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GEOLOGY OF THE CARPENTIER PYROPHYLLITE DEPOSIT

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CARPENTIER TWP, ABITIBI REGION, QUEBEC

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ABSTRACT

The pyrophyllite deposit is located 12 miles northwest of Senneterre, in Abitibi County. It was discovered in 1962 and drilled in 1965 and 1966. It consists of a band of quartz-pyrophyllite schist approximately 400 feet wide, extending over a strike length of more than one mile, and outcrops in two areas. The pyrophyllite occurs in altered and sheared siliceous tuffs and agglomerates of the Abitibi volcanics.

Five pyrophyllite-bearing zones have been identified in the northern part of the deposit: (a) pyrophyllite schist; (b) quartz-pyrophyllite schists; (c) high-alumina zone (32% Al_2O_3), pyrophyllite, dolomite, etc.; (d) quartz-chloritoid-pyrophyllite zone; (e) high-pinite zone.

Pyrophyllite is the most abundant mineral, with lesser amounts of quartz, chloritoid and andalusite. Other minerals which occur in smaller quantities include diaspore, corundum, kyanite, pyrite, feldspar, rutile, staurolite and garnet. Gold appears to be associated with the pyritic zone in the margins of the pyrophyllite-rich rocks. A pyrophyllite content of 70% has been recorded in some sections of the deposit, and it appears to be suitable for the manufacture of tiles and refractory bricks.

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INTRODUCTION

The pyrophyllite deposit located in Carpentier township, Abitibi region was discovered by a geological mapping party working on behalf of the Quebec Department of Natural Resources in 1962. Prior to that time, work in the vicinity had been confined to base metals, gold and asbestos. The significance of the nature of the heavy alteration of the volcanics had not, until then been recognized.

Initial surface mapping and limited diamond drilling has outlined two pyrophyllite-rich groups of outcrops at the north and south end of a schistose zone which has been traced for over two miles within a Precambrian volcanic environment.

Canada's pyrophyllite production is from a series of closely connected orebodies located in Newfoundland. All of it is exported unprocessed to the U.S.A. All of the refined products used in Canada are in turn, imported from the U.S.A. It seems therefore that an indigenous source within a reasonable distance from markets of raw, lightly processed and refined material could, in most likelihood compete successfully with imported products, providing of course, that the indigenous products can meet specifications.

This paper is an account of the limited work carried out to date on the deposit and of the observations and conclusions that can be derived so far.

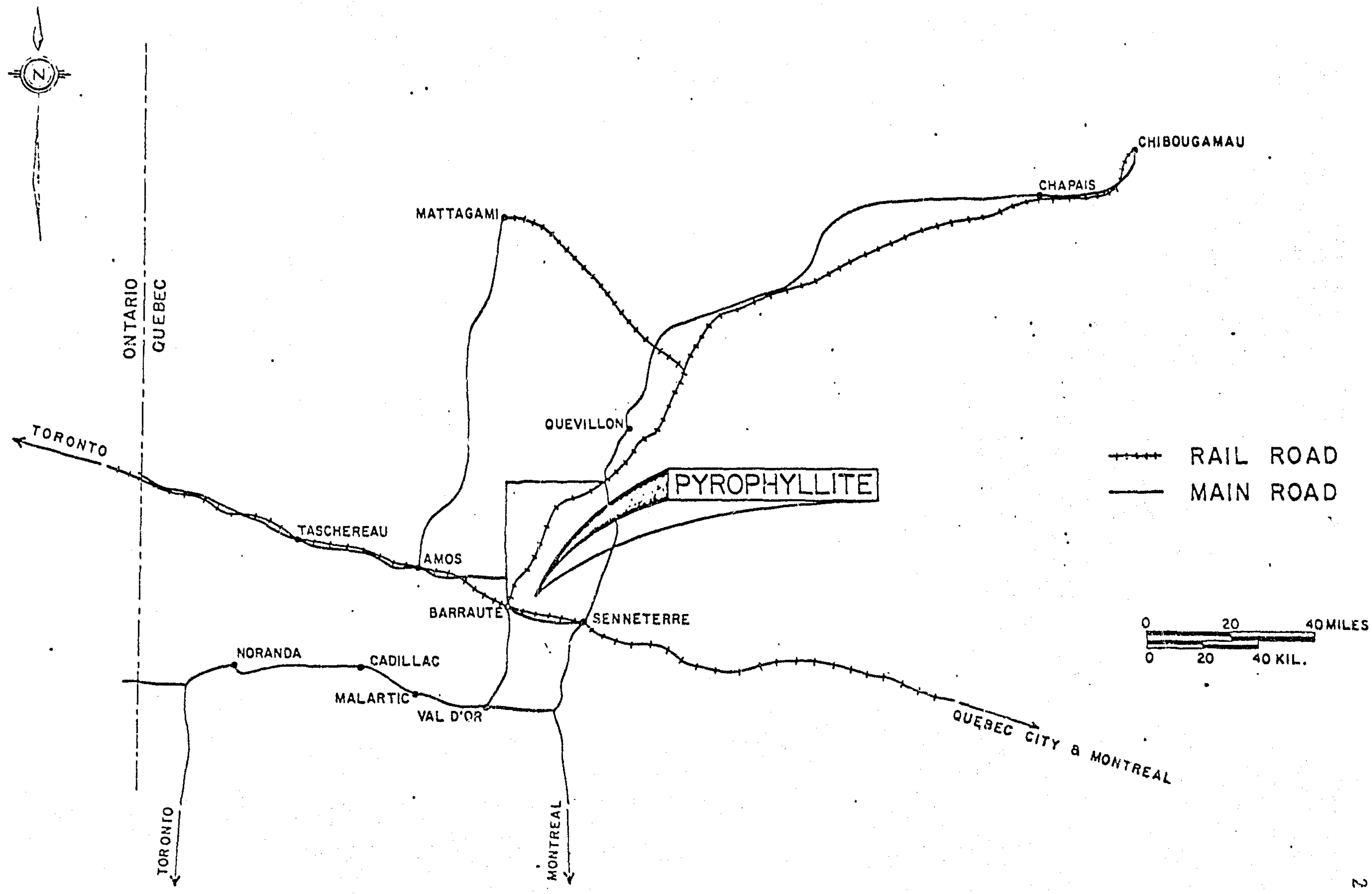


FIGURE 1 - LOCATION

PYROPHYLLITE - GENERAL

Pyrophyllite is a soft light coloured mineral, white greyish or greenish, similar in appearance and properties to talc, although harder than talc, containing alumina instead of magnesia. It is a hydrous aluminum silicate; $Al_2O_3.SiO_2.H_2O$, generally formed by the hydrothermal alteration of igneous rocks, usually felsic volcanics, generally pyroclastics. It may occur in foliated, radiated lamillar or fibrous form or may be compact and massive. Usually it exists as a part of a schistose zone along with other minerals.

USES

Initially, pyrophyllite was used as a carving medium by the Chinese. It is now used as a substitute for talc in refractories, ceramics, as a filler in asphalt, paper paints, enamels, roofing felt and as a carrier in insecticides. The future of pyrophyllite as an industrial mineral lies in the ceramic and refractory industries.

The Norther Miner carried in July 1976 a report on tests made on Australian pyrophyllite used in the making of liner bricks for the steel industry. The pyrophyllite bricks proved to have a lifespan double that of conventional brick linings. This could save the steel industry, millions of dollars a year in Australia alone. Similar tests in the U.S.A. and Japan have confirmed these findings. A combination of pyrophyllite and zircon would again improve the life of the bricks.

Pyrophyllite could find an increased role as a component of refractory plastics, concretes and mortars. It is also a potential source of alumina (Bliss, N.W., 1976)

CURRENT SUPPLY AND MARKET CONDITIONS

The Manuels deposit in Newfoundland is the only major Canadian producer of pyrophyllite. In 1974, nearly all of its open pit production which totals approximatly 60,000 tons was shipped to the U.S.A. for use in tile making.

Japan is the world's largest producer and user of the product with a 1969 production and consumption of 589,000 tons. Such a high rate of production is unlikely to affect the North American markets due to the inability of all but the most valuable minerals to sustain long distance transport costs. However part of the Australian capacity may be scheduled for export.

Total world production is probably of the order of 2,000,000 tons yearly. In a report published by Roskill Information Services Ltd. in 1973, the annual increase in consumption of talc and related minerals was estimated to be 5.5% in North America. Current world prices are believed to be within the range of \$75.-\$120/ton for bulk lightly processed material. However, smaller quantities of specially refined material may fetch as much as \$500./ton.

