

THE GEOLOGY OF THE WEEDON PYRITE
AND COPPER CORPORATION LTD. MINE.

by

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A thesis submitted to the Faculty of Graduate
Studies and Research in partial fulfilment of
the requirements for the degree of Master of
Science.

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APRIL 1959



Number four headframe at
Weedon Pyrite and Copper Corporation Mine

TABLE OF CONTENTS

	Page
<u>INTRODUCTION</u>	1
Location	1
Topography	3
Nature and Scope of Thesis	3
History of Mining in the Area	4
History of the Weedon Mine	5
Previous Geological Work at the Mine	8
Method of Investigation in Field and Laboratory	9
Acknowledgements	10
<u>GENERAL GEOLOGY</u>	12
Previous Work in the Area	12
The Copper Belts	13
Mines in the Area	14
Eustis Mine	14
Suffield Mine	17
Moulton Hill Mine	19
General Geology of the Weedon Mine Area	19
General Mine Geology	21
Quartz Sericite Schist	21
Chlorite Quartz Sericite Schist	22
Greenstone	22
Granite	23
Ore	24
<u>DETAILED MINE GEOLOGY</u>	26
Quartz Sericite Schist	26
Chlorite Quartz Sericite Schist	40
Greenstone	45
Granite	47
Wall rock inclusions	49
Sulphide Replacement of Biotite Inclusions	54
Ore	64
Paragenesis	74
<u>ORIGIN OF THE ORE</u>	76
<u>SUMMARY AND CONCLUSIONS</u>	77
<u>BIBLIOGRAPHY</u>	79

TABLE OF ILLUSTRATIONS

MAPS

Index map	
Block diagram	In pocket
Surface geological map	in pocket
Geological map, 11th level	in pocket
Geological map, 15th level	in pocket

FIGURES

	Page
1. View of the headframe	Cover
2. General view of the countryside	3
3. Breccia	27
4. Structure and texture of quartz sericite schist	28
5. Texture and structure of quartz sericite schist, crossed nicols	29
6. Texture and structure of quartz sericite schist, crossed nicols.	30
7. Altered quartz sericite schist, crossed nicols.	33
8. Alteration of chlorite to anthophyllite.	34
9. Banded chlorite quartz sericite schist.	40
10. Chlorite along shears in the chlorite quartz sericite schist.	41
11. Structure and texture of chlorite quartz sericite schist.	42
12. Structure and texture of chlorite quartz sericite schist (crossed nicols)	43
13. Partially replaced inclusion in the granite.	50
14. Almost completely replaced inclusion in the granite.	51
15. Abrupt contact between granite and an inclusion crossed nicols	52
16. Inclusion in granite surrounded by a halo or reaction rim.	53

	Page
17. Replacement of biotite by sulphides	55
18. Sulphides beginning to replace a biotite inclusion.	56
19. Sulphide inclusions in granite.	57
20. Country rock and sulphide inclusion side by side	58
21. Pyrrhotite being bitten into by sphalerite.	61
22. Replacement of pyrrhotite by chalcopyrite	62
23. Replacement of the granite by sulphides	63
24. Euhedral crystals of pyrite in chalcopyrite	64
25. Rounded pyrite grains surrounded by sphalerite and chalcopyrite.	67
26. Fracturing of the ore minerals	67
27. Age relationships of pyrite, chalcopyrite and sphalerite.	69
28. Detail of fracturing in sphalerite	70
29. Details of exsolved chalcopyrite from sphalerite	71
30. Marcasite crystals	72
31. Detail of marcasite crystals	73
32. Galena crystals	73

CHAPTER I

INTRODUCTION

Location

The Weedon Pyrite and Copper Corporation Mine is located one mile north of the village of Fontainebleau, Wolfe County, Weedon Township of the Eastern Townships of Quebec Province. The Mine Property comprises of 10 claims in Ranges II and III. The nearest town is Weedon, four and a half miles to the west. The city of Sherbrooke is 39 miles south and Quebec is 99 miles to the north.

The country is well supplied with good roads. The Quebec Central Railway maintains a freight and passenger service through Weedon. Telephone and telegraph communications are available, and the district is supplied with ample hydro power.



FIG. 2

General view of the countryside.

The Weedon Mine is located on the hillside in the background.

Topography

The topography of the country is rolling, consisting of many small hills. Weedon is located about 815 feet above sea level and the higher hills nearby extend up to 1400 feet. The granite hill to the northeast of the mine is the highest in the vicinity. The hills and valleys have a definite trend northeast and southwest following the geological structure of the country. The township surveys, roads and major streams are oriented in this direction as well. Much of the country consists of moderately productive farming lands, due to the large number of boulders in the glacial drift.

Nature and Scope of Thesis

This thesis is based on one summer's field work with the Quebec Dept. of Mines and consists of a detailed study of the Weedon

Pyrite and Copper Corp. Ltd. Mine. The thesis includes: 1. A study of the wall rock, its description and alteration; 2. the structure, texture and paragenesis of the ore; and 3. the geological structure of the deposit. The wall rock study has been enlarged to include data from Murray (1952) and his study of wall rock alteration of several mines in the Eastern Townships. In addition, all available reports on other mines along the Weedon geological structure were compiled to study the similarities of the mines.

History of Mining in the Area.

Copper has been known in the Eastern Townships of Quebec since 1841. The earliest official report giving an account of copper occurrences came from the Director of the Geological Survey of Canada, Sir Wm. Logan, who examined copper prospects in 1842 and suggested some favourable areas for prospecting.

From 1859 to 1866, the region was prospected by many "shafts", many of which were no more than small holes or trenches. At first, the deposits were worked for their copper content only, but commencing about 1877, sulphur was also produced from the associated pyrite and used for the manufacture of sulfuric acid. Between 1886 and 1939, 170 million pounds of copper were produced in the Eastern Townships. However, it was the opinion of Bancroft in 1915 that only four copper mines had undoubtedly been financially rewarding, namely the Acton, Eustis, Capelton and the Weedon mines.

The deposits lie within a belt 30 to 40 miles wide and 130 miles long, extending northeasternly from Vermont to the Chaudiere

River. The belt includes what is known as the Sutton Mountain anticline and extends some 20 miles to the east of it.

Mines of the area include the Acton, Albert, Eustis, Harvey Hill, Hunting, Moulton Hill, Suffield and the Weedon mines. To date, only the Weedon Mine is still in production. A new discovery by Cyprus Exploration during 1958 has renewed interest in the area. The discovery lies approximately 7 miles north along the same structure as the Weedon Mine.

History of the Weedon Mine.

The initial discovery of the Weedon Mine was made by Mr. John MacDonald in 1909. He had begun prospecting the area in the Autumn of 1908. Pits were sunk in the rusty schists in the hillside just northeast of the present headframe. In August 1909, he moved to a lower drift-covered area near the present number three shaft and sunk a pit in an elongated grass covered depression on strike with the schists. The 8 x 8 foot shaft passed through three feet of earth, four feet of iron oxide then penetrated solid cupriferous pyrite to a depth of 20 feet. This grass covered depression was the horizontal section of the main lens.

The property was then leased to Pierre de Ricketts of New York who, in turn, transferred it to the Eastern Smelting Co. After several other transfers, the property came into the hands of the Weedon Mining Co., which was composed of C.H. Maxy, J.S. Maxy, L.D. Adams and Mr. Lewis. This company retained ownership of the property and operated the mine, then known as the MacDonald Mine, until its shutdown in 1921.

Three shafts were sunk in the vein to depths of 96, 350 and 470 feet respectively. First the ore was taken directly as it came from the mine by horse drawn teams to the railhead in Weedon at a cost of \$0.80 per ton. In 1912, a Bleichert aerial cable tramway 19,500 feet in length was constructed reducing the cost of transportation of the ore to \$0.06 per ton.

When production ceased in 1921, the mine had produced 584,577 tons of ore with an overall average of 3.5% copper and 40% sulphur. The maximum yearly production was in 1916 when 93,677 tons were produced. Up to September 1, 1914, ore averaged 3.62% copper, 40.74% sulphur, 0.77% zinc, a trace of lead, 0.46 ounces of silver per ton, and 0.01 ounces of gold per ton. Ore sold for \$9.00 per ton, payment being made on the sulphur and copper content.

By 1921, the price of copper had fallen from the high price (\$0.55 per pound) it had been when the mine was brought into production to an uneconomical level, and since all the readily available high grade ore had been mined, the mine was closed down. The mine was kept dry for a year, then allowed to flood.

Beginning about 1949, interest was renewed in base metal mines, partly as a result of favourable metal prices and partly due to the utilization of zinc in the ores. The Weedon Pyrite and Copper Corporation Ltd. was incorporated in Quebec in 1950. Diamond drilling was done on the property during 1950. From these drill results, it was decided to de-water and re-open the mine to recover the high grade ore pillars left from the previous mining and to mine the footwall vein that had been too small to mine when the mine was originally brought into production in 1909.

By February 1951, surface buildings were constructed and the underground workings were being dewatered. A 250 ton mill was completed and production commenced on November 15, 1952. The capacity was increased to 325 tons in 1953. The capacity has since been increased again to where the mill rate as of July 1958 was around 400 tons a day. Three concentrates are produced, namely copper, zinc and pyrite.

In the late part of 1955, a new 45 degree inclined shaft was driven from 5 different headings simultaneously in the footwall about 100 feet from the original number three shaft. The number four shaft has reached a vertical depth of 1100 feet. This was to mine out the 65,000 tons of high grade ore tied up in the number 3 shaft pillars. The new shaft would also permit development and mining of the lower levels. The number three shaft had already reached its limit at the 11th level. Mining between the 11th and 14th level, before the new shaft came into operation, was by means of a winze, resulting in extra handling of broken ore. Operations through the old number three shaft, other than salvage, was discontinued in mid 1957.

Ore reserves as of December 31, 1955, were close to 450,000 tons, averaging 2.16% copper, 1.45% zinc and 29.71% sulphur.

The new number 4 shaft was opened on the 2nd, 4th, 7th, 9th, 11th, 14th, and 15th levels. During the later part of 1957, the 16th level was opened. This is being developed by means of the sinking hoist from the 15th level. The latest ore reserves, as of January 1958, consist of 208,843 tons in the main lens, averaging 2.15%

copper, 32.25% sulphur, 1.05% zinc. The footwall lens has a reserve of 61,184 tons averaging 2.02% copper, 20.72% sulphur, 1.24% zinc. Since these calculations have been made, additional ore has been outlined on the 15th level. Operations at the present time (Summer '58) consists of development on the 15th and 16th levels. Timbering from the old number three shaft is being removed and the old pillars are being blasted out for ore, in addition, mining of portions of the footwall lens is being carried out.

Previous Geological Work at the Mine.

During 1914, J.A. Bancroft examined the Weedon Mine, his report being published in 1915. This is an extensive report on the mine and the only one of significance published. Several other private reports were written but give nothing new and draw largely on the original one done by Dr. Bancroft.

F.D. Adams published a report (1915) on the mine but this deals mostly with mining methods and contains very little geology. An unpublished report was made by C.W. Cushman, former manager of the mine, in 1923 just after the closing of the mine. In 1929, W.F. James wrote another report. This was based on both Bancroft's and Cushman's previous reports, and his own two month surface investigation of the property. At this time, most of the records had been mislaid and the mine flooded for seven years. The next report published was that of L.G. Murray, a McGill thesis on "Wall Rock Alteration of Base Metal Sulfide Deposits in the Eastern Townships". At the time of his report, the mine was not completely dewatered, so his report consists

essentially of an exhaustive study of core from several diamond drill holes in the wall rock.

The present report is the first report of any kind dealing with the structure found at the lower levels where such phenomenon as the granite, wall rock and ore are all in contact. The inclusions of ore and wall rock within the granite have heretofore been undescribed. No detailed work, to the writer's knowledge, has been done on the structure, texture and paragenesis of the ore. Previous reports on the mine were made before the reflecting metallographic microscope came into general use.

Method of Investigation in Field and Laboratory

The information contained in the following sections has been gathered from the writer's personal observations of outcrops in field work, diamond drill core and formal laboratory investigation with polished and thin sections, staining and immersion techniques and supplemented with information from all other written available sources. The summer field season was spent with the Quebec Dept. of Mines assisting in detailed Geological mapping of a five minute map of the Weedon area which has as its centre the Weedon Mine. The five minute area (approximately 23 square miles) was mapped on the scale of 500 feet to the inch. This map will soon appear under the authorship of Mr. Gilles Duquette, Quebec Dept. of Mines.

