



LEGEND

-  ORE
-  4 BLACK CHLORITE ALTERATION
-  3 ALTERED ANORTHOSITE
-  2 ANORTHOSITE

COPPER RAND CHIBOUGAMAU MINES LTD.

SHAFT PORTAGE LEVEL

SECTION 27+00E

1" = 100'

20-2-62

4+005

alteration, and varying in horizontal width from 40 to 200 feet; generally this shear occurs in the more intense alteration where it has a core of quartz-carbonate but it does enter the outer zone of altered anorthosite in places. In section it is seen that although the hangingwall of the shear retains its dip of 47° , the footwall flattens off to about 35° above the 400 level resulting in a widening of the zone in this area.

Faulting is confined to numerous strike faults and one cross fault at the west end of 400 level.

At the east end of the structure there is a gabbro plug which dips at 60° in the direction S 70° E and rakes N 60° E; here the shear swings north round the gabbro and the nose of the gabbro itself is sheared and shattered, altered and mineralized.

The mineralization occurs as (1) replacements in the shear zone and in quartz-carbonate zones; (2) as fault filling in the strike faults with fragments of quartz, black chlorite and altered anorthosite; (3) as disseminations and as fracture filling in the shattered gabbro zone. Sulphides consist of chalcopyrite, pyrite, pyrrhotite and minor sphalerite and arsenopyrite. In the gabbro-ore magnetite is frequently noted. Appreciable gold values occur throughout the ore body and are found in association with pyrite as gold tellurides, as free gold and with silver in a gold-silver alloy.

Development

A four compartment shaft has been sunk to 880 feet and four levels (250, 400, 550 and 700) have been opened up.

Pattern, flat-hole diamond drilling has been carried out at 50 feet centres and inclined inter-level drilling at 100 foot centres. Due to the dip, mining is carried out by horizontal cut and fill stoping using hydraulic fill.

Opemiska Copper Mines

Production at Opemiska commenced in 1954 at the rate of 400 tons per day. The finding of more ore resulted in a series of increases culminating in the present rate of 2000 tons per day, reached in November of 1959.

The property is underlain by a basic sill complex, the host rock of the ore zones, intruded into lavas and later folded with them. The sill complex is differentiated into layers or members of differing composition. The contacts between these members are sharp in the upper portion of the complex and gradational in the lower portion. It is not known whether the layering is due to differentiation in place or to multiple intrusions.

Lithology

The sill members are as follows:

Ventures Gabbro - 800 feet thick, coarse grained, mottled and well crystallized. There is no apparent compositional or textural gradations within this member.

- Sharp contact -

Foliated Gabbro - 300 feet thick, medium grained, similar to the above but foliated.

- Sharp contact -

Upper Green Pyroxenite - 300 feet thick, medium grained, dark green, composed mainly of secondary amphibole. Segregations of pegmatitic gabbro are common. A magnetite concentration exists along the upper contact.

- Gradational Contact -
(10 feet to 50 feet)

Black pyroxenite - 800 feet thick, medium grained, black, composed of euhedral pyroxene. Many peridotite sills. A magnetite concentration exists along the upper contact.

- Gradational Contact -

Lower Green pyroxenite - similar to the Upper Green Pyroxenite but not present in the immediate workings.

Structure

The sill complex is situated on the northern limb of a syncline lying to the south and trending to the southeast. Superimposed on the overturned northern limb of this fold is a drag fold pitching steeply to the southeast.

The ore bodies of the Springer mine occur in the nose of the drag fold whereas those of the Perry Mine occur in the northern limb. The formation of the fold cannot adequately be explained on the basis of present information.

The major fault on the property is the Campbell Lake fault, a broad zone of talc, chlorite, sericite schist striking N 60° E and dipping steeply to the southeast. The displacement on the fault is in the order of two miles, south side east. The Springer mine ore bodies are believed to bear a structural relationship to this fault.

A series of pre-ore faults striking northwest and dipping steeply to the southwest displace the Nos. 1 and 2 veins up to ten feet on the upper levels. One of these faults on the 2000-foot level displaces the No. 2 vein 150 feet. The Nos. 4 and 13 veins have been displaced up to 70 feet by two faults striking west-northwest and dipping 50° to the south.

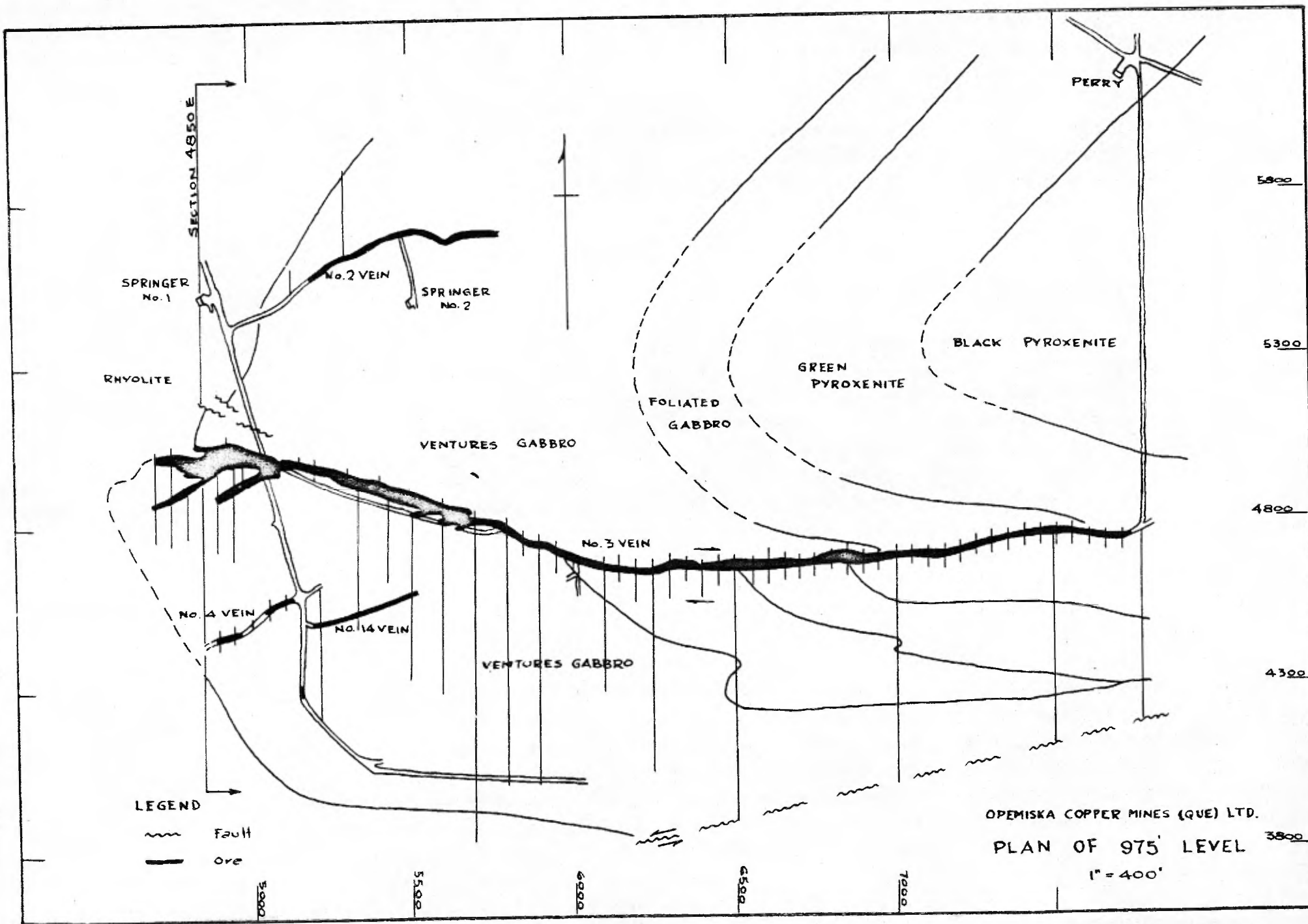
The Springer ore zones follow east-west trending faults dipping to the north. Displacements are small with the exception of that on the No. 3 zone, which occupies a fault zone hinging to the east with horizontal displacements increasing from 300 feet to 1000 feet. The movement is south side down and to the west.