LOCATION, ACCESS, FACILITIES

The Carpentier pyrophyllite property straddles lots 28-35 in Ranges lV and V, Carpentier Twp. It is 12 miles N.W. of Senneterre in Abitibi District. (Figures 1 and 2).

The main transcontinental line of the CNR passes through within 7.3 miles of the North deposit and 5.8 miles of the South deposit. A gravel road approaches within 0.4 miles of the South deposit.

Senneterre is linked by road and rail to Quebec City, Montreal and Toronto. Locally, it is situated close to the Val d'Or mining camp from which mining labor and supplies can be procured. Both electricity and water can be readily obtained from nearby power lines and water courses.

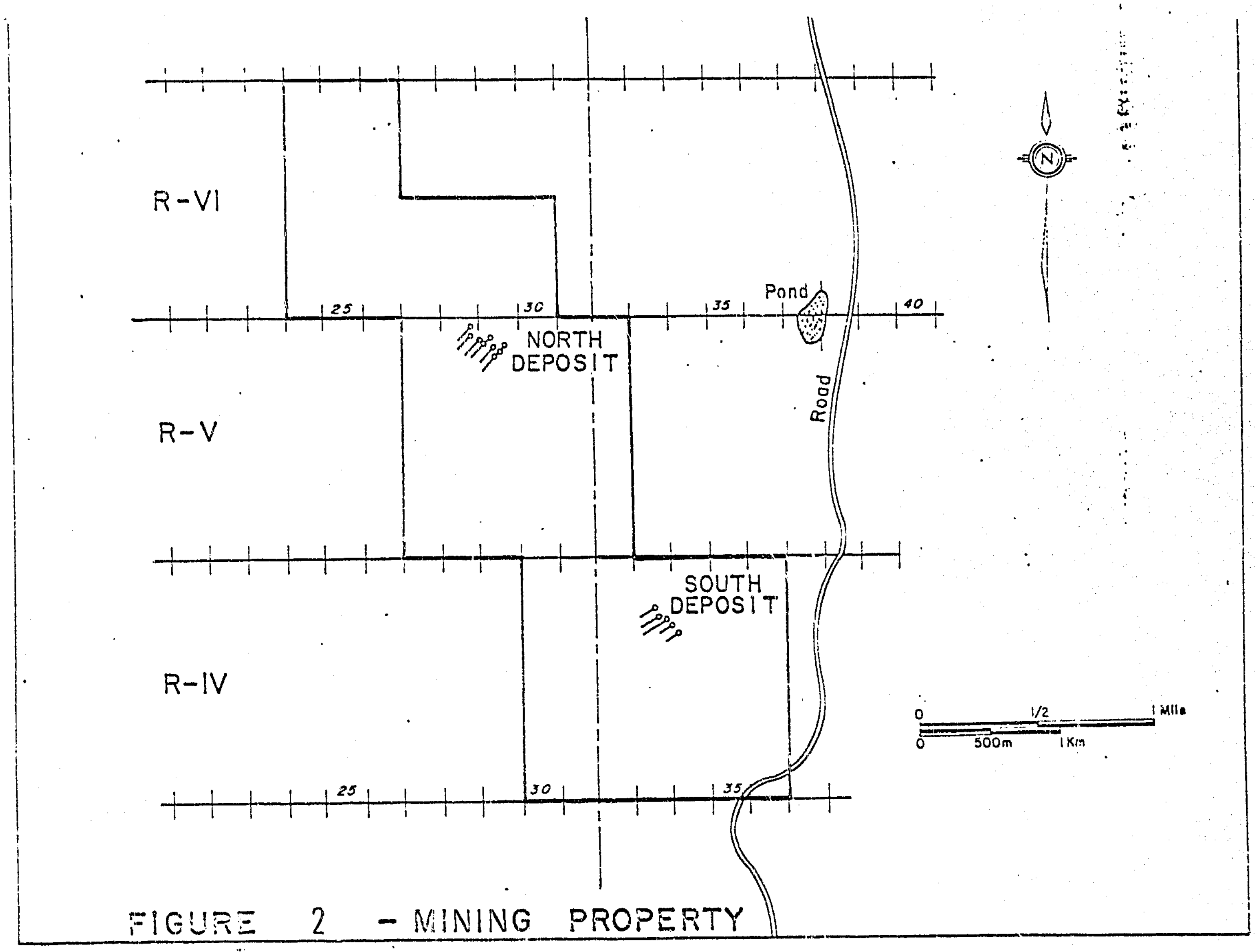


FIGURE 2 - MINING PROPERTY

HISTORY OF THE PROPERTY

The area in general has been actively prospected since 1933 when the main interest was for gold, and by 1945, Bonsecour Mines Ltd had drilled 4 holes in lot 31, Range IV. Schistose, sheared and silicified tuffs were encountered as well as a similarly altered body of feldspar porphyry. Gold values were reported from each hole, the best intersections being 0.24 oz/ton over 5 feet and 0.31 oz. over 8.6 feet. However, no further work was undertaken at the time.

In 1962, Canadian Johns-Manville Co. Ltd conducted geological, magnetometer and electromagnetic surveys over the shear zone occupied by the pyrophyllite. These surveys were essentially aimed at locating further indications of precious and base metals. Indeed, samples assayed did indicate the presence of "minor amounts of gold, silver and copper". However, at this time, little significance was attached to: "a carbonatized tuff... which resembles phyllite", or to "some occurrences of steatite-carbonate schists". The company concentrated its efforts nearby to the north to develop asbestos occurrences.

During the same period, a geological mapping crew working for the Quebec Department of Natural Resources noticed the schistose rocks. Samples were sent for analysis to establish the exact composition. Pyrophyllite was identified.

Domtar Ltd optioned the property in 1964 and carried out a drilling program and some laboratory tests in 1965 and 1966 finally dropping the option in 1974 when it was acquired by the authors of this paper.

TOPOGRAPHY AND PHYSIOGRAPHY

The property is characterized by flat ground and swampy areas cut by a N.N.W. trending ridge of rock outcrops. On the north east side, the outcrops plunge steeply into a swamp. To the south west, the outcrops slope more gently and are progressively covered by sand and boulder deposits which also fill depressions within the outcrop areas.

REGIONAL GEOLOGY

The property lies within the highly productive base and precious metal mining area of the Abitibi Greenstone Belt stretching from Timmins to Chibougamau.

All the rocks in the region are Precambrian in age and are part of the Superior Province of the Canadian Shield. The commonest rocks of the region are basalts, andesites, rhyolites and their pyroclastic equivalents which have suffered regional metamorphism to the green-schist facies. The predominant strike of these rocks is east-west and they are usually found with steep dips.

GEOLOGY OF THE PROPERTY

Within the property itself, rocks are early Precambrian in age. They consist mainly of altered felsic volcanics mainly pyroclastics, and are strongly schistose. A few localized sills of gabbro and diorite have also been recognized.

Gabbro and Diorite

These rocks occur at the N.E. corner of the property as part of a ridge of prominent outcrops. They are medium-grained varying in colour from light to dark green depending on the number of mafics present. Generally these rocks have a pronounced gneissosity, giving place to schistosity in shear zones. The gneissosity and schistosity planes strike variably between N30°W, and N50°W, and dip at 60° or more to the northeast.

Volcanics

A series of schistose metamorphozed volcanic flows and pyroclastic horizons occur, which range from andesite to rhyolite in composition. They strike parallel to the schistosity. A heavily altered band of rocks believed to have been felsic tuffs and agglomerates can be divided in a number of different zones according to their content in pyrophyllite, quartz, pinite, paragonite, chloritoid:

1. Pyrophyllite schist
2. Quartz pyrophyllite schist
3. High alumina zone: with pyrophyllite and alumina related minerals
4. Quartz-chloritoid-pyrophyllite
5. Pyrophyllite-pinite

These zones strike approximately N45°W and dip 75-80° to the N.E.

Aplite Dyke

An aplite dyke of fine-medium grain size and pinkish in colour intrudes the schistose lavas. It has an average width of about 5 feet and contains disseminated pyrite with low values in gold and silver as well as minor amounts of chalcopyrite.

Quartz veins and veinlets cut across the rocks with widths up to 10 inches. Small amounts of sulphide mineralization are locally associated with these veins.

A body of feldspar porphyry has also been reported to the south.

STRUCTURE OF THE PROPERTY

The outcrop trend found on the property reflects the overall strike of the bedding and of the schistosity of the rocks, namely NNW-SSE.