In the vicinity of the mine, more extensive mapping of the rock outcroppings was done by the writer on the scale of 100 feet to the inch (see accompanying map in back pocket). The mine surface plan

was used as base map. On it all the buildings, roads and streams were located so that it was only necessary to place stakes along the roads, etc. at 100 foot intervals and tie in the outcroppings with a hundred foot tape. The rocks change their apparent composition and degree of alteration suddenly from outcropping to outcropping, so it was necessary to collect a great many hand specimens to correlate the geology. Total number of specimens collected from the surface and underground mapping amounted to 370 specimens. From these 53 thin sections and 92 polished sections were made.

Underground mapping was done using the mine survey plans with a scale of 20 feet to the inch (see back pocket for 11th and 15th level map). Not every level was mapped in detail. Those levels investigated in detail were the 2nd, 4th, 6th, 8th, 9th, 11th, 14th, 15th and 16th, as well as the number 4 shaft.

Acknowledgements

I wish to thank, first of all, the Quebec Department of Mines, Mineral Deposits Branch, without which this study could not have been done. Employment for the summer and the cost of thin sectioning was born by the Department.

The examination was greatly facilitated by the mine staff by giving the writer an assistant for underground work, the use of safety equipment, complete access to mine maps, sections, reports, drill core and logs as well as personal communication during the winter months when the manuscript was being prepared. The writer wishes to thank Mr. W.W. Bake and his staff for this co-operation.

I wish to acknowledge the help given me by various members of the graduate school at McGill in offering advice and guidance during the preparation of this thesis. Special assistance was rendered by Mr. George Pajari in staining techniques and to Mr. Wm. Petruk in chlorite identification.

Special thanks go to Miss Carol Chipman for her patience and time in reading the manuscript and correcting English and spelling mistakes.

Finally to Dr. J.S. Stevenson I say "thank you" for your guidance and assistance as thesis director.

CHAPTER II

GENERAL GEOLOGYPrevious Work in the Area

Sir Wm. Logan (1863, p. 30) writes in his "Geology of Canada" that in most areas in the Eastern Townships, the ancient notion that metalliferous deposits are connected with eruptive rocks is not born out. He goes on to say that eruptive rocks are nearly absent from the area, that the diorites and serpentines of the Quebec group are sedimentary in origin with copper occurring chiefly in interstratified beds. Since copper is commonly found in the Quebec Group of rocks, he concludes that this metal must have been quite common in the waters from which these strata was deposited.

In 1870, Dr. James Douglas, in his paper "Notes on the Copper Deposits of Harvey Hill", (p. 47), points out that the so-called copper beds vary in width and copper content. His conclusion was that these beds are not beds and should be classified as impregnations.

In 1882, Dr. F.D. Adams investigated in thin section a suite of rocks from the Townships formerly labeled as being of sedimentary origin. His study revealed that such rocks as diabases, gabbros and diorites were igneous and not sedimentary. In the light of this information, Dr. R.W. Ells was appointed to re-examine the district.

Early workers in the area recognized three main belts of crystalline rocks. These are seen physiographically as three

approximately parallel ridges 25 to 30 miles apart trending in a southwest northeast direction. The rocks are Palaeozoic volcanic and sedimentary varieties almost wholly pre-Devonian in age with locally intruded bodies of igneous rock. The igneous activity belongs to disturbances associated with the Acadian Orogeny at the close of the Devonian Period.

Due to the lack of fossils and the fact that many of these rocks were crystalline and schistose, Dr. Ells concluded that the Palaeozoic rocks were altered sediments of Pre Cambrian age. Dresser, around the turn of the century, found that a very considerable portion of these so-called altered sediments were in reality metamorphosed igneous rocks. Bancroft, in 1915, during his study of the various copper deposits of the Eastern Townships, concluded that many of Dresser's highly altered volcanic rocks were actually schistose equivalents of fine to medium grained intrusive rocks. Many of the copper deposits, he said, are associated with altered rocks, rather than bedded deposits.

The Copper Belts

The three main belts of crystalline rocks mentioned above, are called by Dresser the Sutton, the Ascot and the Lake Megantic belt. The Ascot or Stoke Mountain belt passes through Hatley, Ascot, Stoke, Dudswell, Weedon and Stratford Townships, and contains the majority of the copper occurrences.

Bancroft (1915, p. 65) describes the rocks of the belt as being very schistose, consisting for the most part of chlorite and sercite schist. They strike northeast to southwest with a variable

dip of 35 to 50 degrees to the southeast. The chlorite schists are derived through metamorphism from diabase porphyrites, fine grained diorites or andesites, while the sericite schists are highly altered equivalents of quartz porphyry. Schists of sedimentary origin are not common. Mineralization, continues Bancroft, is at times associated with the sericite schist along the sericite-chlorite schist contact. Frequently, where the schistosity is well developed, rusty zones occur, and extend up to a hundred feet along the schistosity. These rusty zones vary in width from a few inches up to ten feet or more and contain disseminated pyrite cubes and some chalcopryrite. The shearing process has often been accompanied by local crumpling of the schists.

Geology of the Mines in the Area

Eustis Mine

The geology of the Eustis Mine has been compiled from reports written by Bancroft (1915, p. 69), Cooke (1950, p. 175), Douglas (1941) and Stevenson (1937, p. 335).

The lenticular ore bodies are found in sericite schist and arranged en échelon. They are up to 60 feet wide and do not exceed 350 feet in length. With depth the lenses narrow and swell and, at times, nearly pinch out. The lenses frequently overlap so that on certain levels parallel lenses of ore occur. For example, at the 3450 foot level, on the incline, four parallel lenses are present.

The ore bodies are located along a shear in the schists

and dip from 25 to 70 degrees with the rolls of the schist. The walls of the ore bodies are not well defined as the sulphides become more disseminated with distance away from the ore body. The zone of dissemination extends further into the hanging wall than the footwall. In some lenses, nearly replaced horizons of schist are enclosed in the ore, indicating that the sulphides have replaced the sericite schist wall rock. Post ore deformation is minor but has produced some brecciation in the ore and the wall rock.

Copper content varies from lens to lens but generally is higher toward the footwall, and less frequently higher at the hanging wall. The average copper content in one lens is no indication for the next lens. Only one lens is rich in copper, the other three are mostly pyrite and carry a low percentage of copper. The chalcopyrite lens has between 10% and 20% chalcopyrite, with most of the remainder being pyrite. The other two pyrite lenses contain approximately 1% chalcopyrite.

Faulting is not common. One post ore fault has displaced the ore about 60 feet. Dykes traverse the schist and ore bodies at the Eustis Mine. A study by Stevenson (1937) deals particularly with these dykes and their metamorphic effect on the ore. Their metamorphic zone extend out into the ore for about ten feet. Within this zone, such minerals as pyrrhotite, cubanite and the gangue mineral anthophyllite occur.

The main dyke is 40 feet wide and is a lamprophyre (Camptonite) variety. Others are olivine diabase, camptonite and monchiquite varieties, and range in size from small stringers up to the size of the main dyke.

The immediate rock around the mine is divided into two subdivisions, namely schistose quartz porphyry, which when it occurs near the sulphides becomes a muscovite schist. The schistose quartz porphyry has a porphyritic texture. The phenocrysts are quartz and albite with the occasional carbonate grain. Ground mass consists of fine grained quartz and feldspar, coarse grained muscovite, chlorite epidote and titanite. There is a suggestion of rotation of the phenocrysts of quartz as stringers of inclusions are arranged in sub-parallel rows. Albite phenocrysts similar in size to the quartz grains are free of alteration products, but may, on occasion, contain a few shreds of quartz. The chlorite is diabantite and occurs in a shreddy habit. It is not arranged in aggregates so does not imply derivation from pre-existing ferro-magnesium minerals. Chlorite is concentrated in bands of granular quartz that parallels the schistosity and is probably derived from hydrothermal solutions.

Muscovite schist occurs in the ore zone. It is highly sheared and contorted having been partly replaced by both the ore and green rock. Minerals of the muscovite schist consist of muscovite, quartz, chlorite, a carbonate quartz-albite veinlets and disseminated pyrite. The chlorite in the zone is Amesite and makes up about 5% of the rock. It occurs with sulphides as single laths and large fans, having been formed previously to the sulphides during an early hydrothermal stage.

A green rock is found as large blocks and sills in the muscovite schist. It is a massive dull green to light buff rock with a sub-conchoidal fractures and becomes rusty when oxidized. These blocks vary in size from a few inches up to 75 feet long and

from 3 feet to $\frac{1}{2}$ inch in width. Some residuals of schist are found in the green rock especially near the border. Ore replaces it and retains the imperfect banding that is thought to be derived from the original schistosity. The green rock contains euhedral grains of quartz, carbonate (ankerite) with inclusions of quartz, muscovite, rutile, and diabanite, a variety of chlorite.

Suffield Mine

The geology of the Suffield Mine has been compiled from reports written by Cooke (1950, p. 132), Carrier (1954) and Hawley (1945, p. 367).

The ore bodies occur in a rhyolite near the contact with Beauceville sediments. The contact strikes north and dips steeply to the east. The sediments which form the footwall are interbanded quartzite and black slates. A number of thin vertical easternly striking dykes cut all formations.

The porphyritic rhyolite is a light rock consisting of abundant phenocrysts of feldspar in a microcrystalline silicious matrix. A variable quantity of sericite or muscovite is always present in the rock. The rhyolite varies from a massive, very silicious type, low in sericite, to a highly foliated type. The feldspar phenocrysts are oligoclase, corroded and cloudy with incipient sericitization. The ground mass is composed of .02 to .04 mm. quartz and feldspar crystals with phenocrysts up to 2 mm. in diameter of quartz. Recrystallization has rendered the grains coarser and more uniform in size. Some grains could have been introduced later, but there is no real evidence for this. Ankerite metacrysts

are found in chloritized zones and range up to $\frac{1}{4}$ inch in diameter.

There is some difference in opinion as to the origin of the rhyolites. Both intrusive and extrusive origins have been postulated. Douglas (1941) suggests an intrusive origin and names the rock a quartz porphyry. Hawley (1945) and Cooke (1950) call it a porphyritic rhyolite.

From the writer's own reading on the subject and comparison of photomicrographs from these various reports, with the occurrence at Weedon, the writer concludes that the rock in which the sulphide lenses are found have characteristics of a rhyolite in which grains of quartz and feldspar seem to have grown as porphyroblasts. The glassy matrix has been definitely recrystallized and such minerals as biotite and chlorite have been developed during the shearing and recrystallization of the rock.

Carriere (1954) describes the sulphides, at the Suffield Mine, as having replaced a sheared breccia or a sheared contact between two different flows. The replacement of the schists in some of these zones has been almost complete, producing a nearly massive aggregate or mixture of metallic sulphides and gangue minerals. The metallic sulphides consist of pyrite, spalerite, chalcopyrite, galena, tetrahedrite and a small quantity of silver and gold. The ore is in two bodies, the first of which is nearly horizontal and occurs on the first level. It is nearly 400 feet long and 150 feet wide. Thickness varies between 8 and 15 feet. The second ore body lies between the first and second level and within the rhyolite. It is almost vertical, 500 feet long, 130 feet deep, and between 10 and 30 feet wide. Another section of this ore body occurs deeper and along the crest of a small fold.

Moulton Hill

The geology of the Moulton Hill Mine has been compiled from Dresser and Dennis (1949, p. 385).

In 1942, the Aldermac Copper Corp. Ltd., carried out a geophysical survey on lot 20 range III, Ascot Township, just south of the old Moulton Hill Mine. A zone of 600 feet in length and 1000 feet deep was located by diamond drilling. A vertical shaft was sunk, an inclined shaft raised and three levels were opened. Production was started in 1944. Undetected folding has narrowed the ore more than had been expected and had weakened the rock, so that mining was both costly and dangerous. Consequently, operations were abandoned in 1945. 35,175 tons of ore had been milled running at 1.4% copper, 5.78% zinc 1.95% lead with a trace of native gold and silver.

The ore occurred in a shear zone along or near the contact between highly schistose rhyolite and sedimentary schist. These strike northeast and dip 40 degrees to the southeast. Replacement of the quartz rhyolite by sulphides yielded discontinuous bands of massive ore, varying from a few inches up to 8 feet in width. Disseminated zones of sulphides occur next to the massive bands. Pyrite is the prominent sulphide with variable amounts of chalcopyrite, sphalerite and galena.

General Geology of the Weedon Mine Area

The rocks found at the mine include a series of interbedded basic and volcanic lavas, with possibly a few tuffaceous beds. A couple of beds of recrystallized fine grained chert are found in this series. These formations strike in a northeasternly direction with a

general dip of 45 degrees to the southeast.