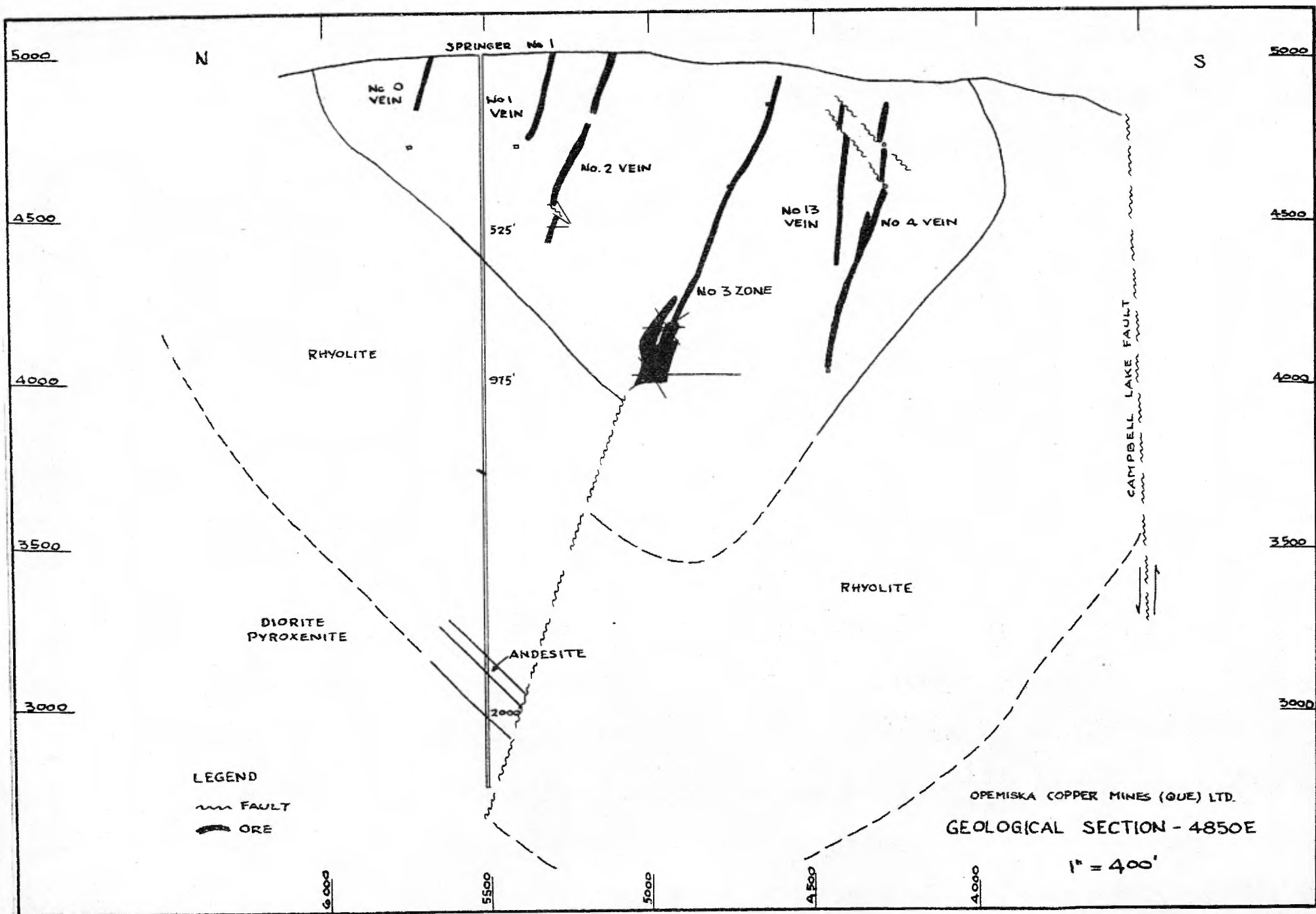
The ore zones at the Springer and Perry Mines are a combination of fracture filling and replacement with the former predominating. Chalcopyrite is the chief ore mineral and it is accompanied by small but significant amounts of gold and silver.

The Nos. 1, 2 and 13 veins are of the fracture filling type with sharp walls. Chalcopyrite, pyrite and magnetite are the chief metallic minerals. Minor amounts of molybdenite are present and locally bands of pyrrhotite up to several inches in width.

The Nos. 3 and 4 zones have less well defined walls and ore limits are determined by detailed diamond drilling. The ore minerals are a fine intermixture of pyrite and chalcopyrite. A broad zone of chlorite alteration, up to 60 feet in width, exists on either side of these zones.

