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R. V. KIRKHAM

GRANDUC MINES, LIMITED (N.P.L.)

VANCOUVER, B.C. MARCH 31, 1975

SUMMARY REPORT

SULPHURETS CREEK PROJECT - 1960-1974

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SUMMARY

The Sulphurets Creek Property was first explored in the early 1930s and was staked by G.M.L. in 1960. This report summarizes the various programs of work, the technical aspects of the property, its current status and presents an opinion of its merits. Proposals for further work are included.

This report is intended for the use of G.M.L. directors and officers. Most of the details regarding 1974 and 1975 work have not previously been reported. The writers have freely drawn from available data both private and published and where appropriate have attempted to acknowledge the sources of their material. It is hoped that this Summary Report, complete with comprehensive bibliography and appendices, will be the first of a continuing series of Annual Summary Reports describing incremental progress on the property.

PART I. GENERAL INFORMATION

1. Location

The Sulphurets Creek property is located 585 miles northwest of Vancouver, B. C., 40 miles northwest of Stewart, B. C. and 20 miles north of the Granduc Mine (Figures S-75-1, S-75-2). It is at the head waters of Sulphurets Creek, an eastern tributary of Unuk River. The Stewart-Cassiar Highway passes 25 miles east of the property. The Alaska-Canada border is 20 miles west and Ketchikan, Alaska, formerly the supply centre for the Unuk River area, is 95 miles southwest. Geographic coordinates are 56°30' North latitude, 130°15' West longitude. The area is part of the NTS 1:250,000 scale map number 104B Iskut River sheet.

The Sulphurets Creek property lies in an area of moraine and glacier-filled valleys, permanent snow fields and steep mountain slopes. Elevations on the property are between 1800' and 6300'. The valley of

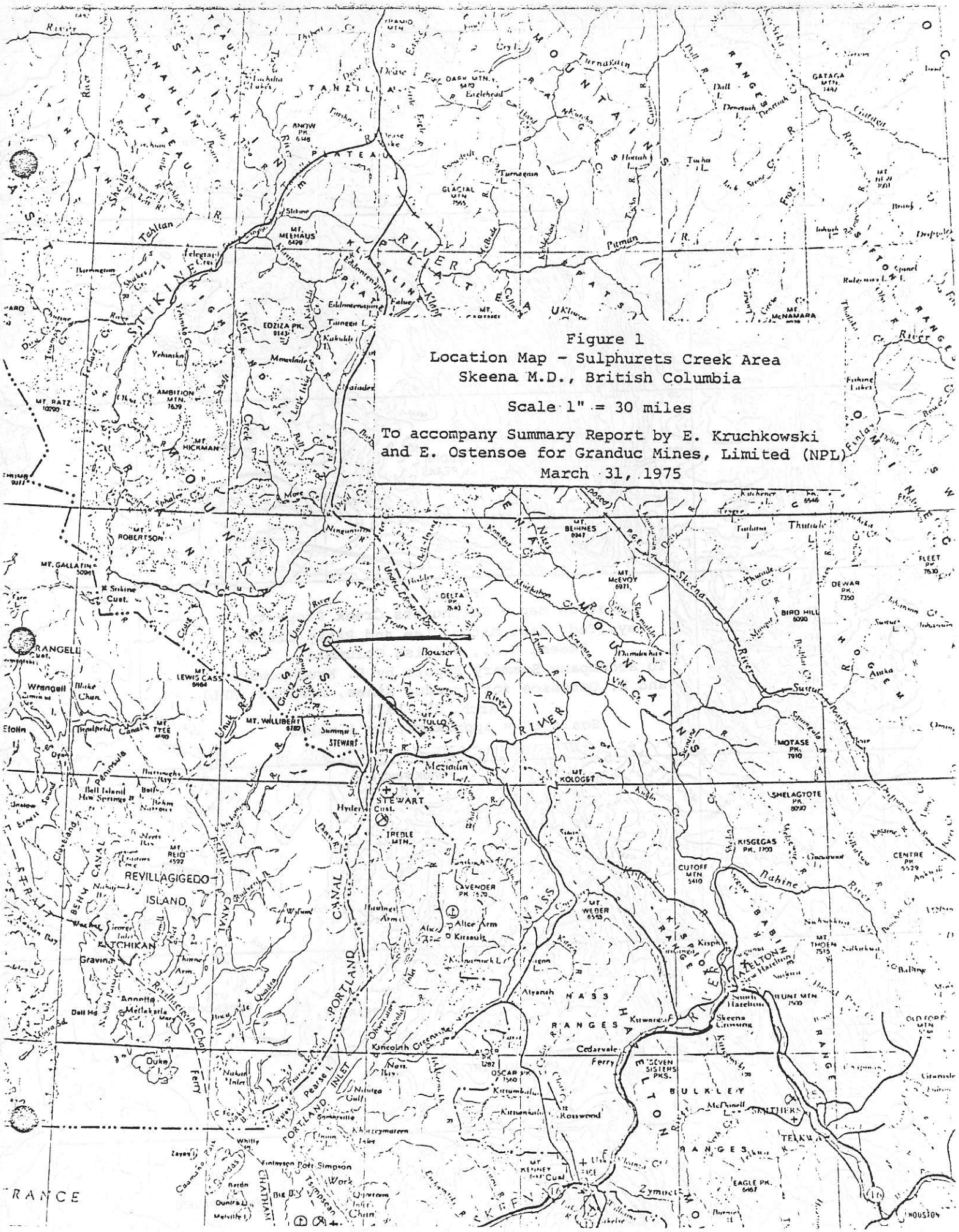


Figure 1
Location Map - Sulphurets Creek Area
Skeena M.D., British Columbia

Scale 1" = 30 miles

To accompany Summary Report by E. Kruchkowski and E. Ostensoe for Granduc Mines, Limited (NPL)
March 31, 1975

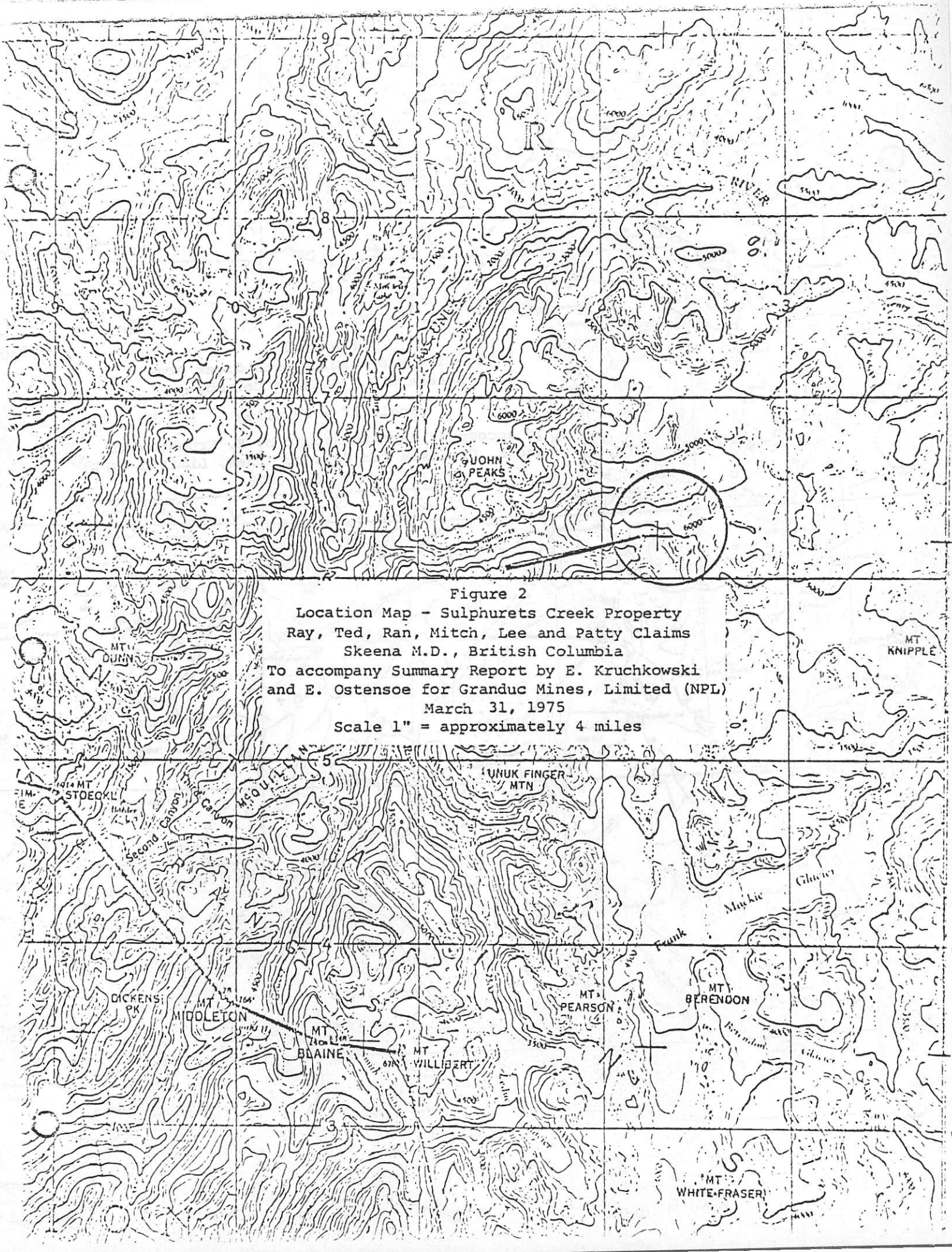


Figure 2
Location Map - Sulphurets Creek Property
Ray, Ted, Ran, Mitch, Lee and Patty Claims
Skeena M.D., British Columbia
To accompany Summary Report by E. Kruchkowski
and E. Ostensoe for Granduc Mines, Limited (NPL)
March 31, 1975
Scale 1" = approximately 4 miles

Unuk River, 9 miles west, is at 800' elevation and John Peaks, a pair of prominent glacial horns 6 miles west, exceed 7500' in elevation.

2. Climate

The Sulphurets Creek area is approximately at the interface between the west coast marine climate and the northern interior climate, both of which are modified by the combined factors of high latitude and high elevations. Winter conditions prevail from October through April with heavy precipitation, including several hundred inches of snowfall and much rainfall, and much cloudiness and occasional periods of severe cold temperatures. During the rest of the year, May through September, weather conditions are generally reasonably warm (temperatures from 40°F to 70°F) with frequent rainy periods and foggy conditions. Clear skies are an infrequent condition, but once established may persist for periods of a week or longer. Strong winds frequently prevail at higher elevations in all seasons.

3. Vegetation and Animals

The major valley, that of Unuk River, is heavily vegetated with the hemlock-spruce forest canopy typical of northern coastal British Columbia and a lush undergrowth of weeds, shrubs and berry bushes. Narrower valleys and areas between 1,000 and 4,000' elevation bear hemlock forests and exhibit numerous avalanche scars and rocky slopes that are unable to support coniferous growth. In summer the latter become densely covered with grasses, flowers and slide alder. Vegetation thins rapidly above 4,000' elevation and trees yield to willows, heather, moss and alpine flowers including gentians, lupins and members of the orchid family. Only sparse mosses and miniature flowers survive above 5000'.