The contact between the lavas and the gabbro-diorite is marked by a major schistose zone extending for well over two miles. Structures are generally aligned with this schist zone and are steeply dipping towards the N.E.

Minor shearing also occurs on the property and can be seen within the aplite dyke and also in the gabbro-diorite which have developed shallow dipping tension joints subsequently filled with quartz.

On a more regional scale, the pyrophyllite zone occurs on the north flank of the Amos anticline some 2 miles N.E. of its axis.

ECONOMIC MINERALIZATION OF THE PROPERTY

Apart from the gold mineralization, the main economic interest in the property lies in its potential as a producer of pyrophyllite and associated minerals.

The pyrophyllite schists occur over a length of at least two miles and are over 400' wide. The zone outcrops at two places. Drilling has been done at these two sites. They are called the North Deposit and the South Deposit, and are over a mile apart. The full extent of the pyrophyllite zone is unknown. (Figure 3).

North Deposit

Domtar Ltd drilled nine diamond drill holes in 1965 and carried out chemical analysis of certain core intersections. (Figure 4).

The holes were all drilled at an angle of 45° towards the S.W. and all encountered quartz pyrophyllite schists dipping towards the N.E. sandwiched between altered volcanics. Macroscopic examination of these heavily altered rocks could provide only limited information as to their nature. Thus a number of holes were sampled and chemically analysed for their content of the significant mineral constituants.

Holes number 1, 2 and 9 in particular provide the most continuous cross-section of the deposit. The quartz pyrophyllite zone was found to be very consistent in width which is over 100 feet.

The various elements of the mineralization are as follows:

Pyrophyllite: Figure 5 shows that all three holes encountered significant pyrophyllite averaging approximately 40% over 130 feet, to a vertical depth of at least 250 feet. While pyrophyllite can be expected to occur in fairly significant quantities beyond this zone, as can be appreciated from cross-sections, the core length of approximately 130 feet appears at this point to be the optimum economic width for this mineral.

Alumina: Figure 6 shows a high alumina zone present in the lower half of the pyrophyllite band at least in holes 2 and 9 for which tests were run. An average alumina content of this zone is approximately 35%. A section ran as high as 41%.

Pinite: Analytical results for pinite, a hydrous silicate of aluminum and potassium, $2h_2O.K_2O.3Al_2O_2.6SiO_3$., really a sericite, shows a zone high in that mineral flanking the pyrophyllite-rich zone in the hanging wall. The thickness of pinite-rich rocks is approximately 40 ft. It is interesting to note that this mineral has been used in refractory manufacturing in the U.S.A. Thus depending on the market envisaged for the pyrophyllite, this zone could conceivably be added as a source of refractory material. (Figure 7).

Kerr, (1940), describes the occurrence and character of a pinitized tuff at American Canyon, Nevada. The rock consists of a mixture of pyrophyllite and sericite. Mining of the pinitized tuffs has been undertaken by the Stockton Firebrick Company for delivery to its plant at Pittsburg, California, for the manufacture of rotary cement kiln linings. Ceramic properties of this material have been discussed in a paper by Page, Raine and Sullivan (1940). It is stated (that the product) "fires to a snow-white colour and to be highly refractory having a fusion point of cone 32".

Chloritoid: Figure 8 illustrates the chloritoid zone which has been recognized in the lower portion of all holes. This zone corresponds almost exactly to the high alumina zone determined by chemical methods. Chloritoid is a micaceous mineral high in alumina of formula: $Fe_2Al_4Si_2O_{10}(OH)_4$. The true thickness of the chloritoid zone is larger than that shown in the illustration.

Quartz: As seen in Figure 9, quartz is ubiquitous throughout the entire zone with an average content of 20-30%. While quartz is a significant impurity, higher amounts can be tolerated in refractory uses of pyrophyllite and exact tolerable quantities would have to be established for the precise applications. However quartz is easily removed with air separation techniques and possibly also by wet methods.

Pyrite: Pyrite was noted in all drill logs on the North Deposit as disseminations and from Figure 10, it can be seen that the overall content of this sulphide is always considerably less than 1%.

Thus, in summarizing the mineralogical analysis and combining their results, three distinct zones shown in Figure 11 define the cross-sectional picture of the North Deposit:

1. High pyrophyllite, high alumina and high chloritoid in the foot-wall zone, assuming that the sequence is right side, as it is believed to be. (See Structure).
2. High pyrophyllite in the centre zone.
3. High pinite in the hanging wall zone.

The band is flanked on both sides by much less altered volcanics.