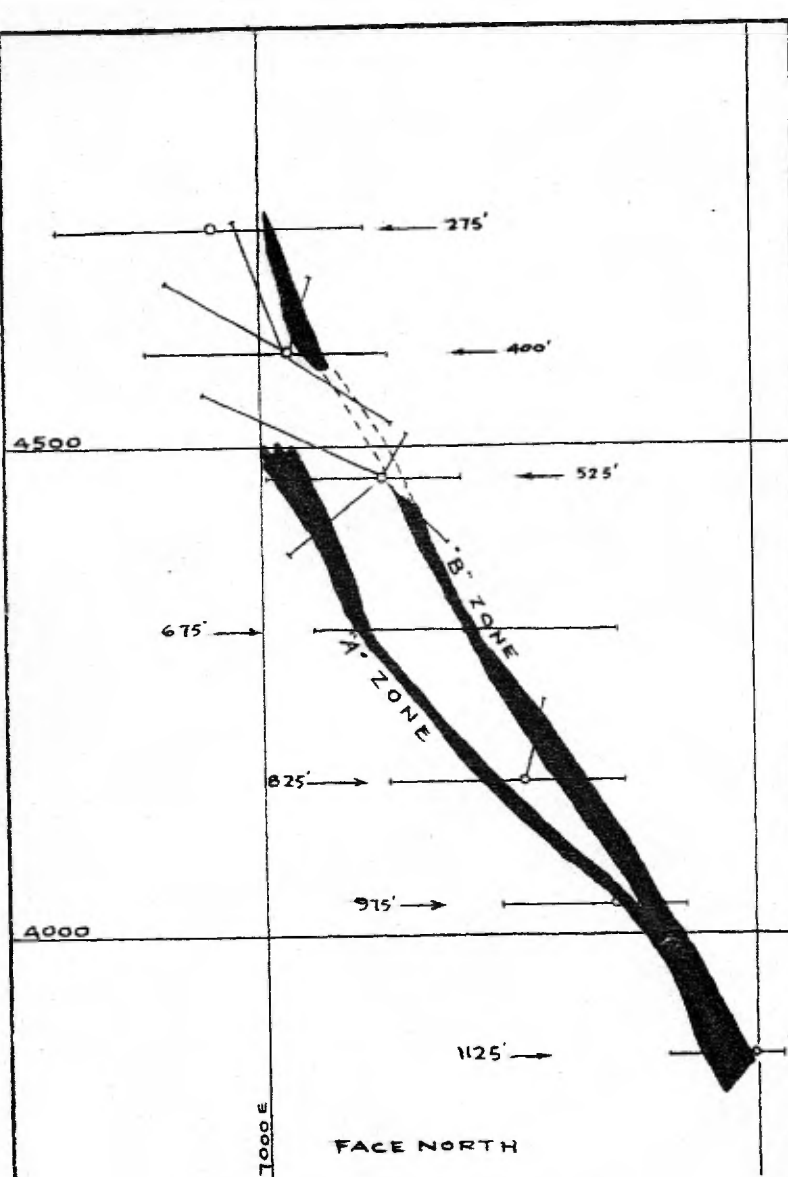
In all zones but the No. 13, the dip strongly influences the width and grade of the ore. A steepening in dip results in a diminution of the ore zone.