The writer has compared the occurrences and petrology of the volcanics at the Weedon Mine with written reports of other mines along the same geological belt. It seems from the reports and their accompanying photomicrographs that the occurrences of recrystallized quartz rich acid volcanics are common to all the mines. Also, in some form or other chloritic zones occur in proximity to the ore bodies, and have in most cases been found to be genetically related to the sulphide bodies.

Approximately 23 square miles around the mine at Weedon was mapped in detail (500 feet to the inch) by Mr. Duquette and his assistant, the writer. It was found that the volcanic formation in which the mine is located, continues along strike for several miles to the southwest. Northeast along strike this formation is cut off by the granite intrusion.

To the west of the volcanics, a small band of argillaceous shales and phyllites is found. Beyond this, another small chlorite zone occurs that could possibly be further volcanics, as inclusions in this formation suggests either pyroclastic bombs or flow breccia. This whole formation of rhyolites and argillaceous shales was called by Cooke (1950) the Sherbrooke formation. Further west, approximately one half mile from the mine, Cooke maps a formation called the Lake Aylmer Group, consisting of bluish limestone.

A light colored muscovite biotite granite of Devonian age cuts all formations. The stock occupies an area of approximately 16 square miles and is a predominant feature of the countryside. This granite is quarried on the opposite side of the intrusive

from the mine and taken to St. Gerard by truck for cutting and polishing in the manufacture of monuments and building stone.

General Mine Geology

Quartz Sericite Schist

The ore bodies are located in a shear zone within a quartz sericite schist as is generally the case with other mines in the area. This very quartz rich schist consists of a fine ground mass of sericite and recrystallized sutured quartz grains, with larger quartz and feldspar grains. The more quartz rich sections of the quartz sericite schist have fewer of these grains, probably because the rock would be more competent in these zones, and thus greatly milled at the time of the granite intrusion. This milling would destroy the larger grains. This particular type of quartz sericite schist is found at the north end of the lens and is characterized by being very hard, brittle and massive. It occasionally has a few very fine shears and fractures which are filled with sericite and biotite.

In the immediate vicinity of the ore body, for a distance of approximately 300 feet in the hanging wall, on the surface, the quartz sericite schist has been highly altered by hydrothermal solutions from the sulphide invasion, with the development of anthophyllite, calcite, actinolite and chlorite. When exposed to the weather, this rock weathers to a very rusty, green and friable rock. This zone of rock shows a slight banding that is due to relic schistosity. The matrix is recrystallized quartz and feldspar with small phenocrysts of quartz and feldspar. Biotite and chlorite has grown in random orientation through the matrix. This hydrothermally altered

zone finally grades out into the "fresh" regionally metamorphosed rock which is the quartz sericite schist and another type of rock probably once a basic lava, but called in this report a greenstone.

Chlorite Quartz Sericite Schist

Another volcanic rock in the formation consists of plagioclase feldspar, chlorite and a little free silica, which would give the rock a composition similar to that of an andesite. This rock type is confined to the footwall of the mine, and instead of being finely ground and becoming a mylonite as the adjacent quartz rich rock did during deformation, it failed with the development of widely spaced shear planes. These shear planes, at the present time, consist of light and dark green bands spaced about $\frac{1}{4}$ inch apart. The light bands are mostly fine recrystallized quartz grains and larger plagioclase feldspar crystals. Within this quartz matrix amphibole crystals of the tremolite-actinolite series occurs as laths and rosettes. The darker green bands are the shear surfaces in which the original biotite has altered to chlorite, with the extra iron from the biotite forming trains of magnetite. Some minor drag folding has been developed in the banding. Hydrothermal solutions and a general rise in temperature associated with the granite intrusion altered the biotite originally along the shearing and converted it to a chlorite, and within the matrix of the rock, green actinolite was developed.

Greenstone

This greenstone was originally a more basic flow than any previously described lithologic unit at the mine. On the surface it

occurs about 400 feet in the hanging wall and although it is not in contact with the ore, nor is it found in the underground workings, it is being included in this discussion because it is one of the ore controls. Like the rest of the rocks in the mine area, it has been sheared. Along these shears chlorite is found, as before, and the matrix consists essentially of plagioclase feldspar, sericite and actinolite. A short distance away from the granite metamorphic aureole, this formation becomes more massive, the intense shearing dies out, and in addition, epidote phenocrysts and calcite are found. A mile along strike of this formation, pillow-like structures were found, indicating the possibility that the rock had an extrusive origin.

Granite

Granite cuts all the formation present and is thought to have originated during the time of the Acadian Orogeny in the latter part of the Devonian Period.

The granite body is just over 4 miles in diameter. Its contact with the country rock lies about 1200 feet northeast in the hanging wall of the ore lenses, and dips steeply west to intersect the ore zone at the 14th level. The sump of the number three shaft is in the granite. The granite is then conformable with the shear or ore zone from the 14th level up to the 9th level as it occurs as the hanging wall in these levels. The granite is frequently pegmatitic at the contacts. Along the contact of the granite and the country rock up to one foot of massive biotite may occur.

Large pieces of the country rock has been stopped off and

f

lie within the granite mass. This phenomenon is very common on the 15th and 16th levels. These xenoliths were then replaced with biotite in many instances. In thin section often the recrystallized sutured quartz matrix can still be seen, even though 80 to 85% of the rock is biotite. Relic banding due to the original schistosity of the country rock is still visible. Around these inclusions in the granite, is a lighter aureole devoid of all ferro-magnesian minerals.

At a later stage of the cooling of the granite, sulphide solutions arrived from below and worked their way up along a mylonitic zone in the schists to the surface. At the same time, the sulphides partly, and in certain cases, completely replaced the biotite xenoliths in the granite. The end result is that two ore bodies were formed along mylonitic zones and variable sized sulphide blocks were formed in the granite. These sulphide bodies within the granite are usually very good sources of ore, although there is no geological means of predicating their location, except by an extensive drilling program. Even this method may not be too effective in outlining tonnages, since these mineralized inclusions may vary from 6 inches or several pounds to 30 feet in diameter or a couple thousand tons. The copper grade of these inclusions is usually high. An inclusion on the 15th level assayed as high as 15% copper. The inclusions may be nearly all chalcopyrite, all pyrite, or a mixture of the two, with or without pyrrhotite.

Ore

The sulphide mineralization consists of pyrite, chalcopyrite sphalerite, pyrrhotite and minor galena, and from this ore pyrite,

copper and zinc concentrates are recovered by a floatation process.

The more basic volcanics, such as the chlorite quartz sericite schist and the greenstone, yielded to stress induced by the granite by shearing along many parallel shear planes. The more quartz rich rock, on the other hand, instead of failing and developing a coarse shear system, as the footwall, was highly sheared and became a mylonite. Two such mylonite zones were developed which gave rise to the main ore lens and the smaller footwall lens. These lens strike with the regional schistosity, N 35 E and dips 45° to the southeast. The two lenses are mineralogically similar. The footwall or number two lens averages about 6 feet in width, which was not large enough to be profitable in the early days of the mine and, therefore, did not warrant development. Additional minor stringers of sulphide mineralization up to one foot width occur in the wall rock between the two ore bodies. The contact with the country rock is quite sharp and only on the hanging wall of the main lens is there any great amount of dissemination. Horseshoes of unreplaced schist occur in both lenses.

All of the ore in the main lens had been mined so could not be examined by the writer. However, Bancroft (1915, p. 276) describes the ore as being granular pyrite, chalcopryrite with some pyrrhotite, minor scattered grains of zinc blend and galena. This is similar to what is found on the lower levels. On the 15th levels, it was noted by the writer that massive chalcopryrite occurs much more abundantly at the ore body-wall rock contact. The core of the lens is composed of mostly massive pyrite grains with chalcopryrite and minor sphalerite surrounding the grains.

CHAPTER III

DETAILED MINE GEOLOGYQuartz Sericite Schist

This rock in hand specimen is light grey to blue grey, very homogeneous, hard and brittle. Striking it with a prospecting hammer gives a steel ringing sound.

A thin section study of specimens of this rock from the northern end of the ore lens shows the rock to be composed of mostly a very fine grained sutured recrystallized quartz. The rock is megascopically homogeneous with more or less parallel fracturing spaced between 2 and 3 mm. apart. This fracturing conforms to the general schistosity of the region and probably originated at about the same time as the zone of rock, which has now been replaced by sulphides, was ground and milled to a mylonite. These fractures were originally filled with biotite and has since nearly all been hydrothermally altered to chlorite by the sulphide invasion. The extra iron contained in the biotite, when it was altered to chlorite, crystallized out as magnetite. Megascopically these fractures appear as fine black lines in the blue-grey rock.

Throughout the quartz rich matrix larger grains of plagioclase occurs. They are highly corroded and only rarely show albite twinning. Needles approximately 1 mm. in length and rosettes of anthophyllite occur within the matrix of quartz grains. This anthophyllite was derived from the chlorite by thermal metamorphism and possibly some hydrothermal processes associated with the granite intrusion. Near the northeast end of the ore body, this rock was

found to be brecciated into 0.5 mm. to 1.0 mm. particles. The fragmental rock particles are surrounded by dark finely divided biotite flakes, resembling that found in the smaller fractures.



FIG. 3
Polished section of a breccia, the particles being surrounded by chlorite.

The specimen represented in figure 3, located closer to the ore body, is a polished section consisting of a brecciated quartz rich rock, chlorite and disseminated sulphides. The biotite surrounding the rock fragments has been altered to chlorite. Brecciation in this zone has produced rock fragments up to 3 cm. long. The chlorite surrounding the particles contains disseminated pyrite and a trace of chalcopyrite.

Away from the alteration at the granite contact and the alteration associated with the sulphides, the quartz sericite schist becomes coarse grained and contains quartz and feldspar grains. This

is the rock described by Bancroft (1915, p. 276) as quartz porphyry. In hand specimen it is very light colored, with quite a lot of sericite developed along the shear planes. Quartz eyes can be seen in some zones of the rock. Compositionally this rock is the same as the quartz sericite schist described above, but this section has not had the larger grains destroyed by differential movement.



FIG. 4 40 X
Texture and Structure of Quartz Sericite Schist.



FIG. 5 40 X
Texture and Structure of Quartz Sericite Schist. (Crossed Nicols)

Figures 4 and 5 show the texture and structure of the quartz sericite schist. Sericite occurs along the shears and is bulged by larger grains of quartz and feldspar that appear to be either porphyroblasts or phenocrysts. Sericite also occurs within the matrix as small flakes and is orientated in the direction of maximum shearing stress. Figure 5 under crossed nicols shows the matrix of fine sutured recrystallized quartz grains. The larger crystals in this specimen are clear and usually are single crystals of quartz. Some grains have a wavy extinction indicating that they have been strained subsequent to their formation.



FIG. 6 40 X
Texture and Structure of Quartz Sericite Schist. (Crossed Nicols)

In figure 6, the same type of quartz sericite schist is represented, but it has not undergone as intense shearing as the specimen in figures 4 and 5. The larger crystals are still angular, although they have been shattered and broken. Sericite is found around the borders and occasionally in between the particles. The rock in hand specimen is a massive dark blue grey rock with clear quartz "eyes". In thin section, these "eyes" are the larger crystals. In addition to the quartz crystals, plagioclase feldspar occurs as larger crystals as well. Their composition is oligoclase, Ab_7An_3 and their size varies from 0.5 mm. to 1.3 mm. Often the plagioclase feldspar crystals have had fine flakes of sericite developed within them.

Grout (1932, p. 356) in his criteria for distinguishing metacrysts (synonymous with porphyroblasts) and phenocrysts, gives a number of minerals that would definitely form as porphyroblasts and another group that are uncertain. Quartz and feldspar fall into the uncertain group and could either occur as porphyroblasts or phenocrysts. If flow structure was present or if the crystals transgressed the structure, then the crystals would be porphyroblasts. These crystals at Weedon have undergone deformation after their formation and have been rolled so that it is impossible for them to transect the structure. The schistosity bends around the crystals and they parallel the structure as seen in figures 4 and 5, so their origin is uncertain. Grout goes on to say that abundant inclusions of other minerals in the larger crystals would suggest strongly a porphyroblastic origin for the crystals. The quartz and feldspar crystals in the quartz sericite schist at Weedon are nearly devoid of inclusions except for fine flakes of sericite. Although not conclusive, this would seem to indicate that the crystals were phenocrysts.