Northern coastal mountains support few animals and, except in migration season, few birds. Flocks of 5 to 20 mountain goats are frequently seen in the Sulphurets Creek area. Grizzly and black bear are rarely seen but, being unpredictable in habit and behavior, are an irritant even when not in evidence. Marten and wolverine are also present.

4. Mineral Claims

The Sulphurets Creek property of Granduc Mines, Limited now consists of 76 mineral claims. In addition Mrs. Grace Dawson holds 6 claims; Don Ross and Stan Bishop of Ketchikan area hold 6 claims. Duke Kilbury and Associates, also of Ketchikan, hold several placer claims on Mitchell Creek at its confluence with Sulphurets Creek. Figure S-75-3 presents the approximate configuration of the mineral claims. Table 1 presents claim data updated to March, 1975.

5. Logistics of Access and Operation

Earliest access to the Unuk River area was from Burroughs Bay, Alaska, then, starting perhaps in the 1920s or 1930s, overland from Stewart via the prospectors' trail to Tide Lake, thence over Frank Mackie Glacier and down either Divelbiss or Teddy Morris Creek. Mining activity in South Unuk River and Tom MacKay Lake areas in the early 1930s, mid 1940s and early 1960s was supported by fixed-wing aircraft. First introduced in 1953 and now the standard method of travel, helicopter transportation has added many civilizing features of convenience, flexibility, safety and speed to prospecting and mining activities. Consequently foot trails and stream crossings have degenerated and at the present time are not practical routes.

Snow conditions preclude field work at higher elevations except during July, August and early September. The Sulphurets Glacier portion of the area opens up in May; Mitchell Glacier is about one month later, depending upon such unpredictable factors as previous winter snowfall and spring weather conditions.

Access to a possible mining operation in the Sulphurets Creek area could be provided from the Stewart-Cassiar road at Tiegen Creek or Ningunsaw Pass, respectively 95 and 102 miles from the Port of Stewart. New road construction of approximately either 42 or 45 miles would be required, of which about five miles at either end would be difficult and the balance would be relatively simple construction. Such a road would, incidentally, also be of value to any possible future developments at Granduc's Max property (10,000,000 tons, [illegible], 0.3% Cu).

Table 1

Claim Status - March 1975

Owned by Granduc Mines, Limited

Claim Name	Record No.	Expiry Date*
Ray 1 - 7		May 31, 1977
Ray 8 - 14		May 31, 1976
Ray 19	18925	May 31, 1977
Ray 20	18926	"
Ray 22	18928	"
Ray Y Fr.	21133	Aug. 6, 1977
Ted 1 - 4	18999-19002	June 3, 1977
Ted 6	19004	"
Ted 15 - 19	19013-19017	"
Ted 31, 32Fr.	19193, 19194	June 24, 1977
Patty 1 - 5	29541-29545	Aug. 7, 1977
Ran 7 - 14	31420-31427	June 29, 1977
Ran 16	31429	"
Ran 18, 19	31431, 31432	"
Ran 40, 41	31453, 31454	"
Ran 42 - 47	31455-31460	June 29, 1978
Ran 48, 49	31461, 31462	June 29, 1977
Ran 50	32236	Sept.15, 1977
Lee 1 - 4	32794-32797	June 26, 1977
Mitch 1 - 3	36316-36318	Feb. 1, 1977
Mitch 5 - 16	36320-36331	Feb. 1, 1977
Owned by Mrs. Grace Dawson, Kirkland, Wn.		
John Bull 3, 4	19739, 19740	June 22, 1975
John Bull 19, 20	19755, 19756	"
John Bull 23, 24	19759, 19760	"
Owned by Stan Bishop, Ketchikan, Aa.		
Arbee 54	19143	June 14, 1975
Owned by Don Ross, Ketchikan, Aa.		
Dawson Ross 1	19887	July 24, 1975
Dawson Ross 3	19889	"
Arbee 35	19124	June 16, 1975
Arbee 39	19128	"
Arbee 55	19144	"

* Assuming that pending Certificates of Work are issued.

Hydro electric power could be developed at several potential sites in the area. Of particular merit is a site on Iskut River, 22 miles from Sulphurets Creek, where studies (Crippen Engineering, et al.) indicate a potential 132 megawatt plant. Much smaller power sites closer by include Harrymel Creek and Sulphurets Creek but these have limited water storage capacity and would likely be operable for only part of the year. Selection of sites for processing plants, airport, townsite, waste rock and tailings disposal would all present manageable difficulties.

Currently, and in the forseeable future, access to the Sulphurets Creek property is restricted to helicopter transportation. In the past, service trips have usually coincided with camp moves or with other work requiring helicopter assistance. Planning is frequently frustrated by adverse weather conditions and by problems of helicopter availability and the vagaries of radio-telephone communications.

6. History

The first record of work on bedrock mineral prospects in the Sulphurets Creek area is found in the 1935 Annual Report of the British Columbia Minister of Mines. Bruce and Jack Johnstone of Ketchikan, Alaska located the "Big Showing" mineral claims on copper mineralization north of Sulphurets Glacier. This is the area in which G.M.L. has concentrated its more recent efforts.

Keith Fahrni, geologist for Granby, apparently visited prospectors in the upper Sulphurets Creek area in 1955. In 1959 an ambitious field program was initiated in the Unuk River watershed by Newmont Mining Corporation of Canada Ltd. on behalf of G.M.L. The first phase of this program (1959) entailed prospectors; the second phase, 1960 - 1962, was a helicopter-borne magnetometer survey followed by claim staking, geological mapping, line cutting, ground magnetic surveys and diamond drilling. Two areas of attractive mineral potential were revealed by this work: the Sulphurets and Max properties. In 1960 and 1961 mineral claims were staked in the

Mitchell Glacier area by Don Ross, Wendell Dawson, and associates, of Ketchikan, Alaska. In 1962, their claims were optioned and examined by Phelps Dodge Canada Ltd. and from 1967 through 1972, by G.M.L.

The 1960 - 1962 work by G.M.L. is recorded in reports by G. W. H. Norman, Appendix I and II, and in a University of British Columbia MSc Thesis by R. V. Kirkham entitled The Geology and Mineral Deposits in the Vicinity of the Mitchell and Sulphurets Glaciers Northwest British Columbia, 1963. This early work outlined a very large area of complex geology, alteration and hydrothermal mineralization. A theory that copper mineralization was related to the Sulphurets Thrust Fault was discredited by two diamond drill holes (1961-1 and 1962-2) but copper and molybdenum were reported in meta-volcanic and meta-sedimentary rocks close to igneous (syenitic) intrusions.

The Sulphurets Creek property was mostly idle from 1963 through 1966 except for a flurry of excitement in 1964 concerning silver values reported in the eastern part of the property. In 1967, G.M.L. resumed work with trenching and silt sampling on both sides of the Sulphurets-Mitchell Creek Ridge. Plane table mapping and diamond drilling were the main activities during 1968. Plane table mapping was completed in 1970. In 1974 when funds were again available, a program of bedrock geochemical sampling and geological reconnaissance was undertaken. This resulted in much new data, new interpretations of geology and mineralization and new mineral discoveries.

7. Expenditures - 1960 through 1974

Details of expenditures on the Sulphurets Creek property in the period 1960 through 1974 are not available. In particular, costs of the early work were not separated from total expenditures in the Unuk River area. The following set of figures is the best possible estimate:

1960 -	airborne geophysical surveys, claim staking and recording, mapping, magnetic surveys	$35,000
1961 -	geological mapping, packsack drilling	20,000
1962 -	diamond drilling, minor prospecting	20,000
1963 -	idle	-
1964 -	completion of airborne geophysical survey	2,000
1965 -	idle	-
1966 -	cash in lieu of work, Ray Y Fr.	100
1967 -	geology, trenching, claim staking and maintenance	15,000
1968 -	surveys, plane table mapping, diamond drilling	100,000
1969 -	recording fees	2,200
1970 -	complete plane table mapping	20,000
1971 -	staking Mitch claims, assessment work	1,500
1972 -	assessment work	800
1973 -	cash in lieu of work, fees	1,500
1974 -	cash in lieu of work, rentals, geochemical survey, reports	30,800
Estimated total expenditures to end of 1974		$248,900

PART II. GEOLOGY OF SULPHURETS CREEK PROPERTY

1. Introduction

This section is written in the expectation that much of its content will become obsolete or require revision following issuance by the B. C. Department of Mines and Petroleum Resources of Bulletin 60, entitled Geology of the Unuk-Salmon River-Anyox Area by E. W. Grove. At present the best available regional-scale data for the area is the 1" = 1 mile compilation map of geology by G. W. H. Norman prepared during 1961. Summaries of useful geological reports follow. The complete texts of several of these reports are included in Appendix I. The writers' current ideas are also presented.

2. Summaries of Geologic Reports

A. 1961 Report by G. W. H. Norman, The Granduc Sulphurets Property, Unuk River Region, Northern B. C. (Appendix I-A)

A review of work done in 1960 and 1961 is accompanied by a discussion of geology, local and regional structure, rock alteration, mineralization and assays and a recommendation that 5000 feet of diamond drilling test the extent and grade of copper mineralization. Dr. Norman suggested that the northeast faults at Sulphurets Creek and at Granduc Mine are part of one continuous major fault zone with right-handed drag offsets. Types of alteration are mentioned. Copper mineralization is thought to be associated with chloritization and northeast faulting. Four packsack drill sites are described and the clusters of drill holes are illustrated, along with composite assays for copper. Gold in placer and gold and silver bearing vein occurrences are described. Molybdenite occurrences along the footwall of Sulphurets Fault and along the south side of Mitchell Glacier are described.

B. 1963 Memorandum Report to John Drybrough from G. W. H. Norman, Sulphurets-Mitchell Area Claims (Appendix I-B)

This 10 page report is a review of the Sulphurets Creek property prepared following receipt of R. V. Kirkham's M.Sc. thesis. The history of the area is summarized and Kirkham's work is discussed in the context of porphyry copper deposits. Some of the problems in making an adequate

test of the copper possibilities are outlined. A favorable area 12000 feet long and 3000 to 6000 feet wide is described. A systematic drilling program totalling 375,000 feet of drilling (500 foot deep holes at 800 foot centers) is referred to but an induced polarization survey of about 100,000 feet in 14 lines is recommended for the copper area. Further prospecting of the gold-silver prospects is also recommended.

C. 1963 M.Sc. Thesis by R. V. Kirkham, The Geology and Mineral Deposits in the Vicinity of the Mitchell and Sulphurets Glaciers, Northwest British Columbia, copies in Granduc's Vancouver office and in library at University of British Columbia. (For abstract see Appendix I-C).

The thesis study was a wide-ranging geological look at the Sulphurets and Mitchell Creek areas combined with laboratory studies. As such it includes a comprehensive petrological study of the igneous rocks and rock alteration.

This study contains much valuable information about the various rock types and presents some ideas concerning the formation of sedimentary units as a result of turbidity currents. It attempts to place the bedded rocks in the then crudely defined time-stratigraphic model.

The name "Mitchell Intrusions" was introduced to designate all intrusive rocks except late dykes and spilitized diabase. Different intrusions are described, along with reference to their mutual structural relationships. Feldspars were studied in detail with the aid of X-ray diffraction, thin sections, the universal stage and phase diagrams. Kirkham concluded that the Mitchell Intrusions were emplaced in a hypabyssal environment. A gradation of composition from syenodiorite and albite syenite in the Sulphurets Valley to syenite, quartz syenite and granite on Sulphurets-Mitchell Ridge and Mitchell Valley was recognized. A common origin and close relationship between all members of the Mitchell Intrusions was indicated.