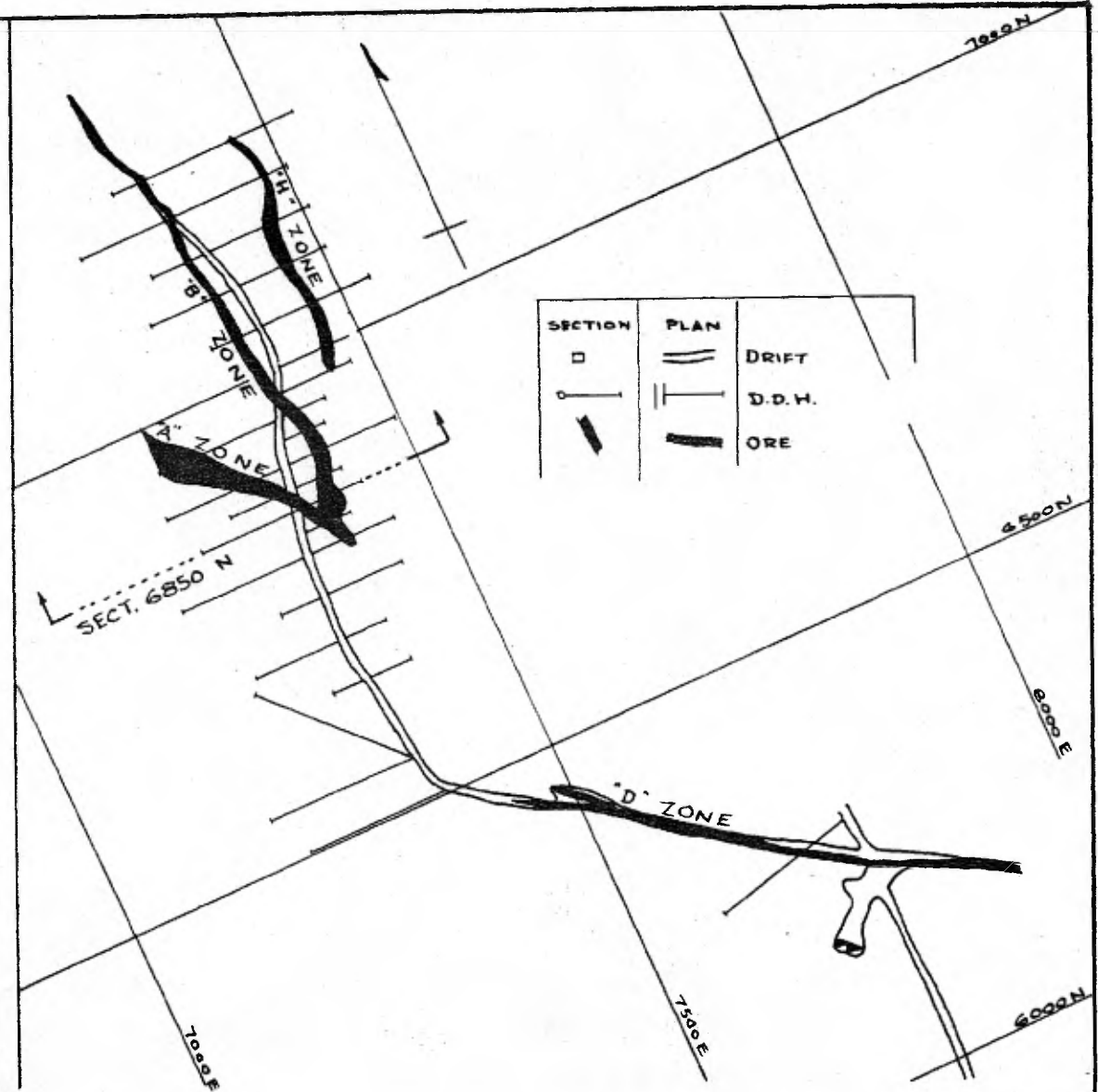


LEGEND
 ~~~~~ FAULT  
 ——— ORE

OPEMISKA COPPER MINES (QUE) LTD.  
 GEOLOGICAL SECTION - 4850E  
 1" = 400'



OPEMISKA COPPER MINES (QUEBEC) LTD.  
 SECTION 6850 N  
 PERRY MINE  
 1" = 200'



PLAN OF 975' LEVEL  
 PERRY MINE  
 1" = 200'

The ore zones at the Perry mine resemble those at the Springer mine in mineralogy and in host rock. However, there is a wide diversity in the attitude of the ore zones of the two areas and within the Perry mine area itself.

The main ore zone in the Perry area is the B which strikes north and dips 65° to the east. It is composed of a series of chalcopyrite and pyrite filled fractures striking north-northwest and dipping to the east. These fractures are constricted to a single fracture near the northern end of the zone where it resembles the No. 2 vein. A series of carbonate filled fractures, similar to those of the ore zone, extend up to 50 feet south of the southern limit of the zone. Chlorite alteration is erratic but less prevalent than in the Nos. 3 and 4 zones.

The D zone strikes northwest and dips 65° northeast. On the upper levels it merges with southern portion of the B zone. The main minerals are chalcopyrite and pyrite with lesser amounts of pyrrhotite. The walls of the zone are sharp but strong chlorite alteration exists up to 25 feet on either side of it.

Other partially defined ore zones have been indicated with various attitudes ranging from a strike of north-northwest to west; all dip in an easterly or northerly direction.

The wide variety of ore bearing structures at Opemiska suggests a complex set of controlling structural factors influenced to some extent by the different rock types constituting the sill complex.

## CHIBOUGAMAU GEOLOGY

### A Summary and Interpretation

#### General

Basically, the Chibougamau District lies within the Superior Province of the Precambrian Shield and at the east end of an easterly-trending greenstone belt that is truncated, some 8 miles east of lake Chibougamau, by an area of gneisses belonging to the Grenville Province. The geologic compilation map that accompanies this report shows the type and distribution of the main rock units and the major structural features of the area.

The oldest rocks are a thick series of tightly folded altered volcanic rocks, feldspathic sedimentary rocks and lesser acidic volcanic rocks. These are extensively invaded by a large variety of intrusive rocks varying in composition from ultrabasic to granitic.

Rocks varying from serpentinite to diorite form the oldest group of intrusives. These occur as sill-like bodies within the volcanic pile to which they are indirectly related. The Chibougamau anorthosite and gabbro complex constitutes the main geological feature of the area and takes the form of a canoe-shaped intrusive with its long axis trending northeast.

Granitic plugs and batholiths are intrusive into all these rock types. A significant mass of granite occurs along the axial portion of the anorthosite complex.

A young group of coarse clastic rocks, called the Chibougamau series, unconformably overlies all other rocks and occurs mainly as isolated remnants within down-faulted blocks.

The north to north-east trending Grenville belt of rocks east of Chibougamau and Waconichi lakes is composed of granite and granitic gneisses; further east paragneisses predominate.

#### Volcanic and Sedimentary Basal Assemblage

The general succession of rock types as determined north of Doré lake, the best studied section to date, is metabasalt in the lower (southern) part of the volcanic pile, andesitic rocks followed by feldspathic lavas in the central part and feldspathic clastic rocks in the upper part. This upper zone marks the trace of a major synclinal

axis and is also invaded by ultrabasic rocks. The total thickness of the assemblage as mapped in this area is in the order of 15,000 feet; the base of the sequence has not been observed because the exposed lavas are in contact with the intrusive anorthosite complex.

Andesites and basalts predominate in this pile of volcanic rocks; they are commonly pillowed, often porphyritic and show amygdaloidal, breccia and other volcanic flow structures. These rocks are typically altered to the greenschist facies.

It is apparent that the rocks of this volcanic assemblage become more feldspathic and acidic in the upper part of the sequence with the result that rhyolitic rocks appear just below and within the upper clastic group.

The nature of the upper clastic group also suggests a parallel change in the volcanic environment from one of quiet out-pourings of basaltic and andesitic lavas to a more explosive and unstable phase. The upper group of clastic rocks is composed of fine grained feldspar-rich sediments and/or tuffs and some slate and silty rock. These rocks are thought to be predominantly pyroclastic in origin, although many have doubtlessly been reworked by water. Disturbed bedding features such as intraformational conglomerates and breccias and penecontemporaneous deformation structures are common, all of which attests to an explosive and unstable environment.

These characteristics of the volcanic group in the type area north of Doré lake can, in some measure, be observed to the west along the strike of the formations. Though the rhyolitic rock, and the sedimentary rocks as well, increase in amount towards lake Opemiska and beyond, where the thickness of these rocks reaches notable proportions, still the relative positions of these units remain the same.

This increase in the rhyolitic unit may be solely dependant on the fact that the western section represents a higher level in the stratigraphic sequence. This is suggested by the presence in this western part of a second and disconformable sedimentary and volcanic sequence above the sedimentary unit of the first cycle. Also the regional anticlinal structure, plunging to the west, that has been outlined in this area would accord with such an interpretation.

The gabbro sills intercalated with the rocks of the volcanic unit are regarded as being hypabyssal equivalents of the lavas; they are fine to medium in grain size, have a bulk composition that is similar to that of the lavas and they show evidence that intrusion took place when the lavas were nearly horizontal in attitude.

### The Ultrabasic Rocks

The ultrabasic rock unit measures approximately one mile in width and is composed of regionally concordant and elongate bodies, commonly discontinuous, that are characterized by moderate interlayering or mixing of pyroxenite, peridotite and some gabbro, many of which are serpentinized.

The stratigraphic position of this unit, being at the bottom of the sedimentary group and generally within the zone of acid volcanic and pyroclastic rocks, is identical across the whole district and the coincidence of a major synclinal axis within the sedimentary unit and directly adjacent to the ultrabasic unit is more than fortuitous. The appearance of the ultrabasic rock would seem to coincide with the unstable and explosive period that gave rise to the upper rhyolitic and clastic group. The evidence at present would suggest that the accumulation of the more feldspathic volcanic, pyroclastic and sedimentary rocks, the intrusion of ultrabasic rock and the initial folding, to which the major syncline would be related, were all contemporaneous events.

This unit may be regarded as a typical orogenic or alpine-type ultrabasic. Yet, in the Opemiska area the belt shows an amount of layering and differentiation that is said to be uncommon in this type of intrusive. In general the unit is thought to be made up of composite intrusions with local differentiation within some of the individual sills.

### The Anorthosite Complex

The anorthosite complex is a layered intrusive composed mainly of anorthosite and gabbroic anorthosite but including associated members varying from ultrabasic to granophyric in composition. These rocks occur as two limbs across a fold axis that trends northeast.