Heinrich (1956, p. 177) in listing characteristics of porphyroblasts gives zonally distributed inclusions, better known as poikiloblasts or sieve structure as a strong criteria for porphyroblasts. He says that porphyroblasts will be developed when the rock has undergone two stages or kinds of metamorphism or a metasomatic introduction of elements to make up the porphyroblasts. At Weedon, the writer does not believe that any material has been introduced metasomatically to form the crystals because these crystals are found in the quartz sericite schist some distance from the mine further away than what would be effected metasomatically.

In thin sections examined, no poikiloblastic or sieve structure has been found, although it still may have existed at one time and has since been destroyed by later metamorphism. The rocks at the mine have undergone several stages of metamorphism. They were originally metamorphosed from rhyolites to the greenschist facies by regional metamorphism. With the granite intrusion, they were again metamorphosed and a third metamorphism was associated with the sulphide invasion.

The evidence is still not conclusive as to whether these grains are porphyroblasts or phenocrysts. If they are porphyroblasts they would have to have originated during regional metamorphism as they are not confined to the mine area but are found in the quartz sericite schist for its entire length. If the rock was originally a rhyolite porphyry, as it probably was, then these grains would be phenocrysts, and the evidence seems to suggest this origin for the grains. For the sake of simplicity, these grains of feldspar and quartz will in the future be referred to as phenocrysts.



FIG. 7 40 X
Altered quartz sericite schist (crossed nicols).

The rock specimen represented in figure 7 occurs in a more highly altered portion of the aureole. The phenocrysts have been nearly completely altered to biotite and the biotite in turn has altered to chlorite and magnetite. Thin needles of random orientated sericite occur throughout the matrix of recrystallized quartz grains.

Hydrothermal solutions and thermal metamorphism associated with the sulphide intrusion has converted the chlorite found along the shears to anthophyllite. This phenomenon is illustrated in figure 8 where needles and bundles of anthophyllite radiate out from nucleii of chlorite. The original shears are still seen in the rock. The clear matrix consists of fine recrystallized quartz.



FIG. 8 40 X
Alteration of chlorite to anthophyllite.

The quartz sericite schist, although its texture may vary from one location to another, remains nearly constant in mineral composition throughout the area. It is made up of approximately 75 to 80% quartz. The amount of sericite varies from one location to the other depending on the shearing, and may constitute up to 5% of the rock. The rest is made up of sodic plagioclase feldspar. The extinction of the albite twins, cut normal to the (010), was measured and found to average around 10 degrees. The index of the fast ray may, at times, be greater or just less than the balsam. From the Michel-Levy graph, this places the plagioclase in the oligoclase range. Textural variations in the quartz sericite schist are controlled partly by the original composition, but to a greater extent by mechanical deformation due to regional metamorphism and the granite intrusion.

During regional metamorphism, the rocks reached the green-schist facies of metamorphism. At this time, the rocks were sheared with the development of sericite along the schistosity. Phenocrysts of quartz and feldspar formed. The ground mass which was probably glassy, became recrystallized. This is shown by the characteristic fine sutured quartz grains that go to make up the matrix.

With the granite intrusion, this very quartz rich rock instead of yielding along previous planes of schistosity, was instead smeared or milled between the more resistant layers of the footwall and the greenstone in the hanging wall. This milling and grinding effect rendered the quartz sericite to a mylonite. After the sulphide invasion, the mylonite was recrystallized. This action gives the rock its characteristic aphanitic somewhat flinty appearance. Under the microscope the matrix is streaked, intensely granulated and the scattered phenocrysts show various stages of mechanical degradation.

The greatest mechanical deformation is due to the granite intrusion. Examples such as figure 6 shows the rock to be well sheared, the matrix recrystallized and the phenocrysts strained but not broken. Closer to the ore body, the rock, figures 5 and 6, has undergone a greater deformation and the phenocrysts are shattered. Next to the ore body, not illustrated, the rock has undergone extreme mechanical deformation to the point where phenocrysts have been obliterated.

Burton (1933) in his thesis on the Lake Aylmer region, 5 miles to the north of the mine, assumed that a thrust fault with a displacement of several miles passes through the mine area and he called it the Weedon thrust. In the light of more recent studies,

(Duquette - 1958) it is not necessary to explain the pattern of formations as due to an overthrust, nor is the evidence conclusive enough to say that faulting of this magnitude has occurred.

Cooke (1950) accepts this theory and maps many faults along contacts in the area, i.e. in his Sherbrooke formation. Some of these faults may certainly exist, but no evidence of them was seen in the map area. Bancroft (1915, p. 278) mentions the occurrence of one fault in the mine workings. The fault did not interfere with mining operations except for a quantity of water which came out of the break.

The writer, therefore, believes that faulting in the immediate mine area is not present except for this one fault described by Bancroft. Intense local shearing from differential movement of incompetent formations between competent layers has taken place. The result is that the incompetent brittle beds of the quartz rich rock have become highly broken and milled. This has given the rock a certain amount of porosity and a large surface area available so that later sulphide solutions could readily attack and replace the rock.

Crickmay (1933, p. 161) in his discussion of occurrences of mylonites in Georgia, says that mylonites appear in local zones where differential movement has occurred. He has noted that there is a "slight cataclastic effect" and the rock "appears to be a pseudo-tachylite". Larger grains of feldspar and garnet resist crushing. He continues; "The zones are not of great width and may be discontinuous. Porphyrocrysts have only peripheral crushing, because smaller grains are attacked first, while the larger ones roll, crack on the edges and become eyes. There is some microbrecciation, but under the right

pressure and temperature conditions, the rocks will retain its coherence. There is some development of muscovite".

It is nearly impossible to determine the original nature of the rock in the immediate vicinity of the ore zone. The minerals present indicate generally that the original rock was an acid flow which has been altered to the present quartz sericite schist described above. Generally, the rock has a matrix that is high in quartz. Some zones contain additional minerals, derived by alteration of former minerals in the quartz rich rock, while other zones have a mineral assemblage that indicates a somewhat more basic original rock. For example, the calcium and aluminum used to make such minerals as diopside and hornblende could only come from an original more basic rock than the quartz sericite schist. Hydrothermal solution and thermal metamorphism from the granite intrusion would be sufficient for these minerals to form.

Examining more closely the location of these minerals assemblages around the lenses, it is interesting to note that minerals characteristic of a more basic rock than the quartz sericite schist occur between the ore lenses. Since acid and basic flows are interbedded in this region, it is not unreasonable to conclude that the ore lenses are separated by a somewhat more basic rock than the quartz rich rock. The control of the ore bodies lies in the fact that the quartz rich rock (now the quartz sericite schist) was sheared and made mylonitic much more readily than the basic rock. These two mylonite zones were then replaced by sulphides forming the two ore lenses.

In addition, upon consulting Murray's thesis (1954, p. 130) on wall rock alternation, it was learned that his chemical analysis

(analyses by Laboratories Branch, Quebec Dept. of Mines) showed a definite decrease in iron and magnesium content as both ore zones were approached, and at the same time, a definite rise in silica content. This is significant in that it shows the rock between the ore lenses to be different from the rock in which the sulphide lenses are found, and further, the rock between the lenses is also more basic, thus unsheared. Metamorphism and metasomatism associated with the granite intrusion produced in the acid and basic rocks two different mineral assemblages. In the acid rock biotite, cordierite, and anthophyllite were formed, because of the low iron and magnesium content. In the more basic volcanics where more iron, magnesium, calcium and aluminum are present, minerals such as diopside, biotite and hornblende were developed.

On the surface, a large area of very rusty friable schists, up to 300 feet in the hanging wall of the main lens is found. It is confined entirely to the hanging wall and decreases in the degree of alteration out from the ore body. Typical outcroppings of this rock occur around the water reservoir.

The schist is composed of approximately 70% chlorite, 20% quartz, 9% anthophyllite and 1% biotite. There is a slight indication of banding in the less altered zones. These bands, in thin section, were found to consist of recrystallized quartz bands separated by narrow bands of chlorite and less often chlorite and anthophyllite mixture. This rock was originally the quartz sericite schist with the biotite banding and has had chlorite introduced into it at the time of the sulphide mineralization. The chlorite in this zone is different from the chlorite that is derived from the biotite. The

chlorite derived from the biotite invariably has magnetite associated with it. The chlorite in the altered zone has no magnetite, is pleochroic (yellowish and green) and has a greyish olive-green color under crossed nicols. The regular chlorite derived from biotite, on the other hand, is somewhat darker green in plane polarized light and dark, almost opaque brown, under crossed nicols. In addition, this altered zone occurs only in the hanging wall, and only in the immediate vicinity of the sulphide mineralization. This altered zone could not be traced underground, as upper levels have been mined out previous to the closing of the mine in 1921, making access to the hanging wall virtually impossible.

Chlorite Quartz Sericite Schist

This rock is confined to the footwall of the mine. No mineralization occurs in it. It is approximately 200 feet wide and extends from $\frac{1}{4}$ mile southwest, along strike to the mine and beyond to where it is cut off by the granite. On the fresh surface, it is unformally green color but with light and dark bands. The band spacing varies from 1 to 7 mm. and is slightly dragfolded in certain areas. Weathering has penetrated up to 7 mm., bleaching the rock to a much lighter green color. The weathering has attacked the actinolite in the felsic sections between the shears, removing the iron and breaking down the amphibole to the point where only the light colored quartz and feldspar is left. The chlorite is more stable and remains along the shears giving the green bands.



FIG. 9
Banded chlorite quartz sericite schist.

Figure 9 shows a portion of the banded chlorite quartz sericite schist with its typical banding. The banding is very regular in this portion, but in some areas it may be drag folded and bent indicating that the rock has undergone a certain amount of deformation since its formation.

In thin section, the central part of the dark bands consists of dark green chlorite appearing almost opaque brown under crossed nicols.



FIG. 10 40 X
Chlorite along shears in the chlorite quartz sericite schist.

Figure 10, in plane polarized light, shows the chlorite as a lighter material in the central part of the shear. On the outer edges of the shear, the darker mineral is talc. In less altered areas needles and rosettes of actinolite occur, but generally the actinolite

has altered to talc. The matrix is feldspar and quartz, with feldspar predominating. The feldspar content is much higher in this rock type than in the quartz sericite schist. The composition of the feldspars cannot optically be determined as they are too highly altered, and contain no well developed reasonably homogenous crystals.



FIG. 11 40 X
Structure and texture of chlorite quartz sericite schist.



FIG. 12 40 X
Structure and texture of chlorite quartz sericite schist (crossed nicols)

Figures 11 and 12 show a portion of this same formation, to illustrate the fine quartz-feldspar matrix and the trains of magnetite contained within the chlorite of the shears. Under plane polarized light, Figure 11, the chlorite filled shears occurs as dark bands. Opaque spots within the bands are magnetite crystals. They also occur to a lesser extent throughout the matrix. Under crossed nicols, the chlorite in the shears appears nearly opaque. The fine grained matrix of the quartz and feldspar between the shears is well illustrated and typical of this banded footwall rock.

Occasionally in thin sections, but not illustrated in these photomicrographs, elliptical sections with a "swirl" pattern has been noted. This is thought by the writer to have been caused by rotation

of the phenocrysts. No phenocrysts as such are present now, as they have all been rolled and subsequently crushed by differential movement.

The writer is of the opinion that not too great an amount of iron and magnesium, which was used to make up the chlorite and actinolite, was introduced. The adjacent igneous activity, being a granite, certainly would not have any great amount of these elements to migrate into the country rock. Therefore, it is reasonable to assume that these minerals were already present in the rock as either amphiboles or possibly pyroxenes. Thermal metamorphism and hydrothermal solutions at the time of the granite intrusion would be sufficient to give the grade and degree of alteration observed in these rocks. Considering the amount of feldspar, quartz and mafic minerals, the original unmetamorphosed rock would have the composition of an andesite. Andesites (Tyrell, 1955, p. 126) consist of over one half felsic minerals and the rest mafics. Up to 10% free quartz may be present. This formation, the writer concludes, generally conforms to this classification, although with such an altered rock attempting to name the original rock is most difficult.

This characteristically banded rock was not encountered anywhere else in the 5 minute map. It is believed to have been derived from the original rock only after several periods of metamorphism. Originally, the rock was stressed and then sheared by regional metamorphism with the development of schistosity. Biotite and/or sericite was developed along these shear surfaces. With the granite and attendant hydrothermal solutions and thermal metamorphism, the biotite was converted to chlorite and magnetite. The

mafics in the ground mass of the andesite were altered to actinolite. With the same disturbance the banded formation underwent deformation which produced drag folding. At the time of the sulphide mineralization much more local metamorphism altered the actinolite to talc.