Bedding, schistosity and cleavage were investigated by means of steriogram plots. Folds, faults, mylonite zones, breccias and bondinage are discussed briefly. Metasomatic alteration by low temperature (400°C) altering fluids emanating from the Mitchell intrusions is hypothesized. Albite, calcite, sericite, quartz, chlorite, pyrite, clay minerals, epidote, biotite and potash feldspars are described.

Possibilities of disseminated very low grade, very large tonnage deposits, their probable genesis, their relation to a prolonged period of alteration and the possible existence of a structural trap are discussed at some length. Kirkham concluded that major "Porphyry-Copper" type deposits may be present. However, the presence of vast quantities of volatiles may have resulted in dispersal of the valuable metals.

The thesis is accompanied by a geological map, geological cross sections and a map showing distribution of alteration minerals. Chapter IV, Rock Alteration, forms Appendix I-D of this report.

D. 1968 Preliminary Summary Report of Geology of Sulphurets-Mitchell Creek Ridge by Roy Wares (Appendix I-E)

This is a very brief preliminary review of results of the 1968 plane table mapping and diamond drilling program at Sulphurets Creek. Wares touched on various aspects of the geology, alteration, structure and mineralization. The pyrite zones were considered due to "sulphurization" of a regional unit and he felt that the related trace copper mineralization was of no economic significance.

E. 1968, Ted, Ray Property, Unuk River, Skeena Mining Division by E. W. Grove in Report of the Minister of Mines and Petroleum Resources (complete text forms Appendix I-F of this report)

Grove reports on the Sulphurets Creek property in its regional context. He states that it is at the northwest end of an elongate regional dome and consists of intercalated volcanic epiclastics, volcanic

flows and marine sediments intruded by a complex of syenite, monzonite and diorite plutons. The report is accompanied by a useful geological map.

F. 1975, Geology and Geochemistry of Mitch, Ray, Ted, Patty and Ran Mineral Claims, an assessment work report by Ed Kruchkowski and Erik Ostensoe, copies on file in Victoria and in Granduc's Vancouver office.

This report is a summary of the status of the Sulphurets Creek property and a detailed description of 1974 field work and the results obtained. Geological data and silver, lead and molybdenum geochemistry were discussed.

3. Regional Geology

The Unuk River district lies between two of the main geological elements of northwestern British Columbia: it is east of the main Coast Crystalline Complex and is on the western edge of the Bowser Basin. Apart from gneissic rocks of undetermined age exposed near Mitchell Glacier and recent basalt flows in King Creek, Unuk River and Iskut River, all rocks are apparently of Mesozoic age. Paleozoic rocks are exposed further to the east in the Oweegee Range.

Intrusive rocks of the Unuk River area include the full spectrum from granite, syenite, granodiorite and diorite to gabbro. The syenitic rocks, of uncertain age, appear to be related to tectonically active zones in the upper South Unuk River and in the Sulphurets Creek area. Foliated diorite-granodiorite, thought to be older than the Coast Intrusions, is prominent at McQuillan Ridge and at Granduc Mountain. Unfoliated granite and granodiorite dominate the Coast Crystalline Complex and form several satellite plutons including those at Summit Lake and LeBrant Creek. Gabbro forms the monolithic mass of John Peaks and is also present west of Tom Mackay Lake and at Snippaker Creek.

Stratified rocks are of sedimentary, volcanic and epiclastic origin. With the exception of pillow lava units few purely volcanic rocks have been recognized in the area.

In the immediate vicinity of the Sulphurets and Mitchell Glaciers a regional elongated dome has been unroofed by weathering and glacial processes. The strike of the long axis of the dome is approximately north 20°W. The south part of the dome structure is largely obscured by glacial cover and permanent snow but it is assumed that the local structure has a length of several miles. The core portion of the dome includes all the rocks of economic interest in the Sulphurets Creek area. Immediately adjoining these rocks to the west is a thick sequence of black and dark brown clastic sediments which vary from argillites to conglomerates. This same formation is exposed in a broad regional fold north of the Sulphurets Creek area and northeasterly in the Treaty Creek area. One and possibly two pillow lava horizons recognized in the area immediately west of John Peaks have been correlated with a regional pillow lava formation which is known to extend at least as far south as the Anyox area (Grove, 1968). Similarly, limestone formations mapped in the south Unuk River, notably at the mouth of Gracey Creek, and near the confluence of Unuk River and South Unuk Rivers are correlated with limestone formations in the vicinity of Granduc Mine. At the latter location, the limestone has been assigned a Triassic age. The area lying between the South Unuk River and the Coast Intrusions consists of a variety of sedimentary and epiclastic-sedimentary rocks. Close to the Coast Intrusions minor thermal metamorphism has been imposed.

A number of regional fault structures have been postulated in the Unuk River area. The strongest of these structures is thought to occupy the Unuk River Valley from the vicinity of the International Boundary to Harrymel Creek and then may be diverted or cut off by a strong northerly striking structure along the latter creek. A similarly strong linear

feature in Gracey Creek valley also strikes northeasterly but its character is unknown. Offsets, if any, are relatively minor. A large number of linear zones of alteration, primarily silicification and/or carbonatization, have been recognized in the Unuk River and Sulphurets Creek areas. A very strong northeasterly striking linear alteration zone about 1-1/2 miles southeast of Tom Mackay Lake is typical of these structures. It is probable that the alteration zones represent ancient areas of faulting or at least fracturing. The core area of the regional dome at Sulphurets Creek differs from the other more elongated alteration zones only in terms of its size and the intensity of alteration.

4. Detailed Geology of Sulphurets Creek Property

A. Introduction

The Sulphurets and Mitchell Creek mineralized zone lies between the Coast Crystalline Complex and the Bowser sedimentary basin in a regional structural element described by Grove (1968) as the Bear River Uplift. The area of mineralization occurs in epiclastic rocks, flows and marine sediments intruded by a complex of syenitic, dioritic and granitic plutonic rocks collectively referred to as the Mitchell Intrusions. The structurally complex Sulphurets and Mitchell Creek areas are further complicated by extensive silicification, sericitization and pyritization and by weathering effects. Thrust and tear faults have been identified but the displacements are in most cases obscured and are as yet unresolved.

Potentially valuable occurrences of metals have been found in several parts of the Sulphurets and Mitchell Creek areas. These and their geological environment have been investigated by several different geologists in the period 1960 to the present but a comprehensive and definitive description of the geology of the area has not yet been prepared. The present writers compiled the accompanying geology maps (Figures 4 - 8) from previous maps, field observations and microscopic examination of hand specimens and bedrock geochemical samples. The map is interpretive as the field work was structured by the geochemical grid (400' x 400'). Petrographic studies now underway (by J. H. Montgomery, PhD., P.Eng.) are expected to help resolve some uncertainties about rock types and to lay the basis for more extensive petrographic work.

B. General Description of Area

A very prominent orange coloured mineralized zone can be traced from the divide between Sulphurets Glacier and Frank Mackie Glacier to the south, northerly across Sulphurets and Mitchell Glaciers to where it passes beneath a snow field that separates Mitchell Creek valley from Treaty Creek valley. This zone forms the Sulphurets Creek mineralized area. Similar discoloured rocks outcrop on the north and south side of Treaty Glacier about 3 miles to the northeast. Several similar but much smaller discoloured areas have been located in the Unuk River drainage area and a very large and similarly anomalous area of silicification, alteration, and mineralization lies west of Snippaker Creek 16 miles northwest of Sulphurets Creek.

The brightly coloured rocks correspond to an area of faulting, thrust faulting, alteration, hydrothermal mineralization and weathering imposed on a variety of plutonic, volcanic and sedimentary rocks. An adequate explanation for the localization of the disturbed and altered area is not available. Dr. Norman speculated that it may be continuation of the Granduc Fault Zone.

The zone is partially limited on the west by a gently dipping (30°W) thrust fault and partially by an unconformity. The east limit of the main area of disturbance corresponds to the postulated position of a steep angle north-south striking structure referred to by Dr. Norman as the "Brucejack Fault". Rocks west of the zone are predominantly marine clastic sediments, possibly of Lower Jurassic age. To the east, fragmental volcanic rocks, tentatively correlated with the Betty Creek formation in the lower part of the Bowser Assemblage, are present. Elsewhere in the general Stewart-Unuk River area this formation has been dated as probable Middle Jurassic age. Thus it is reasonable to assume that the altered zone is comprised of rocks of Lower and/or Middle Jurassic age.

Figure 4 presents the writers' current map of the geology of the Sulphurets Creek property. Figures 5a and 5b illustrate the Main Copper Zone in plan and in section respectively and Figures 6a through 8a are north-south vertical sections at 1200 foot intervals between 2800E and 7600E on the rock geochemical sampling grid.

The entire Sulphurets and Mitchell Creek area has extensive deposits of unconsolidated glacially derived material. These deposits are particularly thick in the valleys of both Mitchell and Sulphurets Glaciers. The glaciers themselves have created deep steep walled valleys which cut across the area in an east-west direction. Glacial ice and permanent snow occupy at least 25% of the indicated extent of the Sulphurets - Mitchell Creek mineralized area.

C. Plutonic Rocks

An array of plutonic rocks has been identified in the Sulphurets Creek area. The total extent of such rocks is relatively small compared to the extent of the hydrothermally altered area.

On the basis of variations in microcline and quartz contents, Kirkham (1963) identified three main types of syenitic intrusions:

1. Albite syenite including hornblende plagioclase porphyry,
2. Syenite and quartz-syenite grading into granite, and
3. Cross-cutting granite.

Kirkham found that potash feldspar occurs sparingly in the albite syenite, is an essential constituent of the syenite-quartz syenite and occurs in a microperthitic form as the only feldspar in the granite. He suggested that the progressive differentiation of a parent magma would account for this variation. The apparent total lack of calcic plagioclase may have resulted from sodium metasometism subsequent to initial crystal formation or may reflect a somewhat uncommon condition of a calcium-deficient magma.

The 1974 field work permitted a tentative alternate classification of the syenitic rocks into

1. syenites,
2. trachyte flows,
3. granite, and
4. cataclastic syenite.

The main occurrences of the syenitic and related intrusions are in a probable sill complex exposed in the hanging wall block of the Sulphurets Fault on the ridge between Sulphurets and Mitchell Glaciers, and in the footwall of the same structure on the lower slopes both south and north of Mitchell Glacier. They were not recognized in the floor of the valley at the toe of Mitchell Glacier.

Porphyritic syenite commonly exhibits euhedral and subhedral pink and white microcline microperthite and subhedral white albite phenocrysts in a greenish phaneritic ground mass composed of albite and altered mafic minerals. Phenocrysts are mostly 2 to 5 mm in length but very coarse grains up to 20 mm in length are occasionally present. Mafic minerals seldom comprise more than 20% of the rock and commonly are less than 5%. Microcline microperthite grains exhibit oscillatory zoning visible without aid of magnification and frequently have a core of plagioclase. Frequently grains of plagioclase and mafic minerals have been engulfed by the zoned materials. Syenites rich in mafic minerals are usually magnetic with 1 to 2% visible magnetite grains. Country rocks adjacent to syenitic rocks are also commonly magnetic.