The primary foliation in the complex strikes parallel to the trend to the individual limbs of the mass. Dip of the foliation is vertical to steeply north in the northwest limb whereas within the southern limb the dip is from 50 to 70° to the southeast. The top side of the sill has not been definitely or directly determined but indirect evidence suggests an anticlinal structure. A synclinal structure would necessitate drastic overturning which would not be consistent with the relatively open nature of the fold.

Petrologically, the anorthosite complex is generally similar to most other stratified basic sheets such as the Stillwater or Bushveld complexes; however, there are some important contrasting features such as the greater amount of anorthosite in the Chibougamau mass and, also, the general sequence of crystallization in this mass appears to differ from that of the other masses. The position of the anorthositic members at the base and gabbro to ultrabasic members at the top or outer edge of the complex is contrary to normal, thereby complicating the determination of the nature of the fold axis that passes through the central part of the mass. These petrologic objections may be more apparent than real in that the known mass may only represent part of the complete original sheet and the outer ultrabasic zone may represent a separate injection. Further, the intense low grade metamorphism suffered by these rocks hinders any precise study of the nature of the rock sequence and of the differentiation.

The rock types represented, prior to alteration, appear to have been anorthosite at the base and gabbroic anorthosite or transition rock (which may have been more extensive than is presently indicated) containing bands of magnetite-bearing gabbros and anorthosites and serpentinous magnetite bands. The gabbros appear near the top or outer edge and are gradational with the lower rocks of the sequence. The pyroxenites and other serpentinous horizons are concentrated at the outer edge and are commonly in sharp contact with the inner rocks of the complex. A narrow granophyric zone has been identified along the edge of the complex south of Gilman lake.

Primary foliation is best developed in the gabbroic facies and especially in the southeast limb of the complex.

The rocks of this complex are nearly completely metamorphosed to rocks of the greenschist facies. The original plagioclase and mafic minerals are altered to aggregates of secondary albite, minerals of the zoisite-epidote group, chlorite, actinolite and white mica; there are also extensive areas (in an adjacent to northeast shearing in Doré and Chibougamau lakes) where even albite is lacking and white mica, carbonate and chlorite predominate. However, there are local areas, such as in the northeast part of Chibougamau lake and especially within the southeast limb, where the rock is fresher and contains labradorite or even bytownite and some relict pyroxene, although most of the mafics have been converted to hornblende, which may be partly primary.

Recently, G. Duquette has identified up to 20% scapolite in a preliminary study of the anorthosite from the southeastern limb of the complex.

### Granitic Intrusives

The main greenstone belt in the Chibougamau-Opemiska area measures from 30 to 40 miles in width and it is bounded to the north and south by extensive areas of granitic rocks, both massive and gneissic. These are probably up-arched granitized rocks and may represent the type of rock to be expected at depth below the rocks of the greenstone belt that has been preserved by virtue of the fact that they may represent the complementary synclorium between the limiting up-arched granitic areas.

Granitic plugs and batholiths are intrusive into the rocks of the greenstone belt. Most of these show clear evidence of forceful intrusion. The most significant masses lie along the regional anticlinal structure between Chibougamau and Opemiska lakes.

The Opemiska granite batholith is a homogeneous, medium-grained, pink granite that contains but few inclusions. Gneissic structure and breccias are found at the edge of the mass, especially at its east end. The mass shows some degree of differentiation from centre to edge with the formation of a more syenitic rock in the outer zone.

The Chibougamau lake mass is a very inhomogeneous potash-poor rock that varies from diorite to quartz-rich granodiorite. Inclusions are characteristic and foliation is common. The evidence suggests that this granitic mass has been much contaminated both by the anorthositic rocks it has intruded and by its early formed differentiates of dioritic composition. These rocks are locally severely altered to greenschist minerals but, in general, the granite can be said to be less completely reconstituted than the anorthosite complex.

The inclusion-rich and contaminated contact zone with the anorthosite indicates a true intrusive contact. Also, the granite would appear to post-date the folding of the anorthosite complex for the mapped horizons within the granite show no sign of bending at the nose of the fold structure and no symmetry across the indicated axis.

Dikes of dioritic to granitic composition, many of which are porphyritic, are common in and adjacent to the granitic mass. Doubtlessly, these are the same dykes that are present in some of the ore deposits of the Doré lake area.

### General

The various features of the geological formations in Chibougamau show, to a marked degree, the close inter-relationships between nearly all the principal rock units, with the exception perhaps of the granitic unit. All units below, or older than, the granite appear to be closely related in time and origin. All units (volcanic, sedimentary and intrusive) are characterized by a high content of feldspar, a feature characteristic of orogenic belts, and are generally poor in quartz and all have been affected by a similar type of low-grade metamorphism. It is difficult or impossible to separate the various units or formations on the basis of relative age relations; rather, the picture is one of a continuous evolution with extrusion, intrusion and sedimentation taking place in different localities at the same time and one where all rock units have a single provenance in a common magma. Thus, the intrusion of the anorthosite could be contemporaneous with ultrabasic intrusion, extrusion of pyroclastics, sedimentation and local folding--only the level of activity differs. There are, in fact, lavas which are so completely studded with coarse feldspar crystals that, considering the ubiquitous alteration, they resemble anorthosite of the intrusive complex.

### Structural Geology

The accompanying geologic map shows most of the known and important structural features of the area. Generally, the easterly-trending greenstone belt is tightly folded and all formations are steeply dipping. A main anticlinal axis, which would seem to be doubly plunging, extends through the Chibougamau and Opemiska granite batholiths. Two principal synclinal axes flank this anticlinal structure.

Strike faults and shear zones trending east are common within the area and especially along fold axes. These are structures produced during the folding of the greenstone belt about east-west axes.

The greenstone belt abuts to the east against the north to northeast-trending belt of rocks belonging to the Grenville Province with the result that the east-trending greenstone belt is conspicuously imprinted by northeast structure. Drag-like bending of easterly trending formation to a northeast direction are seen along the west side of the Grenville front. More important are the large northeast-trending regional faults in the Chibougamau area that fan out from the zone of the Grenville boundary.