Greenstone

This zone consists of a massive chloritic rock, with epidote porphyroblasts. It is located approximately 400 feet in the hanging wall of the mine. Although not occurring in the workings, it is being included in the discussion as it is part of the ore control. Structurally, it is a competent layer lying above the incompetent quartz sericite schist, and the competent banded chlorite quartz schist in the footwall.

Megascopically, the rock is quite homogeneous dark green and massive. Darker green stripes are found in some zones of the rock but not to the same extent as in the footwall rock. These darker stripes are composed of chlorite, and located in shear zones. This formation has been traced along strike for several miles to the southwest. Its variation in width can be explained by the assumption that it is a lava flow. The chlorite stripes located along fracturing becomes inconspicuous approximately $\frac{1}{4}$ mile along strike from the mine, as the fracturing which is due to the granite intrusion dies out. Undeformed greenstone has epidote porphyroblasts scattered throughout the rock.

In thin section (plane polarized light) the chlorite along the shearing is light green, mottled, and quite pleochroic, varying from nearly clear slightly yellowish color to light green, in the

maximum absorption direction. Under crossed nicols, this same chlorite becomes a dark olive drab. The matrix between the chlorite bands is composed essentially of plagioclase feldspar. ($Ab_{86} An_{12}$, "n" less than balsam, extinction 10°). As well as granular feldspar in the matrix, there are some phenocrysts of feldspar.

Isolated laths and rosettes of green actinolite lie within the matrix, and constitute not more than 10% of the total rock. Approximately 5% of the rock consists of talc located along some of the shears. Little, if any, quartz appears in the rock except occasionally there is secondary quartz along breaks. Later calcite appears along fractures and shearing. About $\frac{1}{4}$ mile away from the granite, scattered phenocrysts of epidote appear throughout the rock. Megascopically this epidote is very light yellow-green. In thin section, in plane polarized light, it is clear to slightly yellowish. Under crossed nicols it has moderate interference colors and extinction is parallel to the length of the crystal. The beta ray is characteristically lengthwise of the crystals making the crystals length slow and optically ~~negative~~. The $2V$ is moderately high, approximately 75° . In some phenocrysts, the epidote crystals have been broken and separated with a clear homogeneous quartz filling the spaces in between. Calcite occurs as patches made up of individual grains which are equigranular and at various orientations. The matrix is approximately 50% actinolite and chlorite mixture and 50% fine grained plagioclase feldspar. The feldspar has been highly altered so that only poorly defined albite twinning can be observed. The feldspar phenocrysts contain many incipient alteration products within each grain. Feldspar phenocrysts appear to have been rotated during deformation, and in all probability

the epidote phenocrysts have been rotated as well. This would, in part, account for their cataclastic and broken appearance. Chlorite is found as scattered laths throughout the rock. In zones where the rock has been sheared more chlorite will be found in these shears.

Where this formation passes into the highly altered chloritic zone, described in the section under quartz sericite schist, it loses all its original texture and mineral characteristics. However, the formation can be traced for a short distance in the altered zone by the predominance of actinolite.

Granite

All formations in the area are cut by a granite stock, of Devonian age. The granite is approximately 16 square miles in area and lies in ^aportion of Weedon, Lingwick, Winslow and Stratford Townships. It cuts the volcanics at the mine on surface approximately 1000 feet in the hanging wall of the main lens, and dips steeply to the west.

Burton (1933) has studied the northern portion of this intrusion where it occurs on his map area, and also in the nearby quarry which he describes in his report to the Quebec Dept. of Mines "Commercial Granites of Quebec".

The granite next to the Stratford pyrite deposits, according to Burton, is a medium grained muscovite-biotite even textured granite. The essential minerals are quartz, microcline, oligoclase, muscovite and biotite. Accessory minerals include apatite, "black iron mineral" and zircon. Secondary minerals include garnet, sericite

and limonite. Burton's thin sections were composed of 30% quartz; 42% microcline, 20% oligoclase, 2% muscovite, 1% biotite, 1% black iron mineral, numerous grains of apatite, zircon, limonite, sericite and one grain of garnet. He concludes that since leucoxene is absent the black iron mineral is probably magnetite. The average grain size is 1 mm.

Burton (1933, p. 189) studied in more detail the granite from the quarry, which is located on the other side of the granite stock from the mine. The quarry is in the main part of the intrusive away from all contact alternation effects. Three Rosiwall counts give the following information. (After Burton).

Percentage Volume of Important Minerals

	Quartz	Feldspar	Ferro- magnesium minerals and Muscovite	Accessories
section cut along the rift	13.18	84.20	2.57	0.12
section cut along the grain	13.31	86.30	-	0.32
section cut along the hardway	25.78	71.30	2.84	0.06
average per cent volumes	17.42	80.60	1.80	0.17

The granite is practically unaltered apart from a slight sericitization of feldspar and small amounts of limonite produced by weathering of biotite.

The writer has noticed that certain portions of the granite from the quarry have some schlieren structure or segregation of mafic minerals such as biotite, which occur as long stringers up to several feet long.

Pegmatitic structure has been found on the contact with the country rock, underground in the mine and in the field. Aplite dykes cut the granite. One occurrence is approximately $1\frac{1}{4}$ miles east from the mine workings. In addition, Bancroft describes an aplite dyke in the upper levels of the mine. This dyke cuts the ore, and from this Bancroft supposes that the granite intrusive is younger than the ore. Actually, the granite is older, than the mineralization, and the aplite dyke is a later phase of the intrusion. At the time when Bancroft studied the mine, the lower levels had not been developed and he did not have the advantage of studying the granite-ore relationship. The granite in the mine workings is similar to that described by Burton from the quarry and the Stratford pyrite showing. Immediate to the wall rock, the granite has altered slightly to a green color.

On the 15th level, where much of the development is in granite, the granite is quite often pegmatitic. Large clear low quartz crystals up to 6 or 7 cm. were found in vugs, associated with the quartz crystals were calcite crystals in the form of "nail head" crystals (prism faces are prominent with rhombohedral terminations). Nearby in the rock, where there are some open joints, dog tooth calcite crystals occur, the largest being 1.5 cm. long.

Wall rock inclusions

From the 15th level down, the granite has stopped the wall

rock and completely or partially digested the blocks. All stages of digestion may be found from fresh wall rock to where the inclusion has nearly been completely replaced.



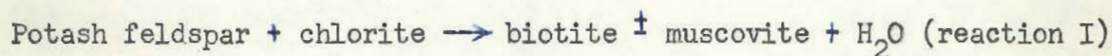
FIG. 13
Partially replaced inclusion in the granite.

Figure 13 is a photo of an inclusion of country rock in the granite. Inclusions such as this are common on top of the granite stock, where this photo was made, as well as in the mine. Schistosity and the angular shape of the inclusion has been preserved very well. Inclusions in the mine vary from this slightly altered type to one that is highly silicified and partially digested as in figure 14.



FIG. 14
Almost completely replaced inclusion in the granite.

Schistosity still is indicated by biotite bands and siliceous replacement zones derived from the granite. Just why some of these inclusions are partially digested and silicified by the granite while others were biotitized, presents a problem. However, if a portion of the country rock was stopped off while the granite was hot, the most probable reaction would be digestion of the block. Blocks broken off later when the granite was cooler would not be digested but instead would be replaced by biotite according to the following reaction given by Ramberg (1952, p. 214).



The potash feldspar is readily available to the reaction from the microcline of the granite, and the chlorite comes from along the shears of the country rock. Ramberg says that;

"The biotite which forms has a considerably greater affinity for iron than has the chlorite mineral. Therefore, the reaction zone represents a place of lower molar free energy of iron than the surroundings. If these elements are mobile, they are forced to migrate toward the reaction zone of growing biotite and concentrate therein."



FIG. 15 (crossed nicols) 40 X
Abrupt contact between granite and an inclusion.

Figure 15 shows the abrupt change between the granite and a biotite inclusion. The biotite appears as small randomly orientated laths, while the larger grained mosaic is granite. These inclusions generally retain their angular shape very well. In nearly every case, the original schistosity may still be seen as banding in the biotite inclusion. This banding has a different orientation for each inclusion in the granite indicating that the inclusions were free to be rotated within the molten granite after they were stopped free of the country rock. These inclusions vary in size from a few inches

in diameter up to 30 feet. Outside the inclusions, the granite is void of any mafics, so that each inclusion is surrounded by a white halo or reaction rim.



FIG. 16
Inclusion in granite surrounded by a halo or reaction rim.

Ramberg (1952, p. 214) describes this phenomenon as a diffusion reaction. He states that;

"If some of the minerals (biotite) forming in the reaction zone have a great "affinity" for a certain element which occurs in the surroundings, this element (this case potassium and iron) will trend to concentrate in the zone, being substracted from the environment by means of diffusion toward the partial free energy depression in the reaction zone. Elements with weak or no affinity for the newly stabilized reaction minerals will be expelled from the newly formed lattice and are thus forced to diffuse out from the reaction zone."

This is what appears to have happened in the granite.

Potassium and iron has diffused from the granite into the inclusion to react and produce biotite. The elements that go to make up the

lighter colored minerals were diffused out of the inclusion of wall rock and came to rest on the border producing the white halo.

Since microcline from the granite and chlorite from the country rock combine to form biotite (reaction I), then around these inclusions there should be less microcline, or at least smaller crystals. In an attempt to check this reaction, sections of granite and various inclusions were cut, roughly polished and stained to determine if there was any increase or decrease in microcline around the inclusion. The experiments were not conclusive, from the writer's observations as the amount of microcline did not seem to vary around the inclusion. However, this does not prove that the reaction did not take place. In order to exhaustively test this reaction, many samples would have to be run from the inclusion up to several feet or more away from the inclusion, or to the point where one was satisfied that the granite was statistically normal.

The inclusions vary one from another as to the degree that they have been replaced by biotite. The reason for the varying degree of replacement is reaction time and/or initial composition. The percentage of chlorite varies from one section to the other of the wall rock, depending on the degree of shearing and the associated chlorite along these shears. Chlorite is a component of reaction I so the amount of chlorite is a function of the quantity of product so formed by the reaction.

Sulphide Replacement of Biotite Inclusions

During the sulphide mineralization stage, these biotite inclusions in the granite were replaced by sulphides.



FIG. 17 40 X
Replacement of biotite by sulphides

Figure 17 illustrates replacement of biotite laths by sulphides. Replacement begins on the border and along cleavages of the biotite laths. Along this same line, mineralization quite often begins at the granite-biotite inclusion contact and replaces the inclusion wholly or in part.



FIG. 18 40 X
Sulphides beginning to replace a biotite inclusion.

Figure 18 illustrates this contact with a zone of sulphide mineralization along the contact. The lower part of the photo is the granite and the upper section is the biotite inclusion. Note periphery replacement of the biotite laths by sulphides similar to figure 17.



FIG. 19
Sulphide inclusions in granite.

Figure 19 shows a sulphide inclusion in the granite. The larger inclusion is pyrrhotite and the smaller inclusion to the right is chalcopyrite. The pyrrhotite has nearly completely replaced the original biotite inclusion. The area nearest the tape scale is still mostly biotite. The smaller inclusion of chalcopyrite on the other hand has very little of the original biotite in it. Note the white two inch aureole or halo immediately next to the inclusion. Beyond the aureole the granite resumes its normal biotite content.

In some instances, this halo effect is not present, but rather the opposite, that is, around a mineral inclusion a border of biotite is found. This border of biotite may range up to 1.5 cm. in width. After observing numerous occurrences of sulphide inclusion surrounded by biotite, the writer noticed that when the inclusion consisted of pyrrhotite, it would be surrounded by biotite. It would seem that the iron that went to make up the pyrite and pyrrhotite of the inclusion reacted with the potassium bearing granite to form the biotite found on the periphery of the inclusion. Chalcopyrite replaced

not only the pyrite and pyrrhotite inclusion, but also the biotite aureole surrounding the inclusion. For this reason, chalcopyrite inclusions are not as angular as other inclusions, because some of the granite has been replaced and they do not have the biotite aureole. See the chalcopyrite inclusion of figure 19. Many inclusions of chalcopyrite still have a small border of pyrrhotite and hence a biotite halo.

Just how the metallic mineralization is able to diffuse through up to 50 feet or more of granite to replace the biotite inclusion will now be considered following Ramberg's reasoning (1952, p. 214). When biotite replaced the wall rock inclusions in the granite, a sufficiently high free energy gradient was set up so that all the iron from the surrounding several inches of granite diffused through the granite to the energy depression zone, which was the inclusion.



FIG. 20
Country rock and sulphide inclusion side by side.