Trachytes were mapped in the area north and east of the sharp bend of Sulphurets Glacier where they are thought to be hypabyssal intrusions. Similar rocks, possibly extrusive equivalents of the trachytes, are recognized in the agglomeratic units nearby. Kirkham distinguished greater amounts of albite and lesser amounts of microcline in the trachyte as compared to the syenite. Both rock types are commonly porphyritic but, unlike the syenite, trachyte contains horn-

blende phenocrysts and has a dark green aphanitic matrix. Feldspar phenocrysts in the trachyte usually are numerous, euhedral and closely similar in size (in the 2 to 4 mm range) in contrast to a scattering of corroded grains of varying size in the syenite. Weak epidote alteration, pervasive throughout the trachyte, is likely a deuteric phenomenon.

The present writers have very limited familiarity with the granite but both Kirkham and Wares (1968) recognized granite as an important "end member" of the Mitchell Intrusions. Cross cutting relationships with granite in the syenite as described by Kirkham were not recognized in the field by the present writers. Two samples of granite were however collected during the course of the 1974 rock geochemical sampling program. The granite is distinguished by an overall dark red to a light purple colour, the presence of visible quartz and by the low content of ferromagnesian minerals. It is holocrystalline with subhedral and anhedral feldspars and siliceous matrix. Feldspars are mostly red with white cores and are microline microperthite and perthite. Quartz, calcite and chlorite veinlets cut the granite.

Cataclastic syenite occurs on the south slope of Mitchell Valley in close proximity to the trace of the Sulphurets Fault. It typically consists of a mixture of granulated and mylonitized syenite and coarse fragments of brecciated syenite. Quartz is abundant in the matrix portion and exceptionally forms as much as 50% of the total rock. Colours vary from dark red to light grey, dependent upon the intensity of alteration that has affected the rock. The broadest area of cataclasis corresponds to the intersection of the Sulphurets Fault and underlying steep angle north-south faults.

D. Andesitic and Dioritic Rocks

On the accompanying map sheet (Figure 4) four subdivisions of the andesitic and dioritic rocks are indicated. Two of the subdivisions, andesite tuff and andesite agglomerate, are clearly of

extrusive origin; the third, dykes and sills, is intrusive and probably consanguinous with the first two; the fourth, hornblende diorite porphyry, is intrusive, crosscuts trachyte and is virtually unaffected by the regional alteration.

The andesitic tuff unit includes crystal and lithic tuff and interbedded tuffaceous sediments of andesitic composition. It is abundantly distributed on the north side of Sulphurets Valley and, together with agglomeratic and epiclastic material, forms an arcuate wedge marginal to and partly assimilated by the syenitic plutonic rocks. On the south side of Mitchell Valley, however, tuffaceous rocks are less common even though the fragmental varieties appear to persist. Crystal tuff members have angular crystal grains and fragments in a microcrystalline groundmass whereas lithic tuffs are composed of small rock fragments in a tuffaceous matrix. Bedding is seldom prominent and frequently is obscured by alteration. Colours vary from light green to grey and alteration is of variable intensity. Weak silicification and weak to moderate development of epidote, chlorite and calcite are typical. Potash metasomatism has occurred close to the syenitic plutonic rocks and in most cases results in a pink coloured crystalline rock that can scarcely be distinguished from the intrusive rock. Similarly ambiguous, the andesitic agglomerate with coarse fragments and a tuffaceous matrix may easily be confused with some of the coarser clastic sedimentary rocks.

Although mostly too small to show on the accompanying geological map, andesite dykes and sills are occasionally recognized in the field. It seems probable that some of these structures are actually small plutons or were feeders at the time of extrusion of the enclosing volcanic debris. The andesite is green, dense, holocrystalline and generally lacks internal structures. Feldspar phenocrysts are occasionally present. Chloritic alteration is pervasive in some dykes but others are virtually unaltered. Calcite, epidote and minor amounts of magnetite are variable components.

Dioritic dykes have characteristics similar to those of the andesite dykes but are lighter in colour and coarser in grain size. Essential minerals are feldspar and hornblende. Micas were noted in only one occurrence.

Hornblende diorite porphyry is present in several areas on the slopes immediately north of Sulphurets Glacier. This rock type is distinctive, having up to 30% euhedral and subhedral hornblende phenocrysts and a dense finely crystalline feldspathic matrix. Hornblende grains may be aligned and are commonly chloritized. Pyrite may be disseminated in coarse grains, exceptionally up to 20% of the rock and is moderately abundant in association with the unit in massive form in lenses and narrow veinlets.

Kirkham gives useful tabulations of visual estimates of mineral compositions of both volcanic rocks and various members of the Mitchell Intrusions. Due to the high percentages of "unresolvable" matrix (30 to 40% in Mitchell Intrusions, 10 to 25% in volcanics) and the abundances of alteration minerals, particularly sericite, chlorite, calcite and epidote, attempts to prove their comagmatic origins by this method are likely to be futile. The overall evidence, both field and laboratory, is suasive and the present writers speculate that further work will demonstrate the close genetic relationship. Recent work by Preto (B. C. Department of Mines and Petroleum Resources) in the Aspen Grove and Afton areas was successfully directed to similar problems.

E. Clastic Sedimentary Rocks

Earlier descriptions of the Sulphurets area have emphasized the importance of volcanic rocks but it is the present writers' observation that true volcanic rocks are relatively limited in extent. A great many tuffaceous and pyroclastic sedimentary rocks collectively referred to as epiclastics, occur in association with the more traditional sedimentary rocks such as arenites and greywackes. Making

the distinction between greywackes and pyroclastics is particularly difficult in the field but was possible with greater degree of confidence in the office where cut surfaces were examined.

Greywackes are present in all parts of the Sulphurets Creek area. Lithic grewacke, in which rock fragments exceed detrital feldspar grains, is predominant in the southwestern portion of the property whereas feldspathic greywacke is most abundant in the eastern and northwestern portions.

Feldspathic greywacke has about 30% and occasionally up to 60% feldspar both as subangular detrital grains and as phenocrysts in rock fragments. Sorting is poor and particles range from silt and clay size through coarse sand and pebble sizes. Colours vary from green to grey-green and are usually influenced by weak chloritization of the rock-flour "paste" matrix. Chert fragments commonly comprise 10% of the lithic varieties of greywacke. In addition to chlorite, carbonate and in particular epidote are common products of alteration.

Kirkham (1963) was firmly convinced that much of the sedimentary material, both coarse and fine grained, had been deposited by turbidity currents or at the very least had been affected by such currents. He found the rocks to typically have an extremely low maturity index, poor sorting and a low degree of roundness of the fragments and grains. On the basis of their recent field studies the present writers have no reason to dispute Kirkham's conclusions with respect to the greywacke component of the sedimentary sequence.

Arenites are distinguished from the greywackes by being very siliceous rock containing less than 10% argillaceous matrix. At Sulphurets Creek the arenite is typically a massive grey, fine-grained, pyritic, quartz-rich rock that lacks good bedding features.

Quartzitic-, feldspathic-, and lithic-arenite varieties of the unit were distinguished in the office depending upon the nature of dominant components as determined on cut surfaces. Wackes, which are similar rocks with more than 10% argillaceous matrix, were also recognized. The arenites are severely complicated by silicification, weathering, staining and leaching. Overall, the arenites appear to exhibit a higher maturity index than do the graywackes.

The arenite unit does not outcrop in the hanging wall side of the Sulphurets Fault. A lateral change eastward, away from the fault, from arenite to wacke to greywacke is thought to represent a facies change. In the past this transition was interpreted as a stratigraphic succession which lead to a somewhat different geological model for the area.

A thick sequence of argillite, siltstone and chert occupies the southeastern portion of the Sulphurets-Mitchell Creek area. These rocks appear to underlie the arenite unit and include minor amounts of wackes, arenites, tuffs and trachytes. In general they are thinly bedded and well indurated or weakly hornfelsed. The argillites are black, pyritic and calcareous; the siltstones, grey, siliceous or cherty, and the cherts are usually grey and highly fractured. Thin limestone lenses were noted, particularly in the upper portion of the unit but limestone is generally an uncommon occurrence. Chlorite, sericite and epidote are present throughout this sequence of rocks.

A very extensive sequence of shales, argillites and conglomerates lies west and northwest of the Sulphurets Fault Zone. These rocks exhibit distinctly lower grades of metamorphism than do the volcanic and epiclastic rocks that underlie the fault zone. North of Mitchell Glacier they are unconformably above the strongly altered series but in the one area that the contact has been observed (E.A.O.-1968) the rusty weathering, "punky", soft, sericitic, clayey and

pyritic alteration typical of the underlying unit was noted pervading fractures in this shale, etcetera, sequence.

F. Regional Metamorphic Rocks

Strongly foliated light coloured rocks are exposed close to the south side of Mitchell Glacier and for several hundred feet immediately downstream from the snout of the ice. Where weathered, this rock is similar in appearance to members of the strongly altered "arenite" unit. Profound differences exist, however, that justify assignment of the lower lying rocks to a separate geological unit.

The silicified arenite contains a high percentage of quartz and pyrite in quartz stockworks and as pervasive metasomatic "flooding". Where recently exposed by glacial retreat the arenite forms prominent steep-faced bluffs and huge blocky talus. Weathering of pyrite that occurs in seams and veinlets produces a dark red-brown oxide "skin" on its surfaces. The strongly foliated rock, in contrast, contains similar quanitites of pyrite and lesser amounts of silica. The pyrite however is disseminated and the silica is disguised in the bulk of the rock rather than prominent in fractures. The unit weathers recessively and its talus pieces are short-lived in the periglacial environment. Its main constituents are quartz, sericite, talc and, occasionally, chlorite. Pyrite, molybdenite and chalcopyrite are present but only pyrite is in significant quantities.

Three subdivisions of the strongly foliated formation are indicated on the accompanying geology map (Figure 4):

1. talc-sericite-chlorite schist
2. quartz-sericite schist
3. chlorite schist.

These subdivisions may reflect variations in parent material.

In 1970, Peter Brown, after plane table mapping in the Mitchell Glacier area for G.M.L., studied the schists with the aid

of thin sections. He noted the lack of feldspars or feldspar remnants but even so considered the rock a highly silicified syenite in which schistosity was defined by sericite and talc. Quartz "tails" with pyrite grains were thought to be stress shadows consequent upon dynamic metamorphism and their conformity to schistosity suggested that the pyrite originated at least prior to completion of the dynamic cycle.

The present writers have insufficient experience with the schistose rocks to offer alternatives to Brown's observations. At present, though without compelling evidence, they are very dubious about the parent rock having been a syenite.

The strongest foliation in the schist is oriented east-west with very high angle dip in contrast to a predominance of northerly trends in most of the overlying rocks. It is possible that the schists represent a regionally metamorphosed "basement" that is exposed due to the combination of regional doming (after Grove, 1968) and deep glacial erosion.

G. Alteration

Widespread and varied alteration patterns characterize the Sulphurets Creek area. The entire zone of alteration and the included copper and molybdenum mineralization is stained by brightly coloured weathering products. In contrast, the Betty Creek formation rocks to the east and the Lower Jurassic (Hazelton formation?) sedimentary rocks to the west are virtually unaltered.