It is to be noted that the Grenville "front" in the area north of Chibougamau and Waconichi lakes is, in great part, a fault contact whereas to the south the boundary is marked principally by a zone of metamorphic gradation with little or no faulting; this is evidence, among other, that the northeast faults in the Chibougamau greenstone belt represent the southerly extension of the Grenville boundary faults that are present north of Chibougamau lake.

Five or more large scale northeast faults are present in the Chibougamau area and these cut all formations, with the probable exception of diabase dykes. Smaller scale northwest to west-trending shears and shear zones adjacent to some of the northeast fault structures are of great economic importance both in the Doré lake area and the Opemiska mine area.

Another structure of importance in the area north of Doré lake is a sheared and heavily carbonate zone striking east-northeast, yet paralleling formations, along and beyond the north contact of the anorthosite complex. This is considered to be a bedding shear in a tuffaceous horizon and related to the folding of the greenstone belt, but it appears to have been reactivated during the formation of the northeast structures. (see economic geology section)

### Economic Geology

#### A Summary with Emphasis on Ore Genesis.

As in many other regions, prospecting and exploration in Chibougamau has brought to light a host of differing mineral occurrences which, though usually of little economic interest in themselves, are of great importance in the study of any favourable region both as a guide to future exploration and, more generally, as an aid in the study of the science of ore deposits.

The map accompanying this report indicates the location of most of the important and differing types of mineral occurrences. For the purpose of this discussion the principal occurrences can be classified or listed in the following manner, with due regard being placed on the type of occurrence, host rock and structure and age relations of the various features:

- (1A) Generally barren sulphide zones in volcanics and sediments. All of the iron sulfide showings and most of the unimportant Cu and Zn showings indicated on the map probably belong in this group.

- older
- ↑
- ↓
- younger
- (1B) Siderite - Iron sulphide zone - Along north contact of anorthosite complex.
  - (1C) Ni, Cu - in volcanics - Eau Jaune Lake and Muscocho Lake.
  - (2) Asbestos - within serpentinites of ultrabasics - Asbestos Island.
  - (3) Magnetite - segregations in anorthosite complex - Magnetite & Caché Bays.
  - (4A) Gold-Quartz Veins - in E-W shear zones in greenstone
    - within shears in granitic masses (David L.)
    - in faults cutting diorite of volcanic assoc. - Norbeau.
  - (4B) Cu, Mo - in brecciated granitic plug - Grandroy.
  - (5A) Cu, Ni, Zn, Co, Au, Mo - in sheared anorthosite Doré & Chib. L. deposits.
  - (5B) Cu, W, Mo, Au - in fractures in gabbroic rock of ultrabasic unit - Opemiska deposits.
  - (5C) Cu - in and adjacent to seds. of "Chibougamau Series" - Waconichi L.
  - (6) Ni, Cu - assoc. with diabase dyke - Lac La Treve dyke.

The group of showings classed as 1A and 1B are generally of the same type - the 1B zone of mineralization is listed separately simply because of its large size and importance in the interpretation of the local geology. These deposits, all occurring within greenstone, are usually concordant with the formations and frequently associated with acid pyroclastics or sedimentary horizons (calcite or siderite beds are noted in places). They are directly or indirectly related to vulcanism. In places where such zones occur near granitic rocks, as at the Opemiska Explorers zone, there is some evidence that the sulphide zone pre-dates the granite. To date, none of these sulphide zones have been found to be of economic importance, although in other regions of the shield area this type of pyritic deposit is of great economic importance.

The large pyritic and sideritic zone (1B) along the north contact of the anorthosite complex is interpreted as representing one more or less continuous zone of mineralization. The zone parallels the volcanic formations, extends nearly 10 miles in length, and in many places the host, or adjacent, rock is found to be a pyroclastic. A strong bedding shear follows the length of the mineralized horizon. Persons familiar with the Michipicoten siderite-sulfide mineralization have remarked on the similarity of this zone to those of the Michipicoten area and it is thought that the Chibougamau siderite-sulphide zone may represent a syngenetic chemical deposit associated with vulcanism. The west end of the mineralized zone consists predominantly of siderite and minor pyrite whereas the east end is mainly composed of sulphides.

The large amount of iron-rich carbonate alteration in the rocks surrounding the siderite zone is thought to be the result of remobilization of carbonate during a later period of hydrothermal activity associated with the deposition of ores in the anorthosite. (see below)

The Ni, Cu occurrences (1C) in the Eau Jaune and Muscocho lakes area is problematic in that no suitable source rock is exposed. The Ni/Cu ratio in the mineralization is greater than 1, which suggests a source rock more basic than gabbro yet the closest intrusive is a granodiorite; however some gabbro, belonging to the basal assemblage, is present in the general area which may account for the source - if so, then it would be the only occurrence of nickel known in the area associated with this rock.

To date, the known occurrences of asbestos (2) in the ultrabasic belt are limited in size and/or have a low tenor. Most of the fibre in the area is associated with a serpentinized dunite and slip-fibre predominates; it must be noted that the quality of this slip-fibre is said to be comparable with that of cross-fibre from other areas.

The magnetite segregations within the anorthosite complex (3) are generally titaniferous but some zones on Portage Island and near Magnetite Bay contain only approximately 1%  $TiO_2$ . The common titaniferous magnetite horizons within the anorthosite are normal differentiation products but the low titanium magnetite zones are found to have been derived from an iron-rich olivine facies whose relation or position in the differentiation scheme is not quite clear. Some of these ores are of possible economic importance.

The numerous gold-bearing quartz veins (4A) occur principally along prominent bedding shears and are most often associated with dykes of some sort that are usually prophyritic. This is the general setting at Anacon Lead Mines, a former gold producer in the area. Other gold-quartz veins are found within the granitic rocks of David lake.

The Norbeau gold zone is a quartz-sulphide-gold vein-filling in a northeasterly trending fault having sheared walls. This transverse fault clearly offsets all rock types in the vicinity of the vein (intrusive and sedimentary) and would date the vein and fault as post basic intrusive and post folding. On this basis, the source of the vein is not the diorite host rock itself; rather, the nearby Bourbeau granitic plug is the most probable source.

Copper and molybdenum mineralization (4B) is present in breccia zones within the granitic plug north of Portage Island. This mineralization may be directly related to the intrusion of the granitic plug, and is so classified here, but an origin similar to that proposed for the Doré lake deposits is a distinct possibility in view of its general similarity with these deposits.

#### The Mineable Ore Deposits

Groups 5A and 5B include all of the producing mines in the Chibougamau-Opemiska area. Geological descriptions of each mine are given elsewhere in this report; the following is a regional interpretation of the events leading to, or associated with, ore deposition.