An important observation was made and is illustrated in figure 20. That is that unaltered country rock inclusions are not replaced by sulphides. In the photograph, an inclusion of unaltered country rock occurs next to an inclusion of sulphides. Only inclusions that have previously been replaced by biotite are subsequently replaced by sulphides. The writer suspects that if the free energy of each of these reactants could be calculated, it would be seen that the free energy gradient between the wall rock and the sulphides is not high enough to have replacement of the wall rock by the sulphides. On the other hand, the gradient is sufficient in the case of the biotite replaced inclusion and the sulphides. The free energy gradient would have to be high enough to cause copper, zinc, sulphur and possibly some iron to diffuse through the granite to react and replace the biotite. Less iron would have to diffuse through the rock than the other metallic elements since the biotite would supply a portion of the iron to make pyrite, pyrrhotite and eventually chalcopyrite. Diffusion would be facilitated if the granite were warm and not completely consolidated.

On the 15th level, two larger than usual biotite inclusions occur. These are not replaced to any large extent by the sulphides. It is difficult to explain why some biotite inclusions are replaced while others have only scattered sulphides. Two observations concerning these inclusions may in part explain their occurrence. First is their size, as illustrated by the level plan (see map in pocket). One of the inclusions is well outlined by a cross cut and numerous drill holes. The other inclusion occurs in the workings in the northern part of the mine, and is thirty feet or more square. The nature

of the biotite in these inclusions may account for them not being replaced. The biotite has a slight pinkish cast. Without accurate chemical analyses of the biotite that is replaced by sulphides, and the non replaced biotite, no definite conclusion can be drawn to show that differences in chemical composition is the criterion for their replacement.

Many of the sulphide inclusions in the granite contain pyrrhotite bands. Such inclusions are usually composed mostly of chalcopyrite, with what appears to be fracture filling of pyrrhotite. This would indicate that the chalcopyrite was early, then fractured, and the fractures filled with pyrrhotite. This is not possible according to the replacement series given by Lindgren (1937, p. 356). What occurred is that chalcopyrite replaced all the mineralization in whose fractures the pyrrhotite had occurred, without replacing the pyrrhotite. Figure 21, will clarify the age relationships of pyrrhotite and sphalerite and also chalcopyrite, since the chalcopyrite is definitely younger than sphalerite.

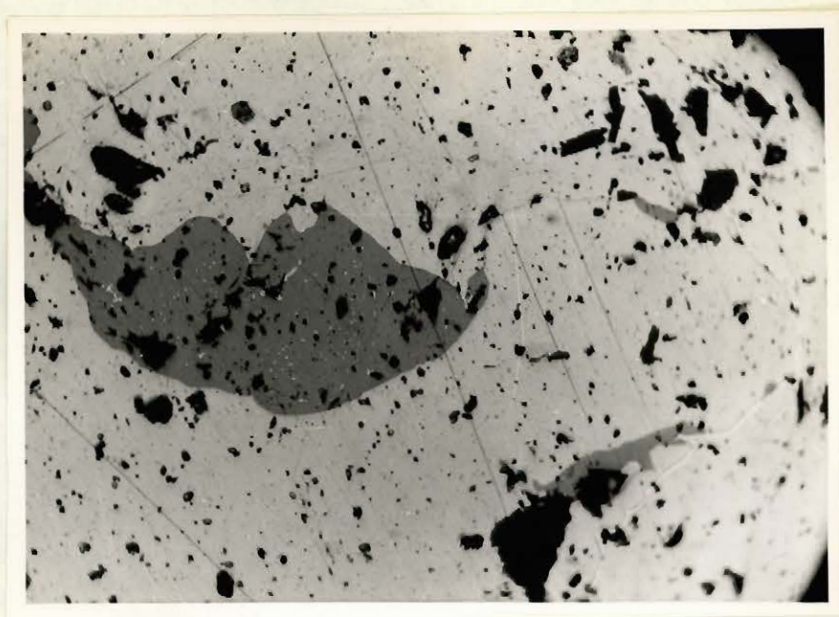


FIG. 21 40 X
Pyrrhotite being bitten into by sphalerite.

Figure 21 shows a portion of sphalerite (dark grey) within a pyrrhotite background. The sphalerite illustrates what Lindgren has called "Caries" relationship, or biting texture. This indicates that the sphalerite is later than the pyrrhotite. Within the sphalerite small specks of exsolved chalcopyrite occur (light grey).

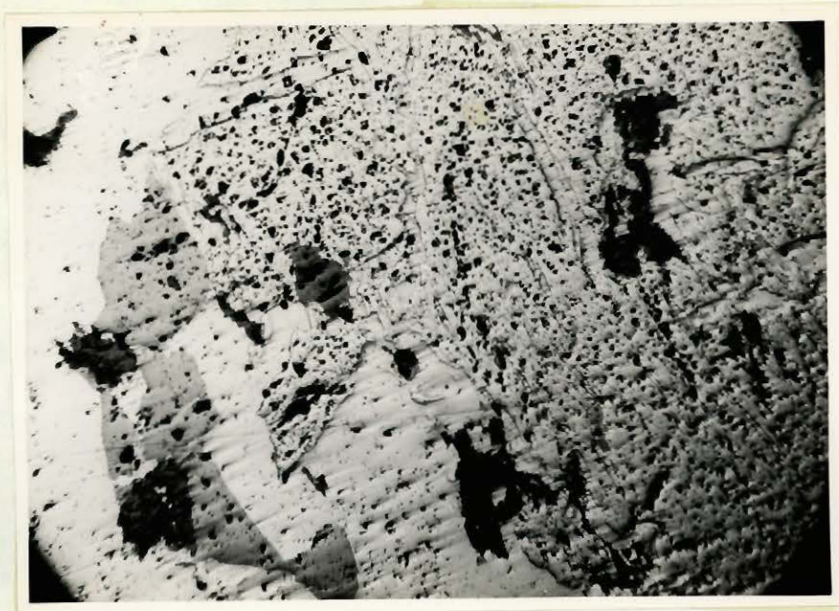


FIG. 22 40 X
Replacement of pyrrhotite by chalcopyrite.

In previous figures, the relationship of chalcopyrite and pyrrhotite in the granite inclusions was not readily observed. However, figure 22 illustrates replacement of the pyrrhotite (light grey) by chalcopyrite (lighter grey and pitted).



FIG. 23 40 X
Replacement of the granite by sulphides.

Occasionally after a biotite inclusion in the granite has been replaced by sulphides, the mineralization process may continue from this nucleus and replace a portion of the granite. This is illustrated in figure 23. Sulphides have worked their way along grain boundaries of the granite, eventually isolating the grains and completely replacing them.



FIG. 24
Euhedral crystals of pyrite in chalcopyrite.

Occasionally in larger inclusions and especially those composed essentially of chalcopyrite, euhedral pyrite crystals may be found. Figure 24 is a photograph of massive chalcopyrite with several euhedral crystals distributed in it. The pyrite is crystallized in the pyritohedron form. The crystals have a bright lustre and do not tarnish on exposure to the atmosphere. Surrounding these pyrite crystals, there is usually a border of sphalerite and pyrrhotite, sphalerite being nearest to the pyrite crystal. The crystal is not replaced or altered in any way by the presence of these minerals on the boundary.

Ore

The ore occurs in two lenses separated by 60 to 80 feet of

non ore bearing rock. Both lenses dip 45° to the southeast following a shear zone in the quartz sericite schist. The lenses extend down to at least the 15th level, a vertical distance of 1100 feet. Below the 15th level, the granite stock terminated the quartz sericite schist formation, the formation which was later mineralized by sulphides from the granite. Sulphide mineralization of ore grade occurs below the 15th level but not as regular sulphide lenses, but as rich pockets in the granite.

After the quartz sericite schist country rock was sheared to a mylonite by the incoming granite intrusion, sulphides associated with the granite intrusion worked their way up along the mylonitic zone. That is replacement could occur readily because of the large surface area offered by the mylonite particles. Replacement of a mylonite by sulphide minerals is further proved by the occasional occurrence of horses of unreplaced schist within the massive sulphides. The ore is confined to the shear zones and occurs as massive sulphides. There is some dissemination of sulphides, mostly pyrite, in the wall rock.

The main ore lens on the upper levels had a maximum length of 570 feet and a width of 45 feet. With depth, it is found that the ore lenses become more narrow and considerably shorter. There is a rake to the south southeast at about 80° . On the 14th level, the main lens has a length of approximately 230 feet and a width of 10 to 15 feet. The number two lens follows the same pattern. Dimensions for the number two lens in the upper levels are not available, but on the 14th level, it is approximately 250 feet long and 5 feet wide.

The two lenses contain similar sulphide mineralization but vary slightly in ore grades. For example, ore grades, as of January 1958, were:

Main lens

2.15% copper
32.25% sulphur
1.05% zinc

Number two lens

2.02% copper
20.72% sulphur
1.24% zinc

The main lens is richer in copper and sulphur but the zinc grade is less than the number two lens. Lead is usually found in all assays but not in economical quantities. Galena was only found in the footwall lens. Gold and silver production, although not too significant, for the year 1958, amounted to 198 fine ounces of gold and 19,952 ounces of silver. Gold and silver are included in the copper concentrate and are paid for separately. Pyrite is the most abundant of the ore sulphides, with chalcopyrite next, then sphalerite. Pyrrhotite occurs somewhat ^eirregularly in the ore lenses, but commonly in the granite in the sulphide inclusions. Pyrite occurs as well rounded corroded grains surrounded by chalcopyrite and less often with sphalerite and galena.

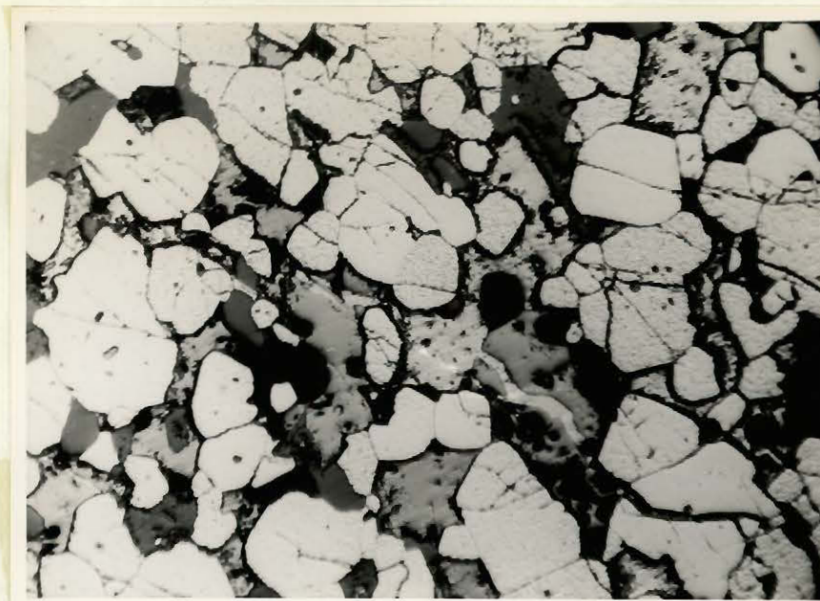


FIG. 25 40 X
Rounded pyrite grains surrounded by sphalerite and chalcopyrite.



FIG. 26 80 X
Fracturing of the ore minerals.

Figure 25 shows the typical ore structure which consists of well rounded granular pyrite grains. These have been partially replaced by chalcopyrite and sphalerite. Fracturing of the ore took place after the pyrite and sphalerite were introduced, as the fractures appear only in the pyrite and sphalerite grains. Chalcopyrite then filled these fractures in the sphalerite and to a lesser extent the fractures in the pyrite. Occasionally, these fractures are filled with gangue. Figure 26 is a close up of the central part of figure 25 showing in detail the chalcopyrite filled fractures.

The type of sulphides vary across the lens, especially in the number two lens. On the border of both lenses, the sulphides consist of chalcopyrite and sphalerite with only the occasional well rounded pyrite grain. Closer to the centre of the lens, the mineralization changes such that approximately two thirds is pyrite and one third is chalcopyrite and sphalerite. The specimen of figure 25 comes from the main lens and although the sphalerite content is higher than normal it is quite representative of the ore. It is composed of 60% pyrite, 20% chalcopyrite, 15% sphalerite, 5% gangue.



FIG. 27 40 X
Age relationships of pyrite, chalcopyrite and sphalerite.

Figure 27 above is a photomicrograph of ore from the number two lens. It may be seen that pyrite (pitted, high relief) again occurs as fractured but well rounded grains, and in addition good age relationships of chalcopyrite (light grey) and sphalerite may also be seen. The sphalerite (dark grey) has been fractured and these fractures subsequently filled with chalcopyrite. Note how the fractures have been altered little by the introduction of chalcopyrite since the sides of the fractures still match.