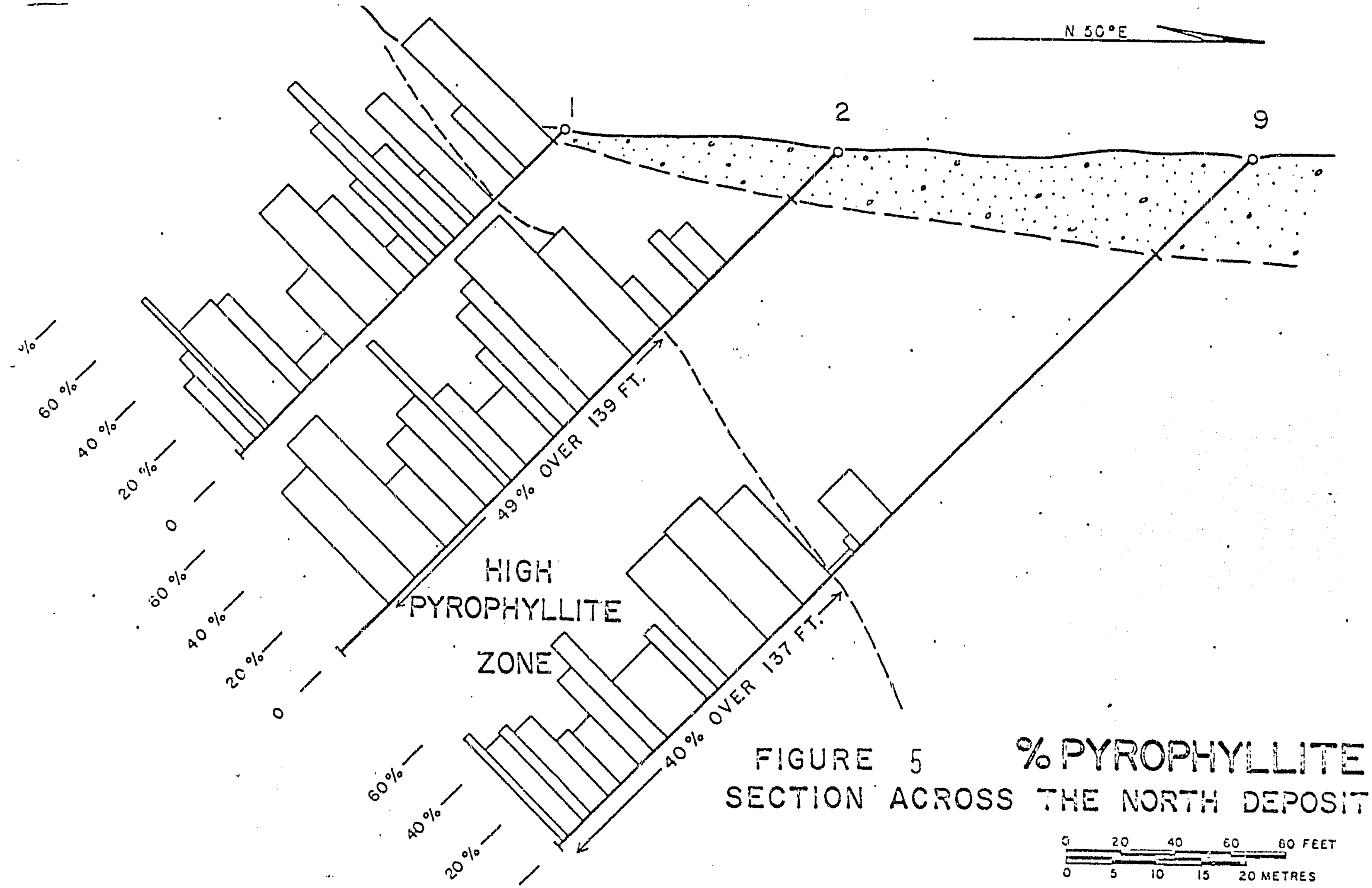


FIGURE 5
SECTION ACROSS THE NORTH DEPOSIT

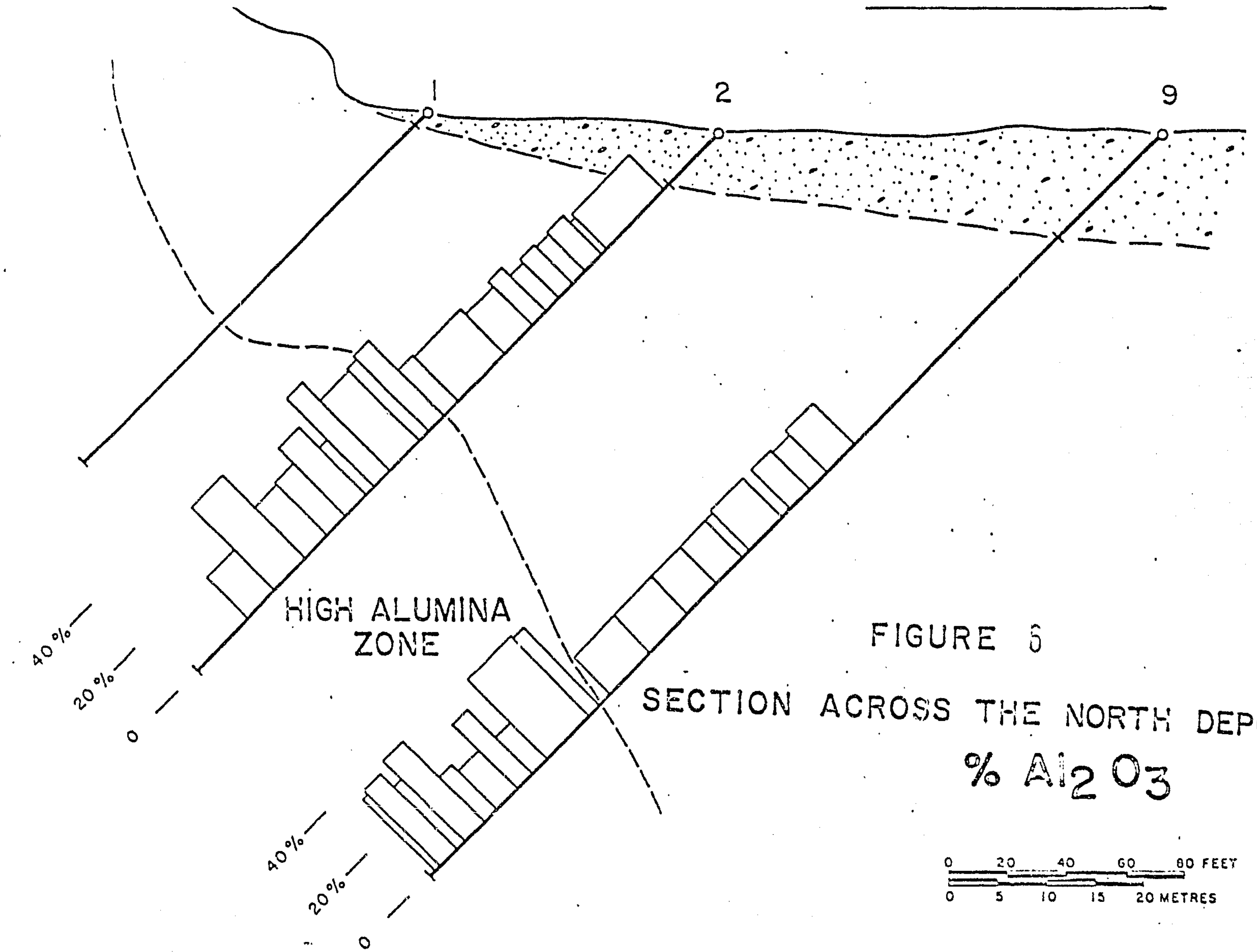


FIGURE 6

SECTION ACROSS THE NORTH DEPOSIT

% Al_2O_3

South Deposit

Six holes were drilled on the South Deposit in 1966. All were drilled toward the scuth west at an angle of 45° and all encountered pyrophyllite schists of varying purity. Samples were chemically analyzed particularly in hole No. 2 which cuts the deposit at the centre of the outcrop area. Figure 12

A comparable picture is obtained from these results indicating a somewhat greater mineralogical complexity and slightly less clearly defined zones as were observed in the North Deposit.

Mineralogical analysis has revealed a certain proportion of paragonite in the South Deposit. Paragonite is a mineral corresponding to muscovite but with sodium replacing potassium. The formula is $NaAl_2(AlSiO_3)O_{10}(OH)_2$. However the exact proportion of pyrophyllite, pinite and paragonite has not been determined. Generally, the three minerals are treated as one. Pyrophyllite is the predominating mineral; pinite is estimated not to exceed 2%-5% of the whole. In Figure 13 the combined content of pyrophyllite, pinite and paragonite is seen to average 64.6% over 92 feet.

In Figure 14, it is seen that the average quartz content is fairly uniform at around 30% which compares very well with that of the North Deposit. Figure 15 illustrates the small chloritoid content of the pyrophyllite zone at least within the compass of the drilled section. However some deeper holes have shown that the pyrophyllite is flanked in the footwall by a chloritoid and alumina-rich zone as is found in the North Deposit. Figure 16 shows that the pyrite content is low and is concentrated in the hanging wall.

RESERVES

Probable reserves for the North Deposit, assuming a length of 600 feet, a depth of 200 feet and a width of 150 feet, total 1,440,000 tons. Lack of extensive chemical analysis on the South Deposit makes the calculations of reserves more difficult. It is envisaged that at least 1,000,000 tons can be found. Possible reserves attached to the two deposits are obviously much higher as both deposits are open at both ends and at depth.

Assuming that the pyrophyllite band is continuous between the North and South Deposits and that it extends beyond the two deposits and at depth, one can infer very large tonnages of the ore material, possibly in the hundreds of million tons.