Alteration and structure are closely related and metals of economic interest, copper, molybdenum and gold, are invariably and inseparably involved with the alteration. Low temperature sodium metasomatism resulted in regional scale albitization. Potash metasomatism, which may have occurred simultaneously with the albitization, contributed to the prevalent sericitic alteration.

Sulphurization is presumed to also have been a phase of this alteration episode. Among the most thoroughly and intensely altered rocks in the Sulphurets Creek area are the siliceous-pyritic arenites exposed on the south slope of the ridge between Sulphurets and Mitchell Glaciers. These rocks consist almost entirely of cherty quartz matrix and a myriad of quartz veins with abundant granular pyrite and minor sericite. This rock type contains erratic low values in gold and generally negligible amounts of copper.

The zone described above is separated from the overlying plane of Sulphurets Fault by a less intensely altered zone of quartz-sericite-minor chlorite-pyrite schist which terminates abruptly at the Fault. The major portion of physical work performed to date has been directed to this zone. Copper minerals, mainly chalcopyrite, with molybdenite and gold values are extensively distributed in the rock, both as disseminations and on fractures.

East of the silicified and sericitized arenite described above and many hundreds of feet away from the Sulphurets Fault, feldspathic greywackes and related rocks exhibit lower epidote-amphibolite and upper greenschist facies regional metamorphism. Characteristic minerals of the assemblage are epidote and albite. Epidote forms more than 50% of some rocks and the presence of calcite, sericite and chlorite suggests that saussuritization occurred.

The regionally metamorphosed rocks near the terminus of Mitchell Glacier have been affected by carbon dioxide metasomatism and by silicification. The occurrence of talc and chlorite and substitution of one mineral for the other are characteristic of these processes acting at low temperatures in greenschist facies metamorphism. The quartz stockwork in and adjacent to the schists likely resulted from concomittant release of silica. In the past an igneous hydrothermal source of silica was assumed. Up-dating of petrologic data concerning these rocks is badly needed.

R. V. Kirkham discussed rock alteration in detail in his 1963 thesis. Among many observations presented, the following are particularly significant:

1. the area of the visible portion of the alteration halo is three times as large as the area of intrusive rocks.
2. all rocks have been affected to some extent
3. weak propylitization is the most common type of alteration (Glossary of Geology defines propylitization as "a hydrothermal process involving the formation of a propylite by the introduction of, or replacement by, an assemblage of minerals including carbonates, epidote, quartz, and chlorite".)
4. regional albitization of plagioclase has occurred (Kirkham posed the question of whether this reflected the main period of alteration or whether it was related to a more widespread spilitic province and this subject deserves further investigation, particularly in view of W.S. Fyfe's recently stated ideas concerning seawater metasomatism.)
5. albite, calcite, sericite, quartz, chlorite and pyrite are the most common secondary minerals
6. a major portion of, if not all, alteration has taken place at constant volume.

H. Structural Geology

The broad zone of alteration described in the previous section is confined to the area between Sulphurets Fault on the west and, at least in the Mitchell Glacier area, Brucejack Fault on the east. To the south the zone narrows appreciably where last observable at the ridge between Sulphurets and Frank Mackie Glaciers and, less obviously, appears to be narrowing at the edge of the snowfield north of Mitchell Glacier. The shape of the zone as viewed in plan is thus a very elongated ellipse with the elongation being in the north-south direction.

To the southeast the trace of Brucejack Fault diverges easterly from the main zone but is similarly accompanied by the rusty-weathering pyrite-sericite alteration assemblage. Other vertical and nearly vertical faults lying west of the Brucejack Fault are truncated by the Sulphurets Fault which also strikes northerly but dips west at a much flatter angle.

Bedding attitudes have been recorded in most parts of Sulphurets Creek area. A consistent pattern for the area has not been developed due in part to the intensity of data-obscuring alteration, to the complicating effects of faults, folds and dyke systems and to the presence of sedimentary facies changes that have been recognized only recently. A regional dome structure has been referred to in reference to the Mitchell Glacier part of the area but if it exists it must trend generally east-west contrary to northerly trends observed in younger rocks elsewhere in the area.

I. Economic Mineralization

The exceptionally large area of sulfide minerals associated with intense but low temperature alteration at Sulphurets and Mitchell Glaciers has many characteristics of major porphyry-type copper-molybdenum mineral deposits. The pertinent characteristics shared with the Sulphurets Creek property include the following: (reference is to Lowell and Guilbert's paper in Economic Geology,1970,Vol.65,pp373-408).

1. mineralization emplaced at relatively shallow depths, i.e. within a few thousand feet of surface
2. ore deposition essentially contemporaneous with intrusion
3. related igneous bodies exhibit minor to pronouncedly elongate shapes
4. porphyry copper deposit environment commonly developed in stocks with cross sections of well under a square mile at the elevation of ore deposition

5. emplacement of related igneous rocks almost totally passive (this factor is difficult to determine at Sulphurets Creek and may not be valid - note brecciation)
6. associated intrusive rocks stock-like with subordinate associated dyking
7. associated intrusive rocks typically intermediate to felsic, the sequence being from dioritic to monzonitic rocks with mineralization affecting all these rock types
8. a nearly universal association of porphyry-type deposits with porphyritic rocks
9. ore deposits commonly bounded by a post ore erosion surface and by at least one post ore fault
10. a large part of mineralization associated with porphyries occurs in pre-ore rocks
11. alteration of porphyry copper deposits includes some or all of the following assemblages: potassic, phyllic, argillic and propylitic (all assemblages are present in the Sulphurets Creek area)
12. alteration typically extends some distance from the outer reaches of mineralization and frequently merges with low-rank metamorphic effects, the two being discriminated only with difficulty
13. small to medium sized deposits of base and precious metals occur peripherally to the porphyry-type mineralization. Common minerals in this zone are sphalerite, galena, silver, chalcopyrite, gold and pyrite
14. the order of abundance of minerals is pyrite, chalcopyrite, bornite, enargite and molybdenite
15. the typical lateral zoning sequence appears to be outward from pyrite-molybdenite, to pyrite-chalcopyrite--molybdenite-bornite, to pyrite-chalcopyrite, to sphalerite-galena-silver-gold. In the vertical sense zoning may be upward through pyrite-chalcopyrite-molybdenite grading into pyrite.

16. hypogene sulfides typically occur in veinlets and as disseminated grains. "As a broad generalization, the porphyrites give the impression of being large masses of homogeneous material penetrated by a reticulate network of fractures and mineralized by a massive infusion of fluids which soaked the mass rather than concentrating mineralization in tabular masses or replacements" - quotation from preliminary version of L. & G.'s paper.
17. a progressive gradation in sulfide occurence is almost invariable from veins inward to veinlets to veinlets plus disseminated to disseminated
18. breccia pipes and crackle zones are commonly present
19. supergene sulfides are usually present; chalcocite being the most common.

Pyrite is conspicuous in most parts of the Sulphurets Creek mineral zone, varying from a "background" of about 0.5% to a maximum in strongly silicified areas of more than 10%. All rock units contain pyrite, either as disseminated grains or in veinlets.

Chalcopyrite is widely distributed in small amounts and occurs as concentrations in certain contact and faulted zones. Epiclastic volcanic rocks on the upper south slope of the ridge between Sulphurets and Mitchell Glaciers contain 0.2 to 0.6% disseminated chalcopyrite. Strongly silicified arenites at lower elevations and to the east of the epiclastics may contain up to 3% chalcopyrite mostly in hairline sulfide fractures but also as disseminations. It is not yet apparent whether the intensity of chalcopyrite mineralization increases with proximity to faults or to certain less siliceous (tuffaceous?) horizons in the arenite unit. A patch of abundant chalcopyrite in syenite located at the top of the ridge was investigated by DDH 62-1 and found to be shallow. Zones of steep angle faulting and the contact between intrusive rocks and underlying schistose rocks south of Mitchell Glacier

bear much copper staining but quantities of chalcopyrite or other sulphides have not been determined. Massive chalcopyrite in veinlets was noted in steep bluffs in a heavily wooded area north of the toe of Sulphurets Glacier and 1/3 mile west of the toe of Mitchell Glacier.

Bornite has been reported from rocks at the south side of the lower part of Sulphurets Glacier but has not been confirmed. Disseminated bornite, obscure on fresh surfaces, occurs in dark coloured coarsely porphyritic feldspar-rich intrusive rocks north of Mitchell Glacier. Elsewhere it is present as a secondary mineral or in minor amounts associated with chalcopyrite.

Molybdenite occurs with chalcopyrite in faulted zones, with pyrite in silicified arenite and extensively in quartz veins and fractures in chlorite-sericite schist. The latter mode of occurrence is typical of molybdenite near the edge of Mitchell Glacier on the John Bull, Arbee and Dawson-Ross claims.

Pyrrhotite is absent or sparcely distributed in most parts of the Sulphurets and Mitchell Creek areas. A notable exception is south of the toe of Sulphurets Glacier where pyrrhotite occurs in and near a diorite intrusion, possibly a sill.

Magnetite distribution is a reliable guide to the contact between intrusive and host rocks. In addition, "fresher" syenitic intrusions characteristically contain 1 to 3% magnetite. No massive or vein-type magnetite occurrences are known but concentrations sufficient to cause compass distortion are present in crushed syenite near Sulphurets Fault on the upper north-facing slope of the Sulphurets and Mitchell Creek Ridge.

Sphalerite and galena occur with coarse limey material on the ridge between Sulphurets and Mitchell Glaciers at the west edge of the altered rocks, in gash veins with barite immediately below the Hanging Glacier, and in several places near Mitchell Glacier in zones of intense pyritic-sericitic alteration. The Sulphurets Creek - Unuk River areas are not particularly endowed with lead-zinc mineralization but all occurrences are of interest due to an almost invariable silver and gold association. In addition, the environment may be favourable for the occurrence of "Kuroko"-type stratabound volcanogenic base metal deposits.

Four types of mineral occurrences of possible economic interest have been explored in the Sulphurets Creek area:

1. Placer deposits of gold
2. Disseminated copper with molybdenum and gold
3. Fracture-controlled and quartz-stockwork molybdenum
4. Gash veins containing sphalerite, galena, ruby silver(?) and electrum in barite-calcite gangue.

Placer gold first attracted prospectors into Sulphurets Creek valley. Total production has undoubtedly been insignificant and was obtained at high cost of money and effort. Main workings were on Mitchell Creek between McTagg Creek and Sulphurets Creek where gold is both very coarse and rather fine. Two sources are indicated; coarse material from quartz veins close to placer workings and fine material from the pyrite-quartz alteration zones several miles to the east.

At present several placer leases are operated during the summer months by Duke Kilbury and Joe Warner of Ketchikan, Alaska using awkward but effective methods. Their professed poor results are viewed with skepticism. Many opportunities for locating placer deposits are recognized. In addition to access problems, all bear the severe burdens of short working seasons complicated by high summer run-off stream

flows, deposits comprised of poorly-sorted unconsolidated gravels, rock flour, clay and boulders and by iron oxide coatings on gold.

Copper mineralization with significant amounts of molybdenum and gold occurs in many parts of the large complex of altered intrusive, volcanic and sedimentary rocks. Mineralization is both fracture controlled and truly disseminated, the latter being most prominent in rocks of intrusive origin.