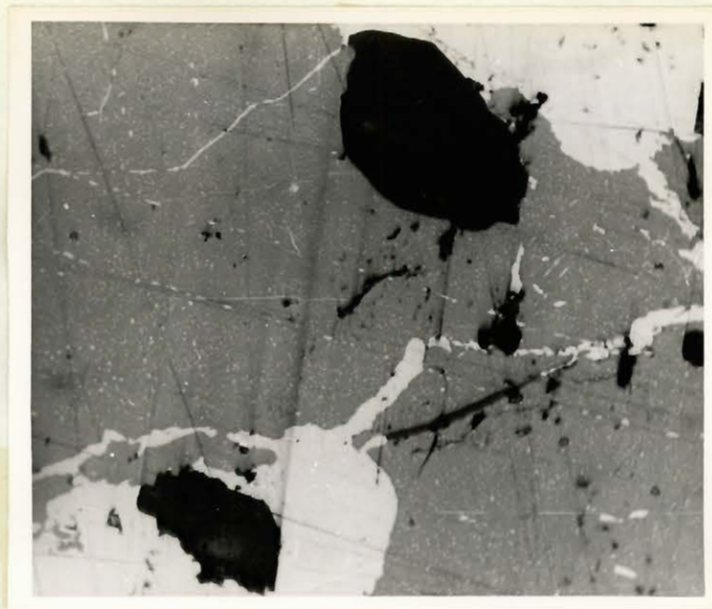


FIG. 28 80 X
Detail of fracturing in sphalerite

A closer view of the fractures under medium power reveals that chalcopyrite has exsolved from the sphalerite. Details of the fractures show that the sphalerite has moved horizontally after fracturing.

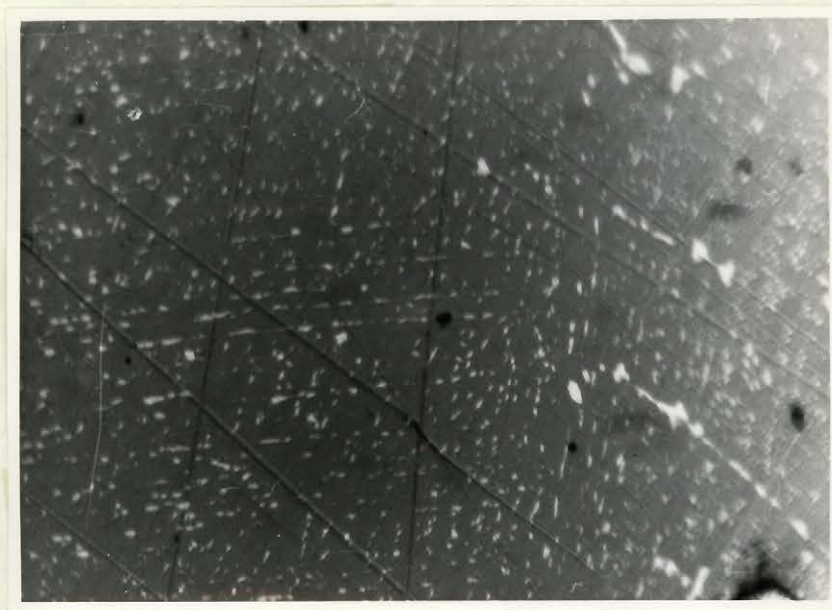


FIG. 29 120 X
Details of exsolved chalcopyrite from sphalerite.

Figure 29 shows the exsolved chalcopyrite (very light grey) occurring along crystallographic directions in the sphalerite (dark grey). Exsolution is further demonstrated by the fact that the pattern of chalcopyrite specks does not have any relation to the outside boundaries of the sphalerite, as would have occurred in replacement, which also would have given widening of the chalcopyrite specks at crystallographic intersection. Each grain of sphalerite has a different orientation as shown by the different orientation of the chalcopyrite speck pattern.



FIG. 30 40 X
Marcasite crystals.

In the disseminated zone of the hanging wall, approximately one foot from the number two lens, marcasite (light grey) occurs with chalcopyrite (nearly white). The grains as observed in figure 30 are somewhat angular in outline and are characterized by a peculiar striping. Each grain is a single unit as illustrated by the typical mottled banding. Marcasite has not been found, by the writer, anywhere else to date in the ore body. Chalcopyrite, which is the other mineral in the shear, has not replaced the marcasite, yet is almost certain to be younger.

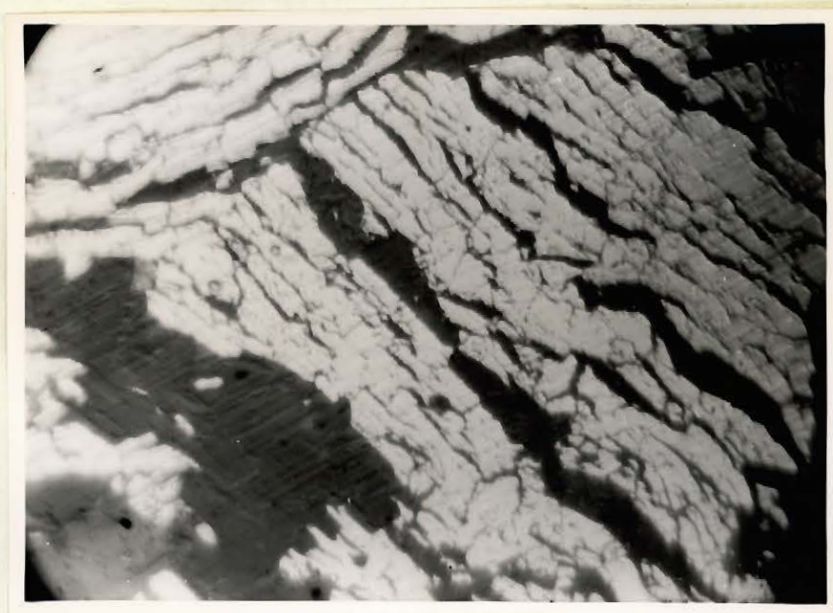


FIG. 31 120 X
Detail of marcasite crystals.

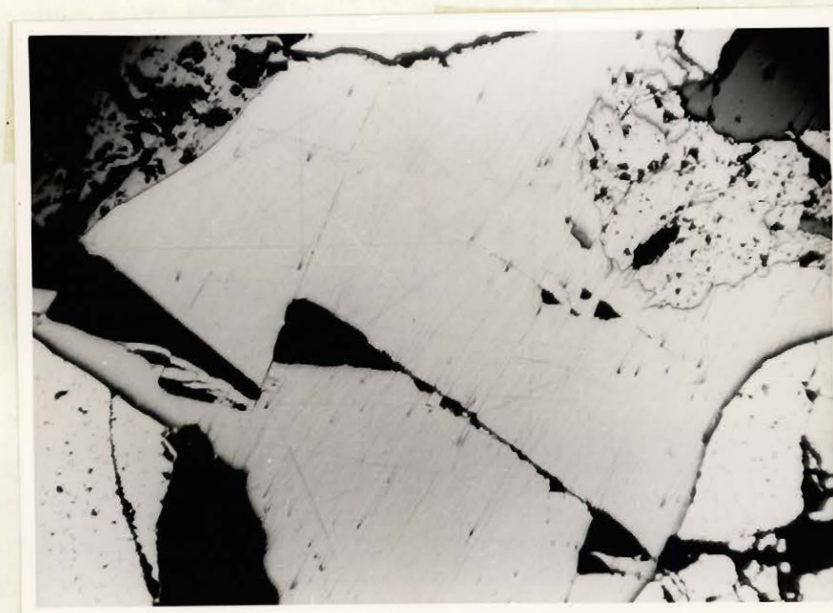


FIG. 32 40 X
Galena crystals.

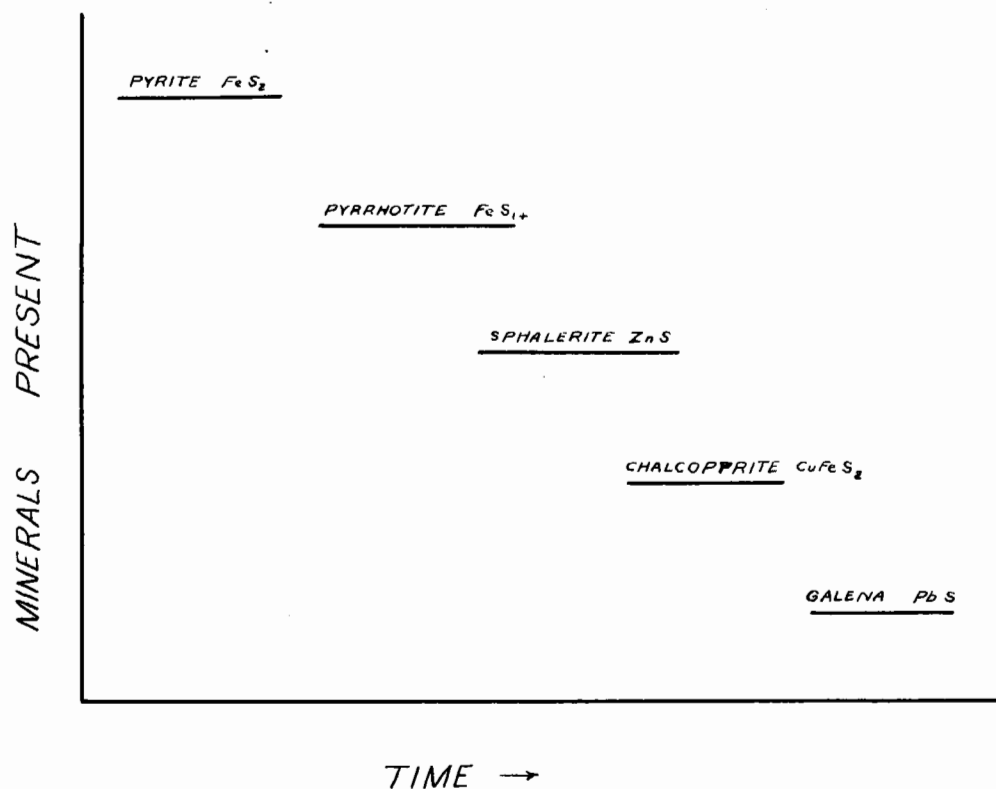
Galena, (nearly white), although assays indicate its presence by traces of lead, is not commonly observed. Lead assays are much higher in the number two lens than the main lens. In the number two lens, the galena is usually found on the footwall side of the lens in association with coarsely crystallized pyrite. Figure 32 is a microphotograph of galena occurring along with pyrrhotite, chalcopyrite and sphalerite between much larger crystals of pyrite. The pyrite crystals are fractured and the other minerals occur in the larger fractures but more commonly around the intergranular spaces of the pyrite. Quartz cuts all the sulphide minerals.

Paragenesis

The oldest mineral, pyrite, is partly replaced by pyrrhotite. Little pyrrhotite is found in the lenses, suggesting that the temperature was not high enough for pyrrhotite to be deposited. Pyrrhotite on the other hand is abundant in the sulphide inclusions in the granite.

The sphalerite and pyrrhotite appear to the writer to be contemporaneous because neither good cutting relationships or replacement characteristics were observed between these minerals. This would seem that simultaneous deposition or possibly overlap could have occurred. But to have simultaneous deposition, the reactants would have to be in a state of equilibrium. Equilibrium could not occur in a system that is constantly cooling such as the granite and the sulphides. This means that the pyrrhotite and sphalerite could not be deposited simultaneously, but still could have their time of deposition overlapping, thus giving mutual boundaries to the two

minerals. Cutting relationships definitely indicate that chalcopyrite is later than all other minerals and has mutual boundaries with galena. Quartz cuts all sulphides occurring along fractures, the fractures indicating a period of movement. This later movement may be associated with the intrusions of aplite dykes found in the mine area and within the granite mass itself.



CHAPTER IV
ORIGIN OF THE ORE

Bancroft (1915, p. 276) arrived at no conclusion about the genesis of the ore. Earlier, he thought it had come from the granite stock. Then he studied other mines in the area such as the Eustis (1915, p. 89) and found such mines did not occur near any igneous intrusion. This information coupled with the fact the aplite dyke cut the ore at the Weedon Mine, led him to conclude that the ore at Weedon must be older than the granite.

Since Bancroft's report, the mine has been considerably further developed so that a study of the granite-ore-country rock relationship is possible. This has been done by the writer. The granite was found to be younger than the surrounding rock since it cuts the rock. During the intrusion, a quartz rich volcanic formation was sheared, in places becoming a mylonite. As a later phase of the granite intrusion, hydrothermal sulphide solutions associated with the granite easily replaced the mylonitic zone giving the present massive sulphide lenses of ore. With the same sulphide solution invasion biotitized country rock inclusions in the granite were replaced by sulphides.