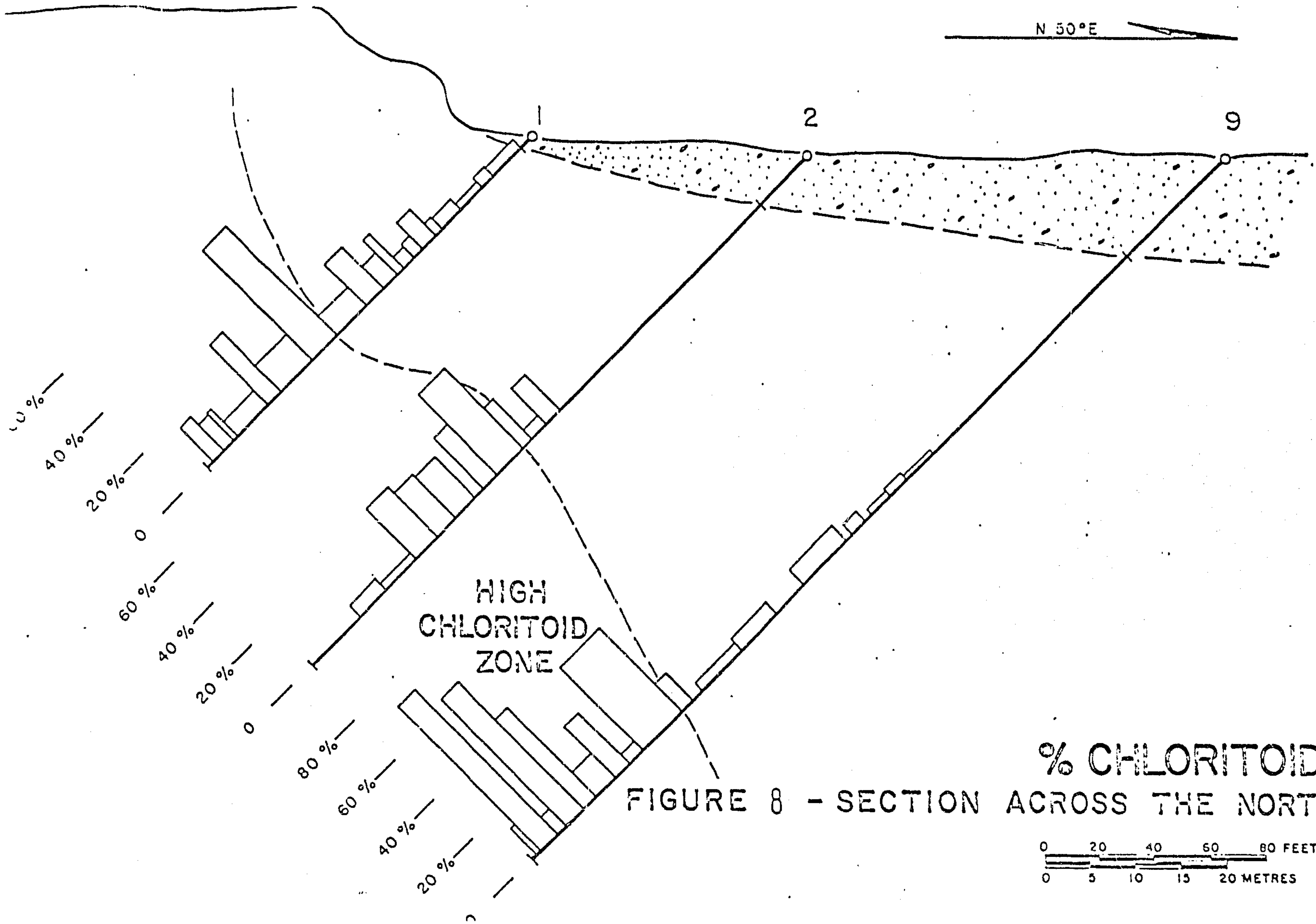
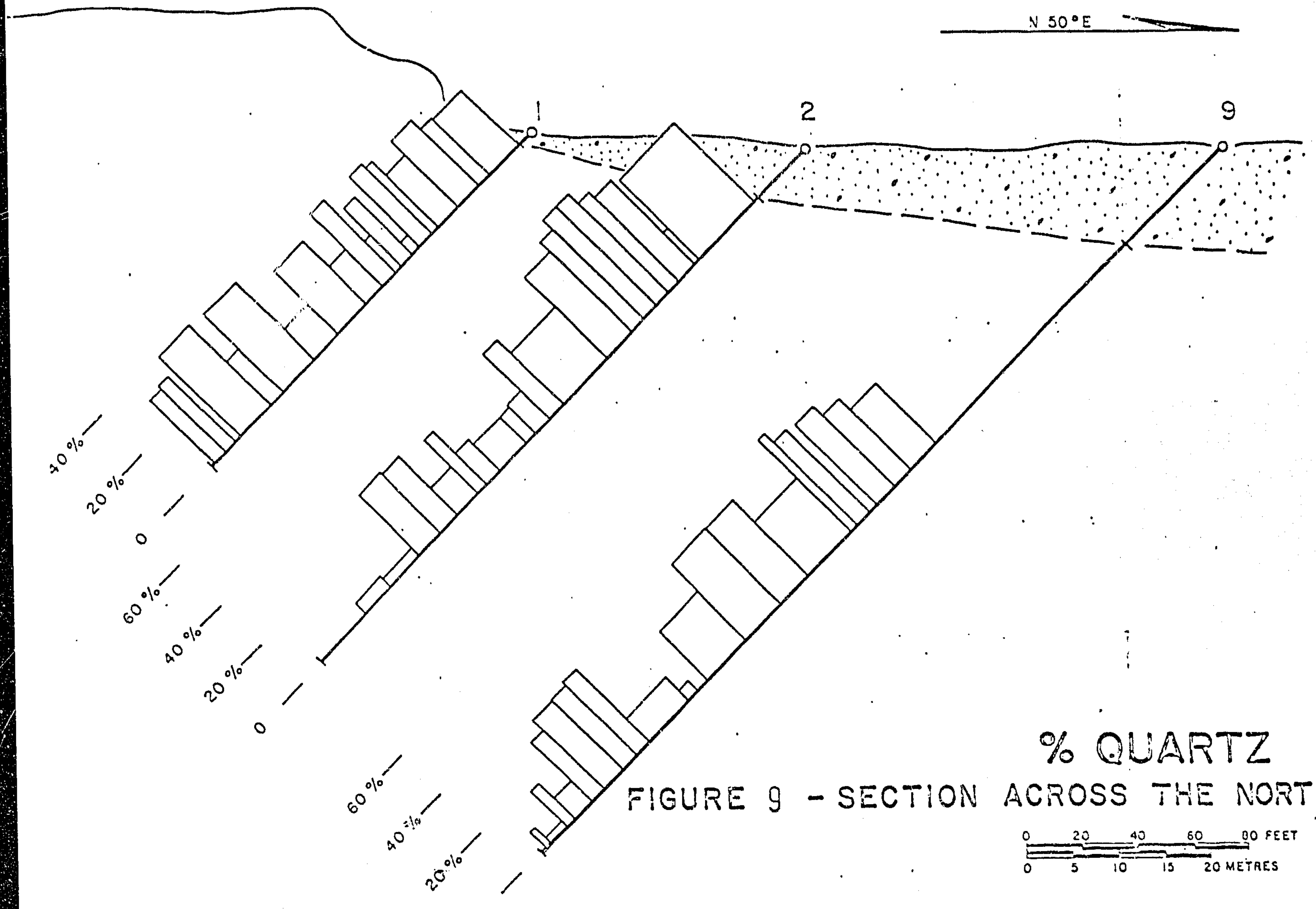
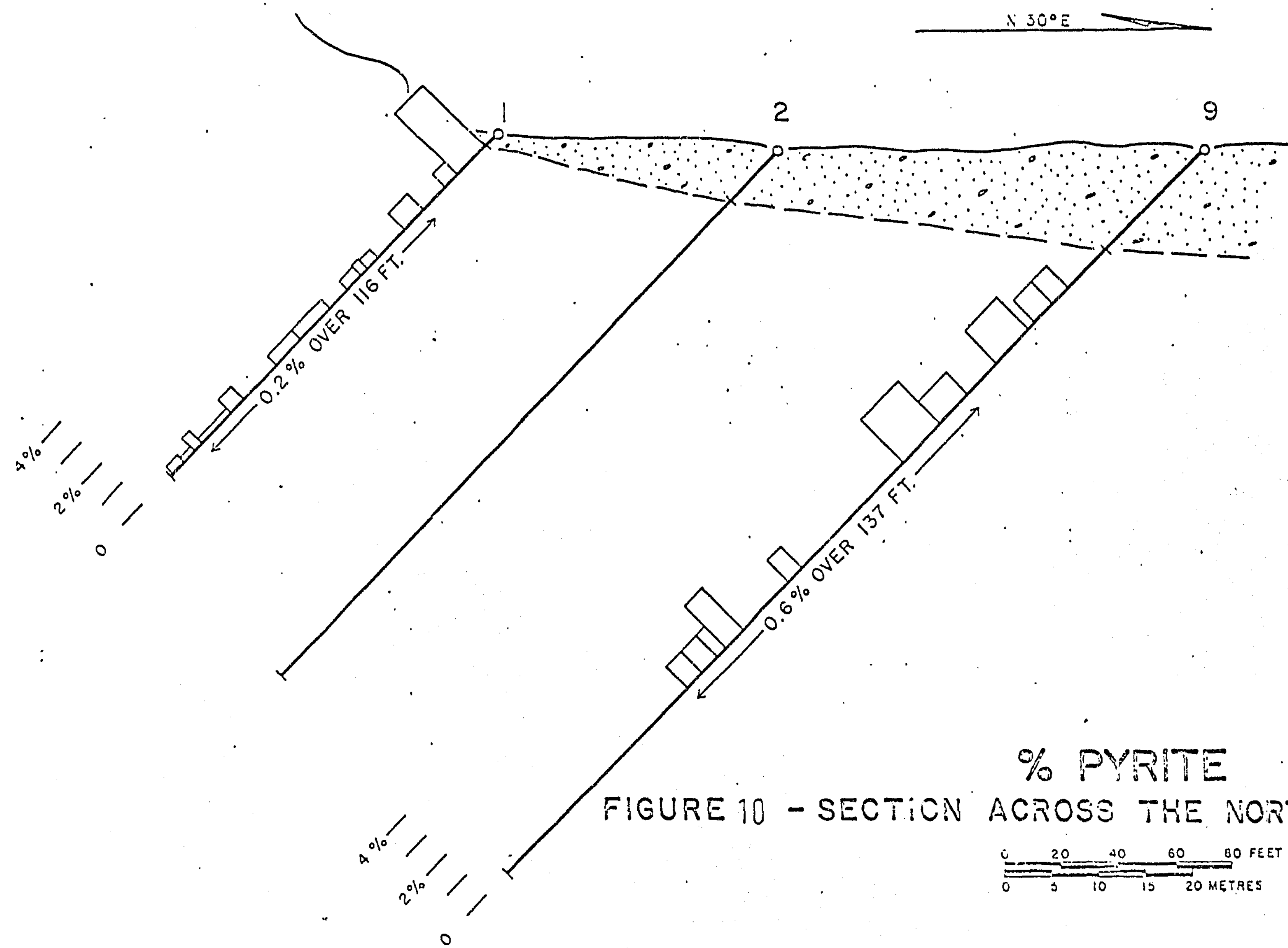