The first notable feature of the Chibougamau-Opemiska ore deposits is that they all occur in distinct secondary structures well within masses of intrusive rock, these structures having no relation with contact zones. Most other deposits in the Superior Province are found in volcanic rocks; if they are associated with intrusive rocks, the deposits usually occur in or near contacts. Also, these deposits are located directly adjacent to the Grenville rock Province and within, or closely related to, northeast trending regional faults that parallel or join other northeast faults along and in the Grenville boundary area.

Essentially, the Doré lake deposits are all contained within highly altered rocks of the anorthositic complex and occur in shear zones or wide schist zones trending N W to E-W; generally the deposits south of Cedar Bay are in the narrower shear zones whereas to the north, wide schist zones are the host rock. Dykes of various types, but of general granitic affiliation and related to the Chibougamau granite mass, are present in most of the mineralized zones and trend northwest; they are more abundant and exercise more control on ore localization in the relatively narrow shear or fault zone deposits and are only locally present in the wider schist zones. The N W shearing is sub-parallel to the dykes in the zones south of Cedar Bay whereas to the north, where dykes are few or absent, the shearing in the wide schist zones approaches a more easterly direction. It is evident in most mines that the shearing is, in most cases, post dyking; further, it appears most probable that the dykes controlled the shearing to some degree.

The N W to E-W shears in the Doré lake area are most prominent in the area between the lac Sauvage fault (the siderite zone) and the northeast Doré lake fault. These two faults apex to the northeast which would explain the occurrence of wider schist zones in the northern section as compared to narrower shear zones to the south where the faults are widely separated. It is suggested that the N W shearing along Doré lake is a complementary shear direction within a fault block that was bounded to the north by the Sauvage fault and to the south by the Doré lake fault.

Recent mapping in the Opemiska mine area also suggests similar conditions for the formation of the ore-bearing N W to E-W structures. At Opemiska the northeast Gwillim lake - Campbell lake fault is thought to branch into two sections, one passing north of the mine area and the main fault passing just south. The N W to E-W veins are thus considered to be complementary structures within the fault block.

The Henderson and Portage ores are localized within a northeast fault which directly establishes the age of the ore relative to the structural evolution of the district. However, the main ore zone at Henderson is itself within an E-W trending structure that is complementary or subsidiary to the major N E fault, which fact points to the importance of structures secondary to the main N E faults as the most important loci of ore deposition - this partly explains why there was ore in the N W structures in Doré lake but none of importance along the Doré lake fault.

Mineralogically, the ore minerals in the Chibougamau deposits show peculiar traits. The variety and amount of metals present in these ores, both in visible amounts and as trace element content, is remarkable and problematic. The following metals are commonly found in the deposits in anorthosite: copper, gold, nickel, zinc, cobalt, molybdenum, lead plus the sulphides pyrite, pyrrhotite and arsenopyrite. In the Opemiska ores are found: copper, gold, molybdenum, tungsten, cobalt, some lead and zinc and uranium plus pyrite, arsenopyrite and pyrrhotite. Such occurrences are not indicative of specific magmatic affiliation but suggest, rather, a mixed origin.

The basic problem can be stated as follows: that the Chibougamau deposits occur within an easterly-trending greenstone belt of the Superior Province and, generally, in a variety of suitable igneous source rocks of the same general system and age (2200-2600 m.y.) yet these deposits show certain peculiar characteristics and are directly associated with northeast faults that originated only with the younger Grenville deformation (900-1000 m.y.).

In the classic study of this area, Mawdsley and Norman concluded that although there may have been some mineralization prior to the development of these northeast faults, the more obvious mineralization postdates these structures. At Opemiska, Derry concluded that the mineralization is much younger than the host intrusive rock and was directly related to the northeast Campbell lake fault that was shown to be Grenville in age. Derry suggested that solutions (inferred granitic source), passing along the Campbell lake fault, leached copper from the gabbro and redeposited it along favourable fractures. Vollo concluded a similar late age for the mineralization at the Henderson mine in anorthosite and suggested that the more or less barren solutions, which accomplished the leaching and redeposition, probably originated in the Grenville zone of "dryer" metamorphic rocks.

An amount of preliminary chemical and petrological work has been carried out on the anorthosite and there are good indications that part of the alteration in this mass is due to causes originating in the nearby Grenville orogenic zone; also, the concentration of the ores by a process of leaching and redeposition could be in accord with the presently available analytical results on trace metal content of sheared, massive, fresh and other types of anorthosite.

The presence of scapolite in anorthosite is instructive in this connection. Scapolite is a rare alteration mineral in the greenstone areas but is of common occurrence in the gneisses of the Grenville area. It is a mineral deposited only under hydrothermal or pneumatolytic conditions and requires an environment rich in the volatiles  $\text{Cl}$ ,  $\text{CO}_2$ ,  $\text{SO}_3$  and water. Thus the occurrence of this mineral is again suggestive of hydrothermal effects due to the nearby Grenville zone.

Such a metamorphic origin is thought to provide a suitable basis for a working hypothesis on ore genesis for the Chibougamau deposits and especially for those in large intrusive masses and directly in, or closely associated with, northeast structures (Portage, Henderson, Opemiska). A similar genesis is applicable to the Doré lake zone of deposits for, as suggested above, the southwest shears are complementary structures between northeast fault blocks or between the Doré lake fault and the older lac Sauvage bedding shear.

Certainly, a suitable method of dating the Chibougamau ores or associated alteration would be of much help in the study of this problem. Campbell Chibougamau Mines has had an age determination made on galena from its ores. Unfortunately, the method used was one of the least reliable for areas of much alteration and complex history, and especially where leaching phenomena are suspected. For these reasons, the indicated age of 2000 m.y. for the mineralization, which does not agree with the geological evidence, is thought to be in error or else not correctly interpreted.

The copper occurrences in the sediments of the Chibougamau series at the north end of Waconichi lake are fault or fracture fillings, with only minor dissemination, in structures that are, again, directly related to the regional northeast faults.

The Ni, Cu concentrations along the lac La Treve diabase dyke appear to be magmatic segregations at the bottom of the inclined dyke. The small size of the showings is dependant on the small mass of the dyke; if there is a possibility of increase in size of the intrusive along the strike extension, then more importance could be given to these occurrences.

References: Liberal access to all published, unpublished and verbal information.

THE TOWN OF CHIBOUGAMAU