Work to date on the copper occurrences has mostly been confined to the so-called "Main Copper Zone" located on the upper south slope of the ridge between Sulphurets and Mitchell Glaciers. 738 feet of packsack drilling, six diamond drill holes totalling 3333 feet, and several hundred feet of bedrock trenching have been completed (Figure 5b). With the exception of DDH 62-1, positive drill results have been obtained. DDH 62-1 unsuccessfully tested the theory that copper mineralization had been introduced via the Sulphurets Fault structure. Collared in mineralized syenite, it passed through Sulphurets Fault at a depth of 824 feet then entered sparcely mineralized silicified arenite. DDH 68-1 tested a broad zone of mineralized epiclastic volcanic rocks and syenitic sills. Remaining drill holes tested the sheared and mineralized siliceous arenite. Assays are indicated on Figure 5a. Zones of good copper potential are exposed both south and north of Mitchell Glacier. In these areas chalcopyrite and bornite are present in and close to various syenitic intrusive bodies, of which some have been crushed and others are apparently either fresh or completely recrystallized.

Large areas of strongly pyritized silicified arenite contain only small quantities of copper minerals. Due to the acid environment produced by weathering of pyrite, copper minerals tend to be selectively

leached from outcrops and care is required in evaluating outcrops apparently barren of copper. Small bedrock pits excavated by means of Cobra drill and dynamite are useful in this procedure and have resulted in new discoveries. In addition, it is practical to distinguish gossans developed from sulfides barren of copper from those that have copper values on the basis of colour: barren weathers yellow; copper-bearing weathers reddish.

Malachite occurs in limey lenses throughout the epiclastic volcanic unit and freshly blasted surfaces are commonly heavily coated with malachite and azurite that rapidly fades and is washed away. More spectacular and persistent malachite stains occur in and close to faulted and crushed zones along the slopes south of the terminal part of Mitchell Glacier. Several of these stains are many hundred square feet in area and represent thin layers of secondary copper minerals deposited from groundwater that seeps from the faults and evaporates as it percolates over the steep smooth rock surfaces.

Gold in small quantities is found in many parts of the Sulphurets and Mitchell Glacier region in association with pyrite, chalcopyrite and arsenopyrite. Areas of better molybdenum values appear to contain negligible or at best very minor amounts of gold. In the Main Copper Area (Figure 5a), about 0.02 oz/ton gold accompanies 0.55% copper. Pyritic zones in the western portion of the Area contain trace amounts of copper but exceptionally up to 0.22 oz/ton gold. Elsewhere in the same general area grab samples containing 0.80 oz/ton gold have been assayed. Parts of the silicified pyritic arenite assays very low in gold (in the 0.003 oz/ton range) and massive pyrite commonly assays 0.01 oz. Au/ton. A practical and reliable method of checking the persistence of gold values has not been employed but the current favourable gold price suggests that more efforts should be directed to this matter.

In the southeastern part of the Sulphurets Creek property in the general vicinity of the Hanging Glacier both electrum and auriferous arsenopyrite have been found. The electrum was found in 1960 in barite-calcite veinlets but the precise location is unknown. Gold-bearing arsenopyrite was located in 1974 during the rock geochemical sampling program.

Native gold was found in 1960 in a boulder southwest of the terminus of Mitchell Glacier; its source is unknown.

PART III. GEOPHYSICS

Airborne and ground magnetic surveys were employed in the early stages of G.M.L.'s work at the Sulphurets Creek property. Early in 1960 a helicopter-mounted magnetometer revealed magnetic anomalies between the Hanging Glacier and Sulphurets Glacier but much of the rest of the area was by-passed due to heavy snow cover which made inoperable the method of using strip photography for flight-line recovery. The survey was completed in mid-summer 1964 when flight paths could be accurately traced. Several magnetic anomalies corresponding to the main zone of faulting and related crystalline intrusions were located.

Ground magnetic surveys were carried out in 1960 in the southeastern portion of the Sulphurets area claims to confirm anomalies found by the airborne instrument. The survey was successful in delineating a pattern of dioritic dykes containing magnetite. Other ground surveys completed in 1960 in the Mitchell Glacier area gave inconclusive results.

The feasibility of using induced polarization surveys to delineate sulfide distribution at Sulphurets Creek was investigated in 1964 by Dr. Arthur Brant, then Newmont's chief geophysicist.

Recognizing severe problems of terrain, permanent snow and pervasive pyritization, he made a negative recommendation.

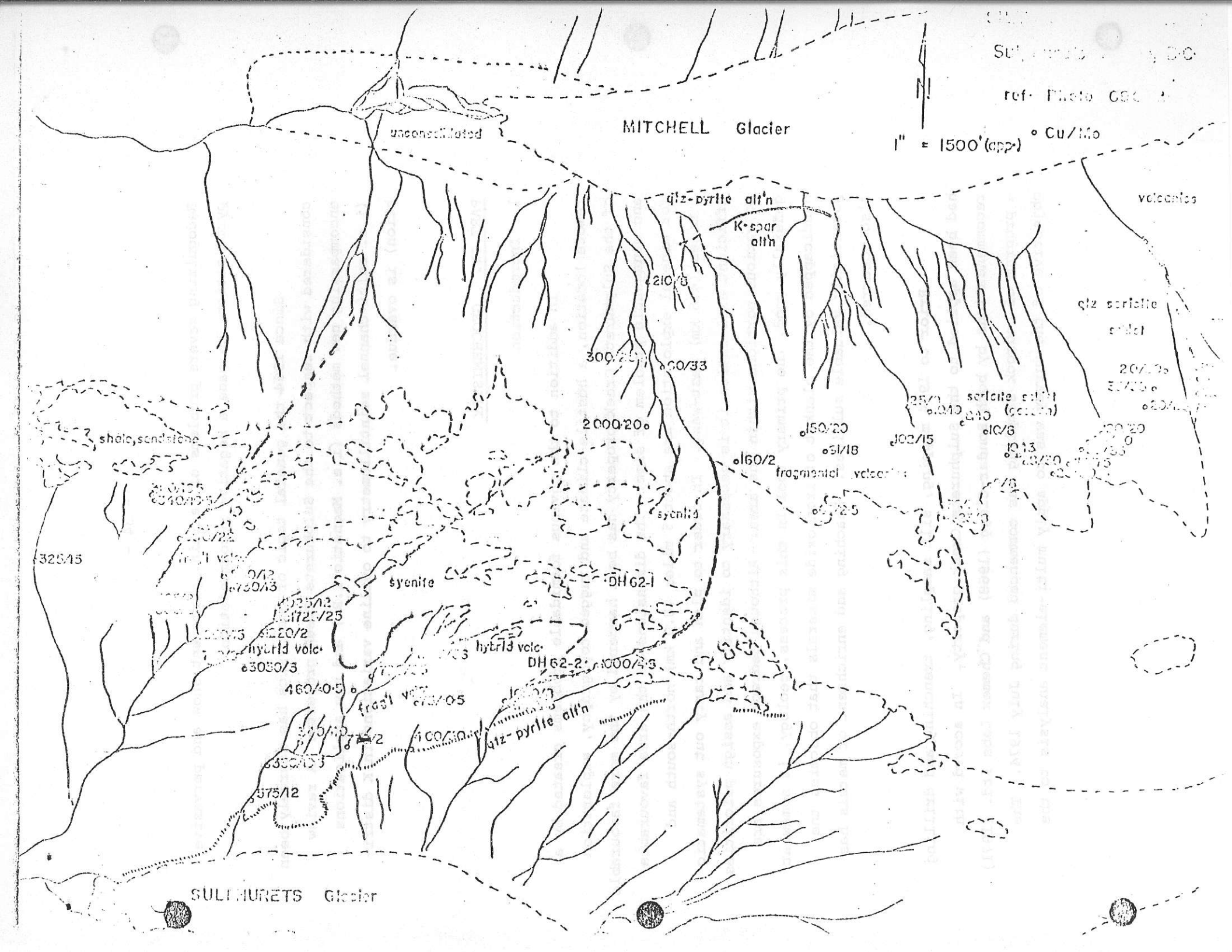
Since 1964 the general topic of geophysics has scarcely been considered with respect to the Sulphurets Creek property. A review encompassing new methods (i.e. Magnetic I.P.) and new applications (i.e. multi-channel scintillometry to outline variations in K distribtion) is overdue.

PART IV. GEOCHEMISTRY

1. Introduction

In addition to the obvious formidable problems created by a remote location, a hostile climate and rugged topography, exploration of the Sulphurets Creek property has been hampered by the more favourable and manageable problem of size. The dimensions of the area favourable for mineral exploration are about 5 miles (8.0 km) north-south and 3 miles (4.8 km) east-west. In order to plan and carry out systematic efficient exploration it is necessary to identify and assign priorities to various portions within the area. Although bedrock exposures are generally good, the primary tool in this process, geology, is somewhat handicapped by the blanket of iron oxide minerals that obscures the potentially valuable sulfides. Leaching and enrichment of metals has also occurred.

Prior to 1974 mapping, silt sampling, trenching and drilling had been applied to the Sulphurets Creek property. In accord with recommendations by both Bondar-Clegg (1968) and Chemex Labs Ltd. (1971) a program of bedrock sampling was commenced during July 1974. The objective of the survey was to apply multi-element analysis to the


MITCHELL Glacier
unconsolidated
qtz-pyrite alt'n
K-spar alt'n
volcanics
qtz sericite
shale, sandstone
syenite
hybrid volc.
DH 62-1
DH 62-2
fragmental volcanics
SULPHURETS Glacier

bedrock samples to identify primary, and possibly secondary, dispersion patterns around potential ore zones. The intent was to sample initially on a 400 foot square grid pattern to be followed by a 200 foot pattern in areas of unusual interest.

2. Orientation Surveys

During June 1968, Fabian Forgeron, Ph.D., of Bondar-Clegg & Company Ltd. carried out an orientation geochemical survey in part of the Sulphurets Creek property. 67 samples, of which 17 were bedrock samples; 14, stream sediments and 26, talus fines; were analysed for cold citrate extractable copper, hot acid extractable copper, lead, zinc and silver, pyrosulfate fusion and thiocyanate colorimetric determination of molybdenum. The survey determined that geochemical techniques could be used to indicate the presence of ore grade mineralization. The problem of scavanging of trace amounts of metal by sorption and by co-precipitation with hydrated ferric oxides to give anomalous metal values tended to partially discount the effectiveness of sampling unconsolidated and surficial material. Of significance with respect to this report were Forgeron's observations that "Bedrock analyses indicate that copper gives a broadly anomalous halo around known copper mineralization and that molybdenum and silver give more restricted halos which may be useful in providing target sites over broad bedrock copper anomalous (sic)" and "there is a copper-lead-zinc association in the talus fines which may be indicative of bedrock sources of silver".

In 1971 H. Bichler and B. Brown of Chemex Labs Ltd. analysed one pyritic sample and one sample with low values in both pyrite and copper and reviewed Forgeron's report in order to provide a second opinion regarding rock geochemistry at the Sulphurets Creek property. They concluded that severe ratio inversions were recognizable and that a program of rock geochemistry would provide useful elemental zoning data.

While the 1974 sampling program was in progress Joseph H. Montgomery, Ph.D., P.Eng., was commissioned to carry out a further field orientation study and to check and advise on the suitability of field methods being employed. He selected five samples of varied lithology which were analysed for 34 elements by semi-quantitative emission spectrographic techniques. Dr. Montgomery's report is appended to this report (Appendix IIA).