The ore lenses were therefore formed by hydrothermal sulphide bearing solutions from the granite and were deposited in an intensely sheared zone in the quartz sericite schist.

CHAPTER V

SUMMARY AND CONCLUSIONS

There seems to be a remarkable similarity among all of the mines in what Dresser calls the Ascot or Stoke Mountain belt. The wall rock, sulphide ore, and the lenticular ore bodies are common characteristics throughout the belt. The origin of the ore on the other hand is not readily determined in all cases.

The ore bodies at the Weedon Mine are the result of volcanics being intensely sheared to a mylonite during the intrusion of the nearby granite stock. During the last stages of cooling of the granite, hydrothermal sulphide solutions were given off by the granite. These solutions passed up along the periphery of the granite and replaced the mylonite zones in the volcanics. This resulted in the formation of two lenses of minable massive sulphides which strike N 35 E and dip 45° SE, and are conformable to the volcanics. The sulphides in the lenses include, in the order of decreasing abundance, pyrite, chalcopyrite, pyrrhotite, sphalerite and galena.

During its intrusion, the granite stopped off portions of the country rock. Some of these xenoliths were completely digested some partly digested while others show very little alteration. Some inclusions in the granite were replaced by biotite. The criteria for replacement by biotite is a combination of reaction time in the granite mass and original composition of the stopped block. Certain biotite replaced xenoliths, probably depending on the composition of the biotite, were replaced by sulphides. The type of sulphide assemblage depends on the stage of replacement, that is, certain

inclusions are mostly pyrite and only partially replaced by pyrrhotite, whereas other inclusions have been completely replaced by chalcoppyrite and constitute high grade ore. Mineralized inclusions vary in size from a couple of inches in diameter to approximately 30 feet in diameter. Sulphide minerals in the inclusions, in decreasing order of abundance, consist of chalcoppyrite, pyrite, pyrrhotite and sphalerite. The writer could find no structural features in the granite that would be an aid in locating the mineralized xenoliths.

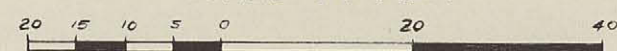
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LEGEND

SCALE IN FEET



- UNOBSERVED GEOLOGICAL CONTACT
- OBSERVED GEOLOGICAL CONTACT
- - - DISSEMINATED SULPHIDES
- ORE
- BIOTITE INCLUSION
- QUARTZ - SERICITE SCHIST
- CHLORITE - QUARTZ - SERICITE SCHIST
- GRANITE



WEEDON PYRITE AND COPPER CORP.

11 TH LEVEL

GEOLOGICAL

TRACED BY: *R.B.*

DATE: MARCH 1959

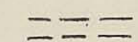
GEOLOGY BY: *Ronald A. Buckley*

WEEDON PYRITE AND COPPER CORP. LTD.

SURFACE GEOLOGY

SCALE 1" = 100'

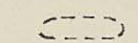
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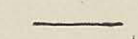
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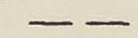
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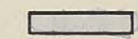
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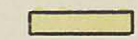
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UNOBSERVED GEOLOGICAL CONTACT



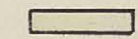
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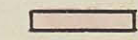
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CHLORITE-QUARTZ-SERICITE SCHIST



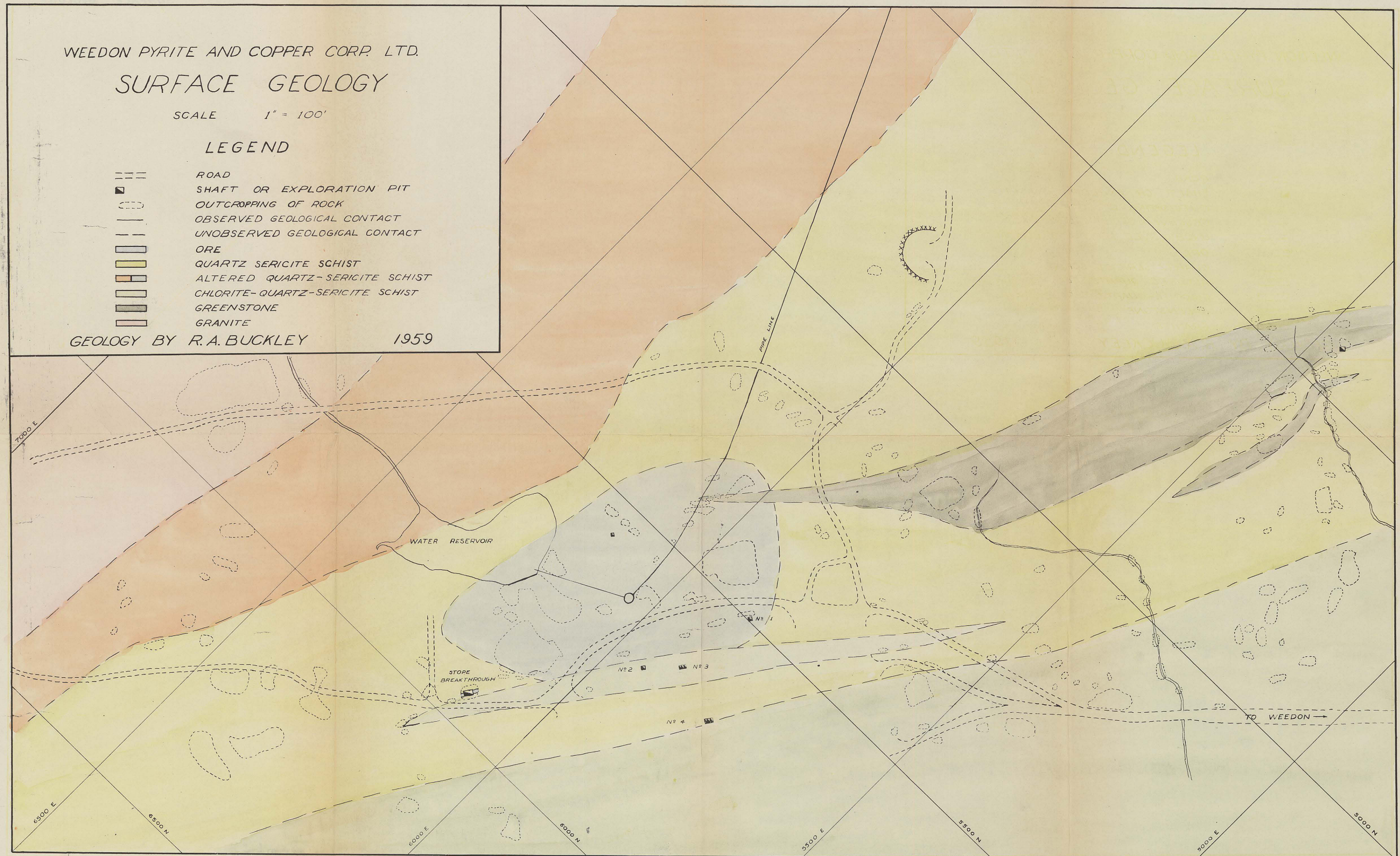
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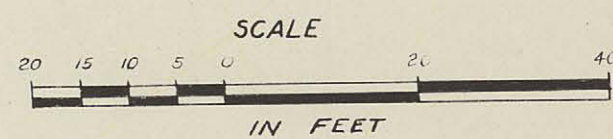
GRANITE

GEOLOGY BY R. A. BUCKLEY

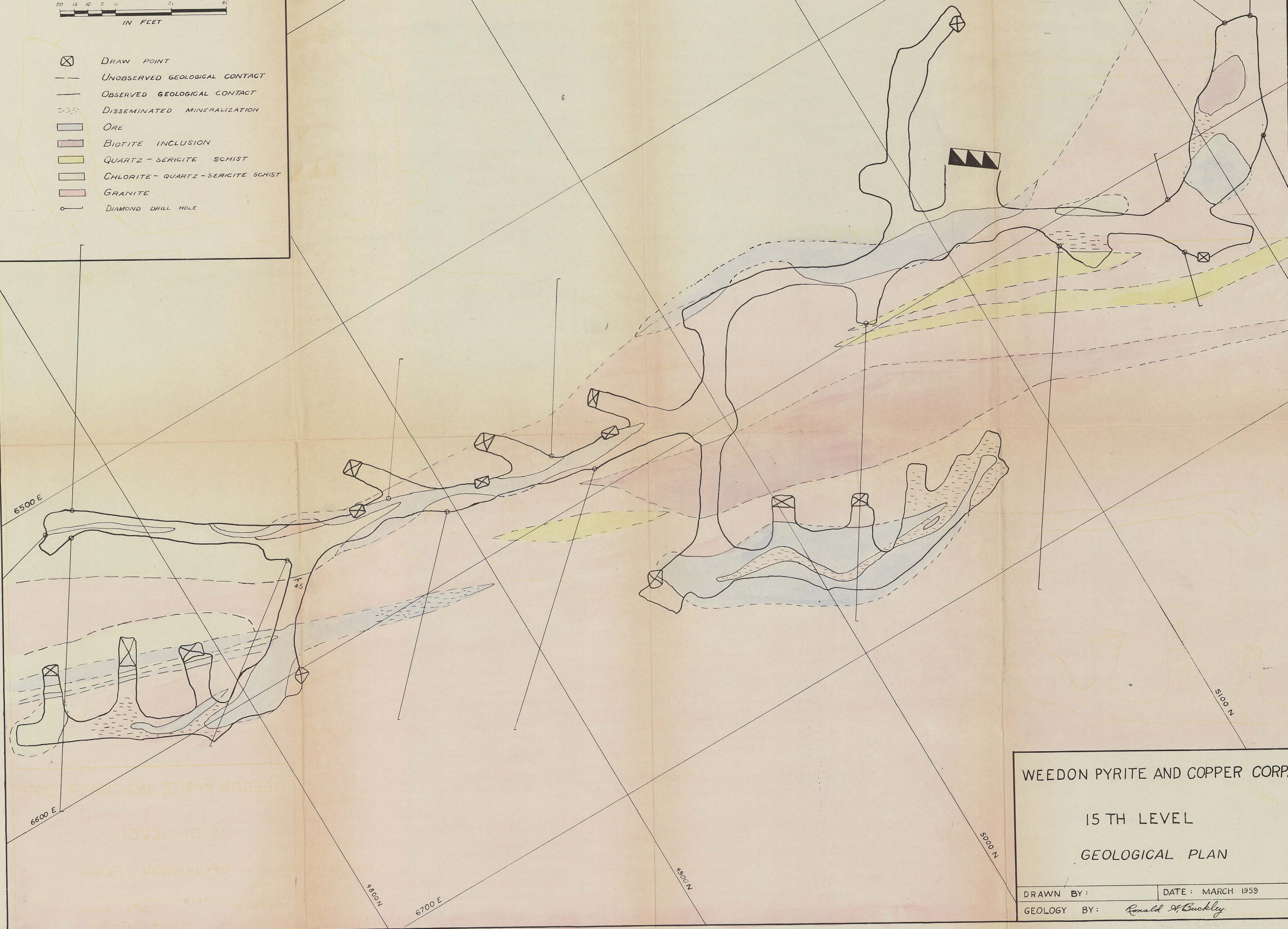
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LEGEND



- DRAW POINT
- UNOBSERVED GEOLOGICAL CONTACT
- OBSERVED GEOLOGICAL CONTACT
- DISSEMINATED MINERALIZATION
- ORE
- BIOTITE INCLUSION
- QUARTZ-SERICITE SCHIST
- CHLORITE-QUARTZ-SERICITE SCHIST
- GRANITE
- DIAMOND DRILL HOLE



WEEDON PYRITE AND COPPER CORP.

15 TH LEVEL

GEOLOGICAL PLAN

DRAWN BY:

DATE: MARCH 1959

GEOLOGY BY:

Ronald H. Buckley



BLOCK DIAGRAM
f
WEEDON PYRITE AND COPPER CORP. MINE

THREE DIMENSIONAL SCALE IN FEET
0 10 20 30 40 50 60 70 80 90 100

■ QUARTZ-SERICITE SCHIST
■ CHLORITE-QUARTZ-SERICITE SCHIST
■ GREENSCHIST
■ GRANITIZED COUNTRY ROCK
■ GRANITE
■ CHLORITIZED ZONE

LINE OF SIGHT: TRUE NORTH
INCLINATION: 30°

DRAWN BY: *Ronald H. Buckley* APRIL 1959
■ ORE LENS