FIGURE 8 - SECTION ACROSS THE NORTH DEPOSIT



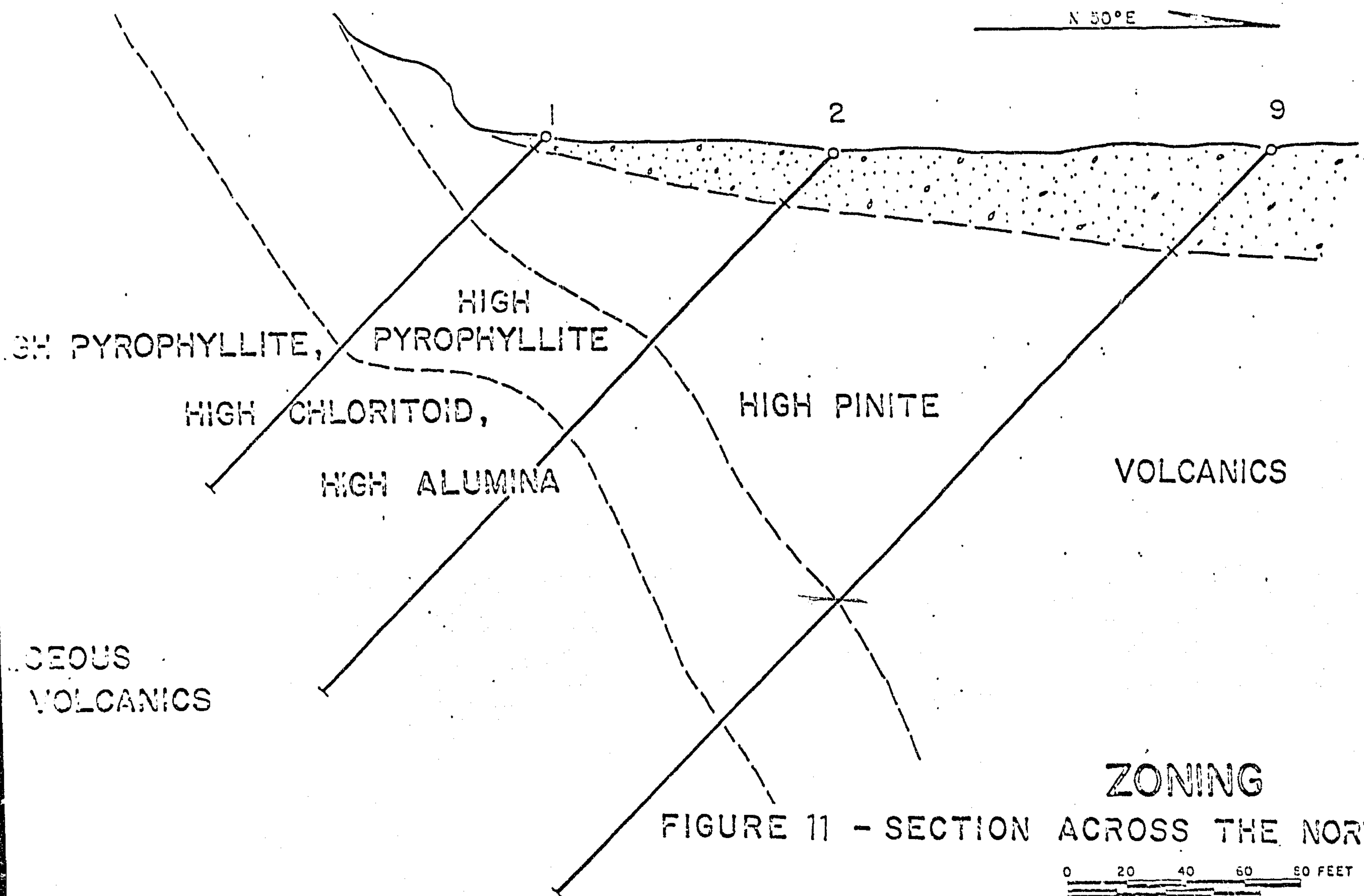
% QUARTZ

FIGURE 9 - SECTION ACROSS THE NORTH DEPOSIT



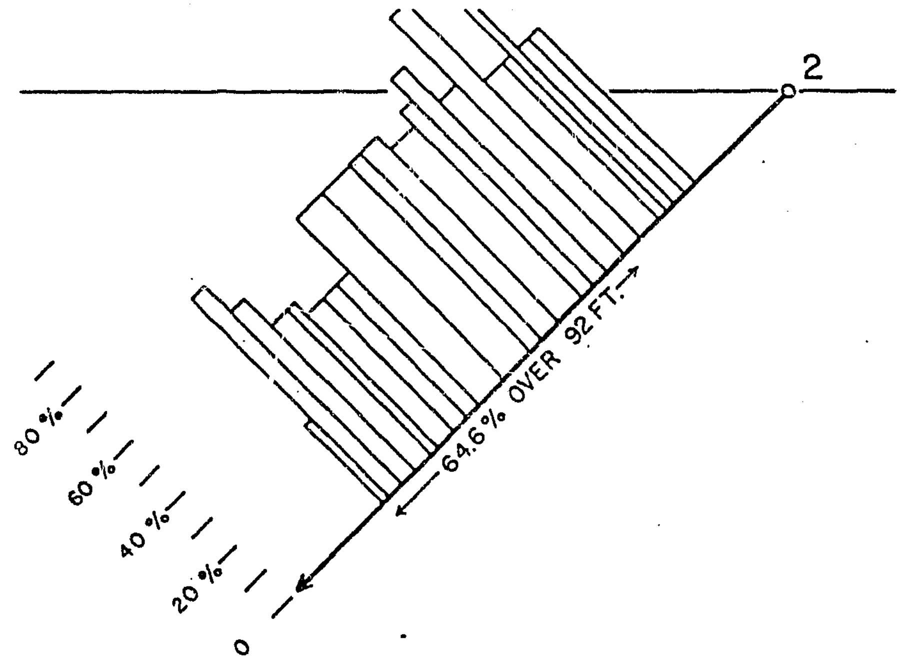
% PYRITE

FIGURE 10 - SECTION ACROSS THE NORTH DEPOSIT



ZONING

FIGURE 11 - SECTION ACROSS THE NORTH DEPOSIT



% PYROPHYLLITE + PINITE + PARAGONITE

FIGURE 13

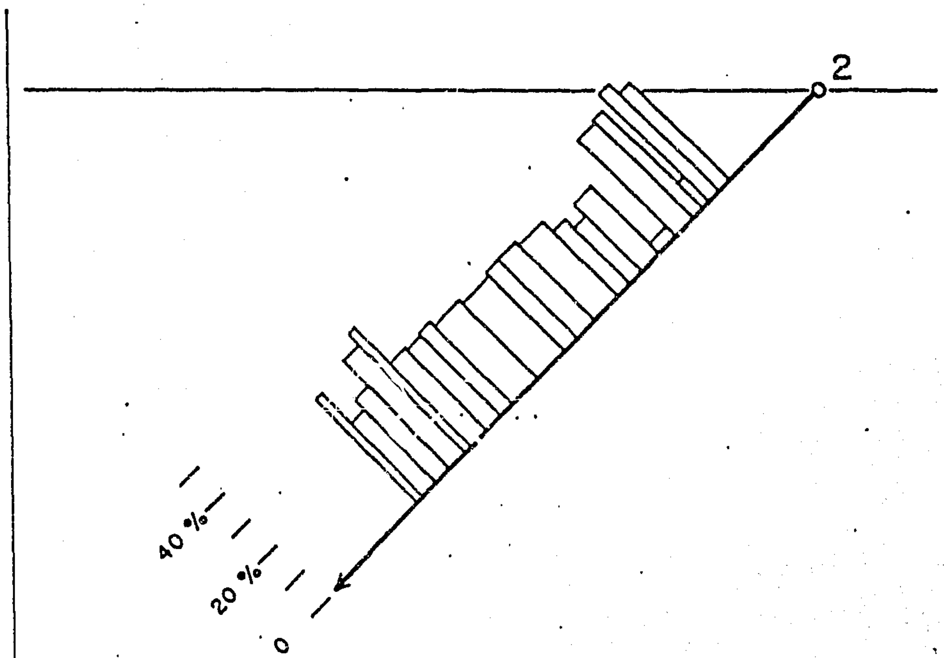
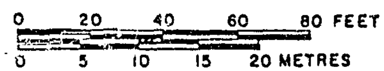