After completion of field work, twenty rock samples representative of major rock units, irrespective of mineralization, were selected and analysed for twenty-four elements (see Appendix IIB). Because of the variety of rock and alteration environments involved, it is probable that an insufficient number of samples was analysed. Following a review of all pertinent data all samples were analysed for copper, molybdenum, lead, silver and gold (Appendix IIC).

3. Analytical Procedures

Samples consisting of between one and two pounds of fresh or reasonably unweathered bedrock were submitted to Chemex Labs Ltd. After passing through a jaw crusher and a gyratory crusher, the sample was split through a "Jones" splitter to obtain about 250 grams of material. The latter quantity was pulverized in a contamination-free ring pulverizer to -100 mesh size. Accurately weighed 10 gram and 0.5 gram portions were then prepared and digested.

The 10 gram sample was ashed at 550°C then twice heated to dryness in aqua regia. The resulting residue was dissolved in 25% hydrochloric acid and aspirated through Varian Techtron Atomic Absorption Spectrophotometer. In the first stage two readings were obtained: one for silver (Ag++) and the other for the interference factor which was then subtracted from the first quantity to give a net corrected value for silver content. Gold was then extracted from the

solution into hydrobromic acid and MIBK, an organic complex. Gold was determined by passing the resulting gold organic extract through the AA unit.

The 0.5 gram sample was digested using 3 ml. of 70% perchloric acid and 2 ml. of concentrated nitric acid for 2-1/2 hours at 203°C. The solution was then diluted with distilled water to 25 ml. volume, and heavy particles were allowed to settle out. The clear solution was processed through the atomic absorption unit and readings were obtained for copper, molybdenum and lead.

4. Treatment of Data

Geochemical data were plotted on base maps prepared on scale of one inch to 800 feet (243 m). On the base maps each sample site is identified by a small numbered circle and the particular geochemical value is plotted nearby using a slightly larger italicized script (Figures 10 - 14).

It was found that in all cases geochemical values exhibited great variation, due, presumably, to the range of rock types present and to the varying alteration and mineralization histories to which the area as a whole has been subjected. Consequently contouring was designed to express relative abundances of metals rather than to be statistically defensible in the strictest sense.

For convenience parts of the geochemical maps were coloured to reflect arithmetic multiples of abundances of metals: yellow indicates metallic ion present in above general background levels for the area, probably little economic significance; blue - anomalous values, possibly close to economically significant mineralization; green - significantly anomalous quantities of metallic ion present in the rock; red - a high concentration of metallic ion.

5. Geochemistry of Copper

Values obtained for copper in bedrock geochemical samples are plotted on Figure 10. Values are plotted in profile on Figures 6, 7 and 8. The lower detection limit for copper in the analytical method employed is 1 ppm. Values recorded in the surveyed area range from 8 to 6560 ppm. 500 ppm (.05%) was selected as a significant value and a 2 factorial multiple of 500 was used as the contour interval, viz. 500, 1000, 2000, 4000 ppm.

The pattern of distribution of significant amounts of copper in bedrock corresponds moderately well with data obtained from prospecting and geological mapping. Attention is drawn to the area just north and northeast of the bend in Sulphurets Glacier where, although copper mineralization had been recognized earlier, copper is more widely distributed than previously suspected. The results of the partial survey south of Sulphurets Glacier are sufficiently encouraging to demand further attention. Although the apparent "double" band of high values across the top of the ridge between Sulphurets and Mitchell Glaciers was unexpected, elsewhere results are predictably high in the Main Copper Zone and other areas adjacent to the Sulphurets Fault. Areas of low copper in bedrock were similarly anticipated and this confirming geological data will allow them to be disregarded with confidence during the period that work is directed to the primary target areas.

6. Geochemistry of Molybdenum

Values obtained for molybdenum in bedrock geochemical samples are plotted on Figure 11. The lower detection limit for molybdenum in the analytical method employed is 1ppm. Values recorded in the survey area ranged from 1 to 340 ppm and a 2 factorial multiple of 10 was used as the contour interval, viz. 10, 20, 40, 80 ppm.

Anomalous molybdenum values obtained south of the Hanging Glacier are not related to any known mineralization or intrusive source and the host rock is greywacke and chert. North of Sulphurets Glacier abnormally high quantities of molybdenum occur in zones closely related to the trace of Sulphurets Fault, and near the contact between syenite and epiclastic volcanic rocks. Neither structural feature is well defined by the molybdenum values. South of Mitchell Glacier, as is the case for the pattern of lead and silver, the lower contact between the cataclastic syenite and the sericite-pyrite altered arenite is conspicuously defined by molybdenum. Samples from the arenite unit downstream from the snout of Mitchell Glacier are the most enriched in molybdenum, perhaps again reflecting proximity to the trace of Sulphurets Fault. Two isolated but strongly anomalous samples are No. 535, south of Mitchell Valley and No. 572, north of Mitchell Valley. Both represent phyllitic pyrite-rich shear zones of rather insignificant dimensions.

7. Geochemistry of Lead

Values obtained for lead in bedrock geochemical samples are plotted on Figure 12. The lower detection limit for lead in the analytical method employed is 2 ppm. Values recorded in the surveyed area range from 2 to 1387 ppm. The majority of values are less than 20 ppm and a 2 factorial multiple of 20 was used as the contour interval, viz. 20, 40, 80, 160 ppm.

Only one anomalous (i.e. 20 ppm or greater) lead value was obtained in the surveyed area south of Sulphurets Glacier. The lead content of syenite located on top of the ridge between Sulphurets and Mitchell Glacier is very low whereas the sedimentary rocks exposed on the south-facing slopes from the toe of Sulphurets Glacier to the Hanging Glacier produced a high proportion of weakly to moderately anomalous samples and a wide scattering of samples abnormally high in lead.

A zone of very high lead content occurs south of Mitchell Glacier in the vicinity of steeply dipping faults and the trace of Sulphurets Fault. This coincides with an area of cataclastic syenite and rather intense quartz and sericite alteration within which trace amounts of galena have been recorded. North of Sulphurets Glacier where copper mineralization has been investigated by trenching and drilling, lead is generally present in quantities only slightly above background.

The wide distribution of samples apparently anomalous in lead was unexpected. Additional office studies, employing different numbers and contour intervals, should be undertaken. In the field, attention should be directed to possibilities of finding stratabound lead deposits. It is noteworthy that copper and lead appear to be largely antithetic except in the vicinity of the lower portion of Mitchell Glacier.

8. Geochemistry of Silver

Values obtained for silver in bedrock geochemical samples are plotted on Figure 13. The lower detection limit for silver in the analytical method employed is 0.2 ppm. Values recorded in the survey area ranged from 0.2 to 46 ppm and a 2 factorial multiple of 1 was used as the contour interval, viz. 1, 2, 4, 8 ppm.

Weakly to moderately anomalous silver values were obtained in the surveyed area south of Sulphurets Glacier, and strongly anomalous values extend across the claim group along the south and west end of Mitchell Glacier coincident with outcroppings of sericite-pyrite alteration imposed on arenite. Elsewhere significant silver values are erratically distributed over much of the slope between Sulphurets Glacier and the ridge top. High silver values do not invariably coincide with areas of known copper mineralization. As with lead, the silver content of syenite is low or only very weakly anomalous.

With some striking exceptions, silver and lead have similar distribution patterns. Silver and copper are less reliably covariant. Several areas requiring further attention were revealed.

9. Geochemistry of Gold

Values obtained for gold in bedrock geochemical samples are plotted on Figure 14. Values are plotted in profile in Figures 6, 7 and 8. The lower detection limit for gold in the analytical method employed is 30 ppb. Values recorded in the surveyed area range from <30 to 6560 ppb with the majority of values in the <30 ppb range and a 2 factorial multiple of 100 was used as the contour interval, viz. 100, 200, 400, 800 ppb.

Distribution of anomalous gold values is generally related to that of anomalous copper values. In the southeastern part of the survey area, in the vicinity of the Hanging Glacier, several samples weakly anomalous in gold occur in an area of negligible copper where gold in electrum and gold in arsenopyrite have been found. The area peripheral to the lower part of Mitchell Glacier is clearly anomalous in copper and silver but gold is not as obviously enriched except at the eastern limit of the survey. The linear anomaly south of Sulphurets Glacier is noteworthy for being very sharply defined. The source may be a vein or fracture structure and additional investigations are obviously required.

10. Conclusions

The writers consider the rock geochemistry project incomplete. Work to this stage has been very successful in outlining a geochemical pattern on the Sulphurets-Mitchell Creek ridge that probably could have been predicted in a general way from previous work. However, significant new areas anomalous in metals were also located and some areas were found to be for our purposes blank, thus narrowing the search.

The problem of relating metal distribution patterns to a broad area of multiple backgrounds and enrichment may well be resolved by statistical treatment of the data. Advice in this matter should be sought in the literature and, when the project is complete, from geostatisticians.

PART V. CONCLUSIONS

The Sulphurets Creek area may contain one or more medium to huge-size deposits of copper ore with significant values in molybdenum and gold. The location and environment indicate that if a mineable ore deposit were located many obstacles to development would have to be overcome. It is reasonable to expect that these could and would be overcome and that a major mining project is feasible.

Modest expenditures on exploration work have invariably enhanced the prospects of the Sulphurets Creek property. Its geological features are remarkably similar to those reported at porphyry-type copper deposits throughout the world.

The Sulphurets Creek property is nearing the stage of exploration where major expenditures will be required. Upon completion of the rock geochemistry and geology project initiated in 1974 it is probable that a large program of diamond drilling will be indicated as the next stage of work.

PART VI. RECOMMENDATIONS

1. Rock geochemistry and geology studies should be completed.
2. Areas of significant metal concentrations indicated by the 1974 work should be thoroughly prospected and re-sampled in greater detail.

3. Additional claims should be staked to cover areas of potential beyond present boundaries of the property.

4. High grade gold occurrences should be prospected and trenched. Placer gold possibilities should be investigated.

5. Statistical analysis of geochemical data should be undertaken.

6. Desireability of analysing all samples for additional elements should be determined and, if indicated, should be pursued.

7. The feasibility of applying geophysical methods should be reviewed.

8. Petrologic studies should be expanded in a systematic manner and a thorough literature search should be carried out.

9. Diamond drill core presently stored on the property should be removed to weatherproof storage.

10. Better campsite facilities should be established.

11. Methods of financing a major program of diamond drilling should be investigated. Prospective joint venturers should be encouraged to visit the property during mid-summer 1975 while field work is in progress.

APPENDICES

APPENDIX I

GEOLOGICAL REPORTS

APPENDIX IA

1961 Report by G.W.H. Norman, The Granduc Sulphurets Property, Unuk River Region, Northwestern B. C.

Office Copy

THE GRANDUC SULPHURETS PROPERTY

UNUK RIVER REGION

NORTHERN B.C.

1961 Report

Location and History

The Sulphurets property is a 69 claim group of 34 Ray and 35 Ted claims on Sulphurets Creek, 8 miles east of the junction of this Creek and Unuk River, and 20 miles north of the Granduc Mine. The property was staked for Granduc Mines Ltd. in 1960, to include a series of 200 to 600 gamma magnetic anomalies located during an airborne magnetic survey by helicopter of Unuk River drainage basin. The original staking in 1960 consisted of 37 Ted claims and 24 Ray claims. Two Ted claims were dropped and 10 additional Ray claims were staked in 1961.