The site of the present town was chosen by the Quebec Department of Mines after the completion of the road to this district in 1950 and it was founded in 1952 as a "mining village" under the auspices of the Provincial Mines Department. During the period from 1953 to 1957, community affairs were directed by a resident council appointed by the Mines Department and an elective municipal system was established in 1958 to operate within the framework of the Provincial Acts pertaining to a "mining town".

The rapid growth of the town of Chibougamau is a direct consequence of the progressive increase in mineral production from this district since the start of operations in 1954. Being located in an isolated region 150 miles from the nearest community and starting in a conspicuously modest fashion, when in 1953 there were only 4 or 5 constructions, but a few hundred residents and the first municipal revenue (\$10,000. courtesy of Campbell Chibougamau Mines), the town has grown and evolved continuously for eight years and now has a population of over 6,500, a municipal revenue approaching one half a million dollars yearly and enjoys all of the facilities common to a modern progressive town in the more populated regions of the province.

The following table of figures is presented to show the material aspect of the development of Chibougamau.

|                         | <u>1956</u> | <u>1958</u> | <u>1960</u> | <u>1961</u> |
|-------------------------|-------------|-------------|-------------|-------------|
| Population              | 2,800       | 3,035       | 5,331       | 6,500       |
| No. of families         | 600         | 625         | 1,000       | 1,200       |
| Municipal Revenue       | 160,144     | 275,032     | 380,615     | 475,000     |
| Taxable Prop. Eval.     | 3,825,000   | 8,032,700   | 9,910,000   | 10,933,000  |
| Non-taxable " "         | 175,000     | 765,956     | 971,054     | 1,700,000   |
| Building Permits Issued | 52          | 37          | 153         | 152         |

During 1961, the value of construction projects totalled a record amount of over 4.3 million dollars. These projects include the construction of a 75-bed hospital, certain constructions for the future R.C.A.F. Radar community, a few commercial projects and 70 residential constructions, more than half of which were financed by the Central Housing and Mortgage Corporation.

Steadily improving means of communications have minimized the town's isolation and have contributed, in fact, to show that Chibougamau is the ideal centre for all present and future mining or other developments within a radius of 50 to 100 miles or more. Railroads lead both to the lake St-John-Saguenay area and to the Val d'Or-Rouyn district and the road leading to Val d'Or will shortly supplement the traditional access via lake St-John. In addition, a municipal airport is under construction.

The large portion of the non-taxable property evaluation (tabled as \$1,700,000) represents the value of school buildings in Chibougamau. Because numerous children are a characteristic of a young population, new school buildings are overcrowded as soon as they are erected. Also, a new and attractive municipal library provides an auxiliary educational facility.

The town has instituted a zoning system which divides it into industrial, commercial and residential sectors. Paved streets and concrete sidewalks are present in the commercial and most residential sectors. The business establishments in the commercial sector rival those in any town of comparable, or even larger, size; the number, size and variety of these establishments is an unsuspected characteristic of Chibougamau. Having noted these favorable conditions the Royal Canadian Air Force has chosen to establish their future community within the town so as to make full use of the many facilities available in Chibougamau.

Recreational facilities available vary from movie theatres and television to curling and skiing. Aesthetically, the Chibougamau region is one of the most attractive in the Precambrian Shield area; the town itself, however, does suffer from a lack of general landscaping but, despite difficult conditions of soil and climate, a steady improvement is being made in this connection.

These various characteristics show that Chibougamau has progressed along with the mining industry in a rapid but yet orderly and organized fashion during the past 8 to 10 years. The Chibougamau mining centre is ready and capable of further expansion and looks with optimism to new developments both near at hand and further afield.

PROSPECTS FOR THE FUTURE

The various mining operations have ore reserves for a period of from 3 to 12 years; the figures are not to be considered as final for, as a rule, additional ore is usually found as mining operations proceed at any one mine. More important is the fact that there are good possibilities of new deposits being found within the presently producing area of anorthosite and within the favourable host rock and structures of the Opemiska area. The large anorthosite mass has yet to be fully explored, especially at depth.

Other minerals in or near the anorthosite mass are of possible economic importance - these are the iron ore concentrations near the north shore of lake Chibougamau and the asbestos occurrences north and east of the lake.

Geologic evidence suggests that our present ores are not akin to the common "greenstone" or "volcanic" ores typical of the base metal mines in the Superior Province of the Precambrian Shield - the finding of such types with the volcanic assemblage of the Chibougamau District always remains a distinct possibility.

The exploration of the new Lac Frotet area, located some 50 miles north and geographically part of this district, is a result of the initiative of the mining concerns in Chibougamau and this new area is presently showing signs of possible economic mineral deposits.

A decision concerning the mining of the large iron formations outlined in the Albanel area has yet to be made. Although located over 100 miles to the north, such a development would certainly increase the importance of the Chibougamau mining centre.

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CONTRIBUTORS

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February, 1962.

## DEPARTMENT OF NATURAL RESOURCES

MEMORANDUM

TO: Dr I.W. Jones

FROM: Robert Assad

SUBJECT: C.I.M. geological excursion

DATE: September 19th, 1962.

Herewith is a copy of the report on the "Geology & Mining Development of the Chibougamau, Quebec, Mining District" which the Department, through your consent, obligingly offered to duplicate for distribution to those attending the 1962 C.I.M. geological excursion in Chibougamau on October 1st to 3rd.

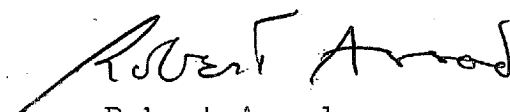
You will note that the credit on the title page is as you suggested. The method of reproduction is that customarily used for preliminary reports; I might add that an excellent and most rapid service was rendered by the "Service des Impressions".

The report here submitted lacks only a copy of the regional geological map of the district, showing the main structural features and mineralized zones; these are being reproduced by the various mines in Chibougamau and I will have one reserved for your copy of the report.

I should like to thank the Department for allowing me to spend the time required to augment and complete the contents of the original report which I prepared last February; I am obliged also for the permission to aid in the organization of this geological excursion.

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|--------------------------------------------|
| Ministère des Richesses Naturelles, Québec |
| SERVICE DE LA                              |
| DOCUMENTATION TECHNIQUE                    |
| RM: 12142                                  |

Yours very truly,

  
Robert Assad  
Mineral Deposits Branch.

RA/ld