FIGURE 14

% QUARTZ



SECTION ACROSS THE SOUTH DEPOSIT

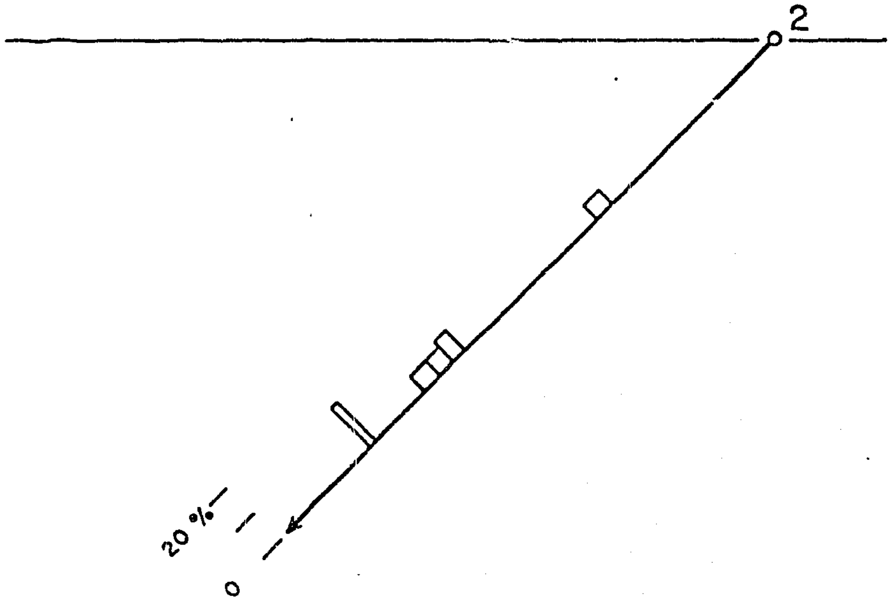


FIGURE 15 % CHLORITOID

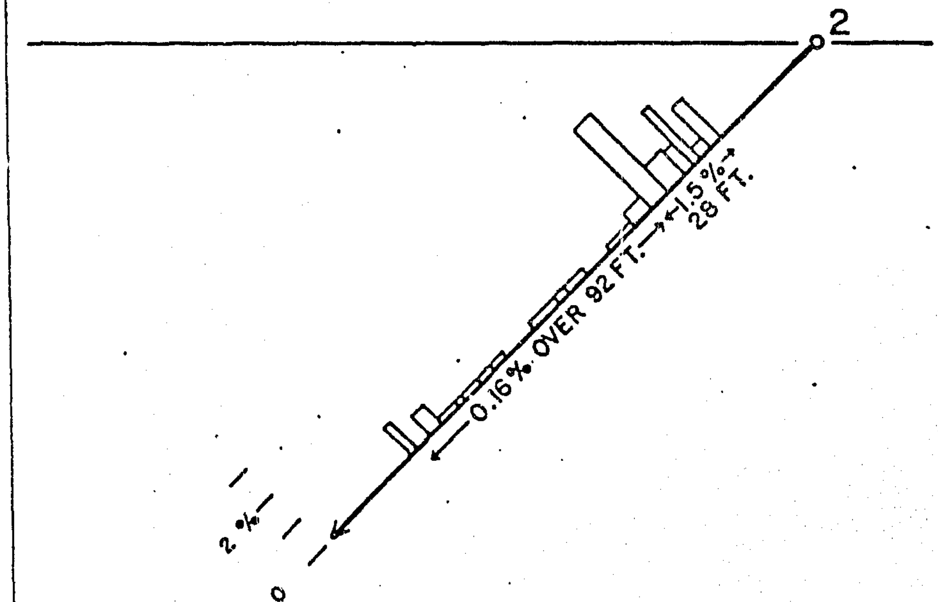
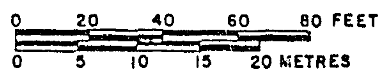


FIGURE 16 % PYRITE



SECTION ACROSS THE SOUTH DEPOSIT

CHEMISTRY, MINERALOGY AND GENESIS

The chemical analysis results put forward a picture of overall depletion in FeO/Fe_2O_3, MgO, CaO, Na_2O and K_2O content. Al_2O_3 is high; it averages 24.34%. The SiO_2 content itself averages $\approx$ 65% which would be in line with that of dacitic rocks if no alteration had taken place. However, the original rocks are believed to be acid volcanics; therefore silica has also been depleted to some extent.

The chemical analyses reflects strongly the mineralogical content of rocks which are composed predominantly of pyrophyllite, paragonite, pinite, chloritoid and quartz. Andalusite, diaspore, corundum, chloritoid, kyanite, staurolite, sillinanite, tourmaline, garnet and dolomite have all been found in minor quantities and are believed to be closely interelated in origin.

All the minerals found in the deposit are either original constituants of volcanics or are capable of being formed either directly or indirectly from hydrothermal solutions acting on them.

The initial process whereby this would occur is sericitization, i.e. simply the conversion of feldspar into muscovite. Indeed paragonite and pinite are chemically identical to muscovite.

Schmidt, 1940, after Buddington, 1940 and Kerr, 1940, states "The term "pinite", originally used as a mineral name in which sense, it covered a broad range of alteration products derived from various aluminosilicate minerals, has recently come to be employed as a rock name to indicate an acidic, volcanic rock of rhyolite, andesite or trachytic character including often a tuff form of such rocks, that has been highly altered by hydrothermal agencies, with the conversion of the original aluminosilicate minerals to the hydrated silicated pyrophyllite and sericite.

This alteration process is sometimes termed pinitization, especially where the dominant secondary mineral is sericite rather than pyrophyllite..."

Sericitization is commonest in regions where an appropriately high temperature, the chemical activity of water, and mechanical stress all work together; features which would all be well represented in a schistose zone in a volcanic region such as the one under discussion. Sericite, though commonly formed from orthoclase can also be generated from plagioclase feldspars.

Clarke, 1959, states, "orthoclase may be transformed to muscovite by addition of colloidal alumina equivalent in composition to diaspore". However, he goes on to say that, "the existence of such solutions are unlikely geologically". Alternately, "water at high temperature and under pressure forms muscovite, free silica and potassium silicate, the last being leached away". The liberated silica could of course recrystallize as quartz. Clarke adds, "A similar reaction with albite should yield the sodium mica, paragonite".

In addition, as has been already noted, quartz veining occurs in adjacent rocks and these veins could possibly represent some of the silica leached out by the various solutions. Quartz has also been seen in this section as pseudomorphs after muscovite, a further indicator of the mobilization of silica subsequent to the muscovite formation.

Thus, in brief summary, it is envisaged that the mineral assemblage found within the deposit is formed by hydrothermal and other solutions leaching out K_2O, MgO, CaO, Na_2O, and possibly some silica. This would differentially increase the alumina content and be accompanied by a reduction in volume.

The source of these solutions may be twofold, namely, associated with the original volcanism or associated with later emanations from subsequent granitization processes occurring at some distance. Naturally, the shearing and crushing would enable the solutions to penetrate the otherwise impervious volcanics assuming these were not tuffs, as well as creating a range of physical conditions conducive to chemical reactions producing the wide range of aluminum-based minerals present.

Obviously the wide variety of aluminum-related minerals cannot originate from simple sericitization. Processes similar to those found in the chemical reactions of "bauxitization" followed by dehydration through metamorphism could well lead to such a variety of minerals. Bauxite can be formed by a number of processes but Clarke (1959) argues: "It is most likely that in many cases, the formation of acid solutions by oxidation of pyrite is the first step in the alteration; they dissolve alumina from the rocks to yield it up again upon mixture with alkaline solution or solutions of calcium carbonate". As already mentioned, there is a depletion in pyrite within the zone of greatest alteration which would tend to substantiate this idea. Clarke goes on to say that the precipitation may occur in place, or transportation may be involved, and naturally the solution of alumina from rock-forming silicates would be accompanied by the release of silica. In presently active volcanic regions of the Pacific "the acid emanations from volcanoes doubtless play an important part in the decomposition of the silicates and the solution of alumina".

Finally, in support of this theory, the pyrophyllite schists of Newfoundland show almost identical chemical compositions to those of Carpentier and the work on those deposits has shown them to be the result of hydrothermal alteration of rhyolites and felsic pyroclastics.

Papezick, 1977, expresses comparable opinions concerning the Foxtrap, the North Carolina and the Japanese deposits. Leaching and partial removal of silica and alkalies by volcanic acid solutions is the general process invoked. The solutions may, in some cases carry sulphates and boric acid. In general pyrophyllite would then be the result of metasomatic alteration of felsic rocks under low-grade metamorphic conditions halfway between the prehnite-pumpellyite and the greenschist facies.

Recent work by Wojdak, 1977, concerning the Sam Goosly base metal deposit, shows that zoned aluminous alteration minerals can occur at the time of the broadly syngenetic emplacement of a pyritic Cu-Ag-Au-Sb mineralization within pyroclastic dacites. In particular, an andalusite zone changes along strike to an andalusite-pyrophyllite zone. Chemical analysis of the altered volcanic host rocks suggests significant loss of soda and lime accompanied by a residual concentration of silica and alumina. According to Wojdak, this process takes place in a high temperature geothermal environment.

It was suggested by Roscoe, 1977 that the deposits could well be the results of real bauxitization processes affecting the underlying bedrock and creating related paleosols which somehow have resisted removal by continental glaciation. This hypothesis can only be checked or refuted by way of deep drilling.

One could envisage the formation of the pyrophyllite deposit as the result of a two-step metasomatic process:

1. Initially, hydrothermal alteration processes would be those advocated by Descarreaux, 1973, and others, at the time of the extrusion of the acid volcanic rocks. The syngenetic deposition of pyrite would have been accompanied by enrichment in SiO_2 and MgO and by depletion in Na_2O and K_2O. The end result would be the chloritization of the volcanics.

2. Schistosity was developed later, possibly at the time of folding.

3. A second phase of hydrothermal activity took place, in all likelihood at the time, or following the period of folding and schistosity. This resulted in the leaching of the sulphides which, in turn created the acidic solution which effected further leaching and elimination of some of the silica and of much of all of the other oxydes, with a consequential residual enrichment in Al_2O_3 and the reprecipitation and recrystallization of some of the silica in solution as individual quartz particles. Sericitization took place, the temperature being higher than initially. Pyrophyllite, paragonite and pinite were formed as well as the other aluminous minerals, andalusite etc.

Other possible causes for the mineral assemblage and chemical composition could, theoretically exist. These can be summarized as:

1. Metamorphism of sedimentary rocks containing a high alumina content could well produce the minerals found, many of which are commonly associated with this process: andalusite, sillimanite, chloritoid, kyanite, etc.

2. Hydrothermal alteration of nephelitic, alkaline volcanic and igneous rocks causing the leaching of Na_2O and K_2O and the crystallization of quartz.

3. Solutions from the granitization of pelitic sediments causing the migration of aluminium, iron, magnesium and calcium could be channeled into a schistose zone and create "a basic front of zones characterized by a concentration of one or more of the migratory elements". Walhlstrom (1958)

However, no alkaline volcanics or pelitic sediments have ever been identified in the Abitibi region of Quebec; therefore, it is unlikely that the pyrophyllite deposits could have been formed from such rocks.

FEASIBILITY CONSIDERATIONS

There are no practical difficulties foreseen in mining the ore by open pit methods. The infrastructure in the immediate area is more than adequate to satisfy a mining operation.

Some preliminary testing has already been undertaken of the methods that could be used to refine the ore and the results of these tests have indicated that no unforeseen problems should arise in the removal of the gangue minerals.

Air Separation of Quartz

Two samples of coarse and fine material (see below) were passed through a Roller Analyzer. Originally, the material contained 26% quartz and it was found that after two passes, 80% of the quartz in the fine material had been removed, whereas no reduction in the coarse material quartz content had been noticed.

Obviously, air separation has significant potential for the removal of quartz and should be pursued further.

Magnetic Separation of Chloritoid

Tests have been carried out to compare dry and wet separation methods used in the separation of chloritoid on both fine and coarse material. It was known that material larger than 35 mesh cannot be effectively treated. Thus two size fractions were tested: 1) -35 mesh +150 mesh, and 2) -150 mesh to dust. It was found that magnetic cross belt followed by wet magnetic separation processes removed 89.6% of the iron content. This appears to be a satisfactory result. However, the Hope Cross Belt separator used for the experiment requires the magnetic particles to be lifted 1/16"-1/8" against gravity, a disadvantage that would not be encountered if an Induced Magnetic Roll Separator were used.

It should be noted that the sample used for this test contained at least twice, if not three times the amount of chloritoid that would be encountered in normal milling operations.

CONCLUSIONS

From the studies detailed in this paper, a number of significant facts can be concluded:

1. The Carpentier pyrophyllite deposit contains an extremely large tonnage of material high in pyrophyllite. The infrastructure for working the deposit is already in existence.

2. The band has been investigated at two sole outcrop locations, namely the North Deposit and the South Deposit. It is likely that additional concentrations of pyrophyllite exist between the North and South Deposits and beyond for a total length of at least two miles.

3. The North Deposit can be split into three zones flanked by altered volcanics:
   a) High pinite zone (not necessarily an impurity)
   b) High pyrophyllite zone
   c) High pyrophyllite, chloritoid, alumina zone.

   Quartz is found in all three zones.
   The high pyrophyllite zone is estimated to contain about 45% pyrophyllite over a width exceeding 130'.

4. The South Deposit is not so well defined at this stage, but is believed to be similar to the North Deposit. It consists of a zone 92 feet thick with a combined pyrophyllite, pinite and paragonite content of 64.6%.

5. Accessory minerals include andalusite, diaspore, corundum, kyanite, staurolite, sillimanite, tourmaline, dolomite, garnet, rutile and pyrite.

6. Tests have shown that the major impurities can be removed by simple and inexpensive methods.

7. The most probable origin of the deposit lies in the hydrothermal alteration of acid volcanics, essentially sericitization and muscovitization. Possibly this happened as the result of a two-step metasomatic process: normal hydrothermal alteration contemporaneous with the deposition of volcanics and sulphides followed by leaching by hotter hydrothermal acid solutions.

Thus in summary, the Carpentier pyrophyllite deposit, which is available for development is of major potential interest for the production of a valuable raw material for the Canadian and U.S. markets.

BIBLIOGRAPHY

Bliss, N.W., "Non-Bauxite Sources of Alumina: A Survey of Canadian Potential", CIMM Bulletin, Oct. 1976

Buddington, A.F., "Pyrophyllitization, Pinitization and Silicification of Rocks around Conception Bay, Nfld," Journal of Geology, Vol.24, No.2, 1916

Clarke, F.W., "The Data of Geochemistry", U.S. Geological Survey Bul.770, 1959

Deer, W.A., Howie, R.A., Zussman, J., "An Introduction to the Rock-Forming Minerals", Longman Group Ltd, London, 1971

Department of Energy, Mines & Resources, Canadian Minerals Yearbook, Canada, 1975

Department of Energy, Mines & Resources, "Ceramic Plants in Canada". 1975

Quebec Department of Natural Resources, S.P. 2, "Metallic Mineralization in the Regions of Noranda, Matagami, Val d'Or, Chibougamau".

Descarreaux, J., "A Petrochemical Study of the Abitibi Volcanic Belt and its Bearing on the Occurrences of Massive Sulphide Ores", CIMM Bul., Feb. 1973

Eveleth, F.J. and Somanchii, S., Report on Geological Survey, Bonsecours Group of Claims, Carpentier Twp, Canadian Johns-Manville Co. Ltd, G.M. 12595

Ford, W.E., (ed), Dana's Textbook of Mineralogy, John Wiley and Sons Inc.

Job, A., and Fickel, H.R., "Study of Pyrophyllite Deposit", Report No.2, Domtar 1965.

Kerr, Paul F., "A Pinitized Tuff of Ceramic Importance", Journal Amer. Ceramic Soc., Vol. 23, No.3, March 1940.

Lefond, J., "Industrial Minerals and Rocks", 4th ed., American Inst. of Mining, Metallurgical and Petroleum Engineers Inc., New York, 1965.

Page, G.A., Raine, F.F., and Sullivan, V.R., "Development and Primary Studies of Pinite", Journal Amer. Ceramic Soc. Vol.23, No.3, March 1940.

Papezik, V.S., "Pyrophyllite Deposits, Products of Metasomatic Alteration of Felsic Rocks under Low-Grade Metamorphic Conditions", Abstract Annual Meeting, GAC' MAC' SEG' CGU Meeting, Vancouver, 1977.

Roscoe, S.E., Oral suggestion made at the time of the presentation of the paper CIMM Annual General Meeting, 1977.