A group of approximately 50 Arbee claims were staked early in 1960 by Don Ross and Stan Bishop of Ketchikan, Alaska, to include mineral showings on Mitchell Glacier. This staking was done when local inhabitants of the region learned that Granduc was doing airborne magnetic surveys and exploration in Unuk River area. Granduc's Ted-Ray Claim group was staked first and have priority over the partly overlapping Arbee claims. $300 was paid by Ross in lieu of assessment work for 8 Arbee claims adjoining the east side of Ray claims on the ridge between Sulphurets and Mitchell Glaciers in June 1961; the remaining Arbee claims were allowed to lapse and were restaked as the John Bull group by Wendell Dawson for Ross and associates. No work has been done yet on the claims adjoining the Ted-Ray group and they will lapse during the period June 14th - 18th 1962, unless the required assessment is completed.

Work Performed

The airborne magnetic survey of the Unuk River drainage area was carried out in April 1960. Areas in which magnetic anomalies occurred were staked in late May and recorded in early June. Ground inspection of the anomalies was carried out June to October 1960.

The work in the Sulphurets Property in 1960 consisted of reconnaissance geology on ½ mile to one inch and a few ground reconnaissance magnetic surveys on 200 scale. 5000 feet of magnetic lines were run across the claims along the two sides of the Mitchell Glacier, and a 5000 foot base line and 14,000 feet of side lines were run on the southeast end of the property, east of Sulphurets Glacier.

Sufficient geological and geophysical work was carried out in 1960 :-

1) to indicate that the anomalies were due to small concentrations of magnetite, disseminated in the rock or in small clusters, associated with chalcopyrite and pyrite;

2) to indicate that chalcopyrite also occurred in syenite porphyry, which underlies extensive areas on the claims where there are no anomalies;

3) to show that further work would be required to determine the grade and extent of the copper mineralization;

4) to fulfill assessment work requirements for the first year.

During 1961 a more detailed type of mapping was carried out for the company by R. V. Kirkham, a graduate student at University of British Columbia, to determine the structure of the rocks and the sequence and significance of the extensive rock alteration as a guide to the best exploration procedures. Thirty-two Packsack holes, totalling 732 feet, were drilled to obtain samples for assay, in four separate areas. Two of the areas were selected to get samples of the better type of mineralization and two of the areas were selected to fulfill assessment requirements for claim groups without moving the drill camp, because of insufficient time available.

Geology

Lithology

The accompanying 1000 scale map by R. V. Kirkham gives the general distribution of rock units in and near the claims and their attitudes. The oldest rocks are believed to be volcanic. They underlie the greater part of the claims and consist of massive andesite breccias and tuffs. Argillite and sandstone occur in small amounts with the volcanic rocks and are either interbedded or infolded. The sedimentary rocks, consisting of argillite, greywacke and conglomerate, underlie the extreme western and northern edges of the claims and a large area directly northwest of the claims. The volcanic rocks are cut by syenite and syenite porphyry sills or sheets nearly parallel to bedding, and the sedimentary group are cut by trachyte porphyry, which may be a finer-grained variety of the syenite. The syenite intrusives trend north-northwest and are cut by a series of fine-grained diorite dikes, a few of which are shown on the map. These dikes strike east and dip north.

Local Structure

The relationship of volcanic rock groups to sedimentary rock groups in the general region north of the claims indicates that the volcanic rocks probably lie along an anticlinal structure. This structure extends northwest across the south half of the claims, but is cut off by northeast faults (Sulphurets Fault) along the west side of the property. Topography shows that the faults dip west. The rocks on the west side of the faults strike northeast at right angles to those east of the fault and dip northwest. They consist of greywacke argillite and conglomerate, except for a small area in the central part of the claims underlain by syenite and volcanics. This area of syenite and volcanics may lie between strands of the northeast fault zone.

Regional Structure

The more important structural features of the region are shown on the attached 2 mile scale plan. The relative position of the northeast fault across the Sulphurets claims to the northeast faults across the Granduc property suggests that these faults are part of one continuous major fault zone that extends north-northeast across the district. The Sulphurets and Granduc fault zones not only have a common alignment and a similar dip, but the movement in both places has produced right-handed drag offsets and is accompanied by overturned folding toward the southeast.

The total right-handed drag on the Sulphurets fault may be as much as five miles, if the syenite sheets on the Sulphurets property were originally part of the group of syenite sheets north of Treaty Creek glacier. A series of diorite and foliated granodiorite intrusions older than the main coast batholith, extend southeast from Unuk River to Granduc. The only similar foliated granodiorite and diorite intrusives older than the batholith southeast of the Granduc fault zone occur about five miles southwest on Texas Creek, Alaska, and indicate a right-handed shift comparable to that present north of Sulphurets Glacier.

The large right-handed offset that is indicated for Sulphuret - Granduc fault zone suggests that the northwest striking syenite sheets in the southern part of the Sulphurets property are dragged in the fault zone to a northeast strike in the north half of the property. A drag of northwest striking folds into a northeast trend clearly occurs at Granduc. Excessive rock alteration has made it difficult to map the detail features of the structure and it seems highly probable that the syenite sheets and associated rocks in the south half of the property are cross-folded and more intricately deformed than is indicated on the map.

Rock Alteration

The 2 mile structural map gives the distribution of the silicified and altered zones in the district. A study of the alteration in the Sulphuret section of the district is now being made at the University of B.C. by R. V. Kirkham, as a thesis for a master's degree. The alteration consists of silicification, carbonatization, sericitization and pyritization, and any of the first three types listed may predominate. The alteration resembles that which takes place along some gold veins or along complex gold and silver bearing base metal veins. In the Unuk River region the alteration appears to be definitely associated with fault and deformed zones, and is confined to the northern part of the area northwest and east of Unuk River, north of its junction with the South Unuk fork. Between Granduc and Unuk River, along the South Unuk the alteration is of a higher temperature type characterized by biotite, and amphibole.

Some of the different types of alteration are shown with very approximate accuracy on the accompanying 1000 scale geological map. In general, the altered rocks stain brown on weathering by oxidation of the contained pyrite and contain very minor amounts of copper, lead, and zinc. On the Sulphurets property, particularly along the Sulphurets fault zone, chloritization occurs and chalcopyrite is present in place of pyrite.

Mineralization and Assays

Chalcopyrite mineralization was found in the syenite rocks on the claims in 1960, particularly on the ridge between Mitchell and Sulphurets Glaciers and north of Mitchell Glacier. The copper content of many of the exposures was estimated to be approximately one percent and the chances of finding a porphyry copper type of deposit appeared to be favourable.

Field work in 1961 indicated that the copper mineralization was probably associated with chloritization and with northeast faulting. A Packsack drill was moved to a camp near the centre of the property on August 6th and sites were selected for testing the rocks on either side of the northeast fault. Site 1 was selected on the footwall side of the main fault, where a stream cuts down through overburden to silicified chloritized rocks mineralized with chalcopyrite. Site 2 was selected on the hanging wall side where slightly chloritized unsheared syenite, well mineralized with chalcopyrite, was exposed in a series of outcrops on the south side of a large area of snow. Sites 3 and 4 were random selections to fulfill assessment requirements.

The general pattern of the drill-holes is indicated on the accompanying maps. At Site 1 nine holes were drilled at 50-foot intervals along a line trending southwest, then west-southwest for 450 feet. Total footage drilled was 185 feet, or about 20½ feet per hole. The 185 feet averaged 0.5 percent copper, which ranged from 0.2 to 1.63 percent. The molybdenum content ranged from 0.2 to 0.4 percent.

At Site 2 ten holes totalling 251 feet were drilled, which averaged 0.63 percent copper and ranged from 0.05 to 1.14 percent copper. At this site the central 140-foot width averaged 0.86 percent copper.

Four holes, totalling 102 feet, were drilled at the 3rd site. They averaged 0.295 percent copper and ranged from 0.13 to 0.42 percent.

Nine holes, totalling 200 feet, were drilled at Site 4. They averaged 0.144 percent and ranged from 0.03 to 0.21 percent copper.

Attempts were made at the turn of the century to work the gravels along Sulphurets Creek, three miles below the glacier, for gold. Nuggets nearly ½ ounce in size are reported, in the 1903 Minister of Mines report, to have been found but high water in the creek during summer is stated to have hampered work. Fine gold was found at the junction of Sulphurets Creek and Unuk and dredging leases for these gravels are reported in 1929.

Gold and silver bearing vein material has been collected at three widely-separated localities on and near the company's Ted-Ray Claim group and the earlier discoveries of gold along Sulphurets Creek suggests that there may be an adequate source for the gold that would be worth the effort of a more thorough prospecting next season. The first

discovery of gold silver vein material was made by prospectors Barclay and Wright in 1959, for Granduc, 8000 feet southeast of the southeast corner of the Ted-Ray claims, on the east side of Bruce Jack fault. A sample taken across 4.3 feet assayed Au 0.32 Ag 45.7, but the values were concentrated probably in a narrow stringer.

The second discovery was made by J. H. Montgomery in 1960, while doing reconnaissance geological mapping. A small character sample from the location, which is 1 mile south of the toe of Mitchell Glacier, assayed Au 0.32 oz Ag 28.4 oz.

The third discovery was made in 1961 by R. V. Kirkham, late in the evening while finishing a traverse on the Ted Ray claims. The location is 7000 feet north of the southeast corner of the claims, near the toe of a hanging glacier. His description in his notes states that veinlets of calcite and barite form one to three percent of the rock for four hundred feet. The sample taken from a sulphide clot in one of these veins showed free gold and electrum plates. Assay of material selected from the sample by discarding all pieces containing visible gold or electrum gave Au 12.62 oz Ag 333.3 oz.

Molybdenite occurs in small amounts associated with chalcopyrite in the silicified rocks along the footwall of the Sulphurets fault, in the vicinity of Packsack drillsite 1. A molybdenite bearing zone without copper occurs along the south side of Mitchell Glacier, west of the Bruce Jack fault. This zone is highly sericitic and in places contains closely-spaced small quartz veinlets. Intense shearing has smeared out part of the molybdenite into fine streaks. One sample of better than average grade assayed 0.695 percent of molybdenite. The area in which good grade samples of molybdenite can be obtained locally is more than 1 mile square and lies entirely on the claims of Ross and associates. The problem of evaluating the deposit lies in the relatively small proportion of good-grade molybdenite rock that can be recognized and its scattered occurrence in rock without visible molybdenite. Further systematic investigation of the molybdenite occurrence is recommended, provided the claims of Ross and associates can be obtained on reasonable terms, or restaked if dropped next year.

Recommendations

5000 feet of diamond drilling, if justified by results, is recommended to test the extent and grade of copper mineralization along and near the fault between Packsack drillsites 1 and 2.

A complete layout of holes cannot be attempted with the present information regarding the dip of the fault and the extent and dip of the copper-bearing chloritic zone at Packsack site 2. The dip of the zone is probably west and the first hole should be drilled vertically on the western side of Site 2 to the fault, if possible. If the fault cannot be reached, a series of holes (some angle holes east) should then be drilled eastward at intervals until the fault is cut. Additional holes will have to be laid out pending results obtained. At least one hole should be drilled at a location on the fault directly north of Packsack Site 1, to probe the footwall side of the fault.

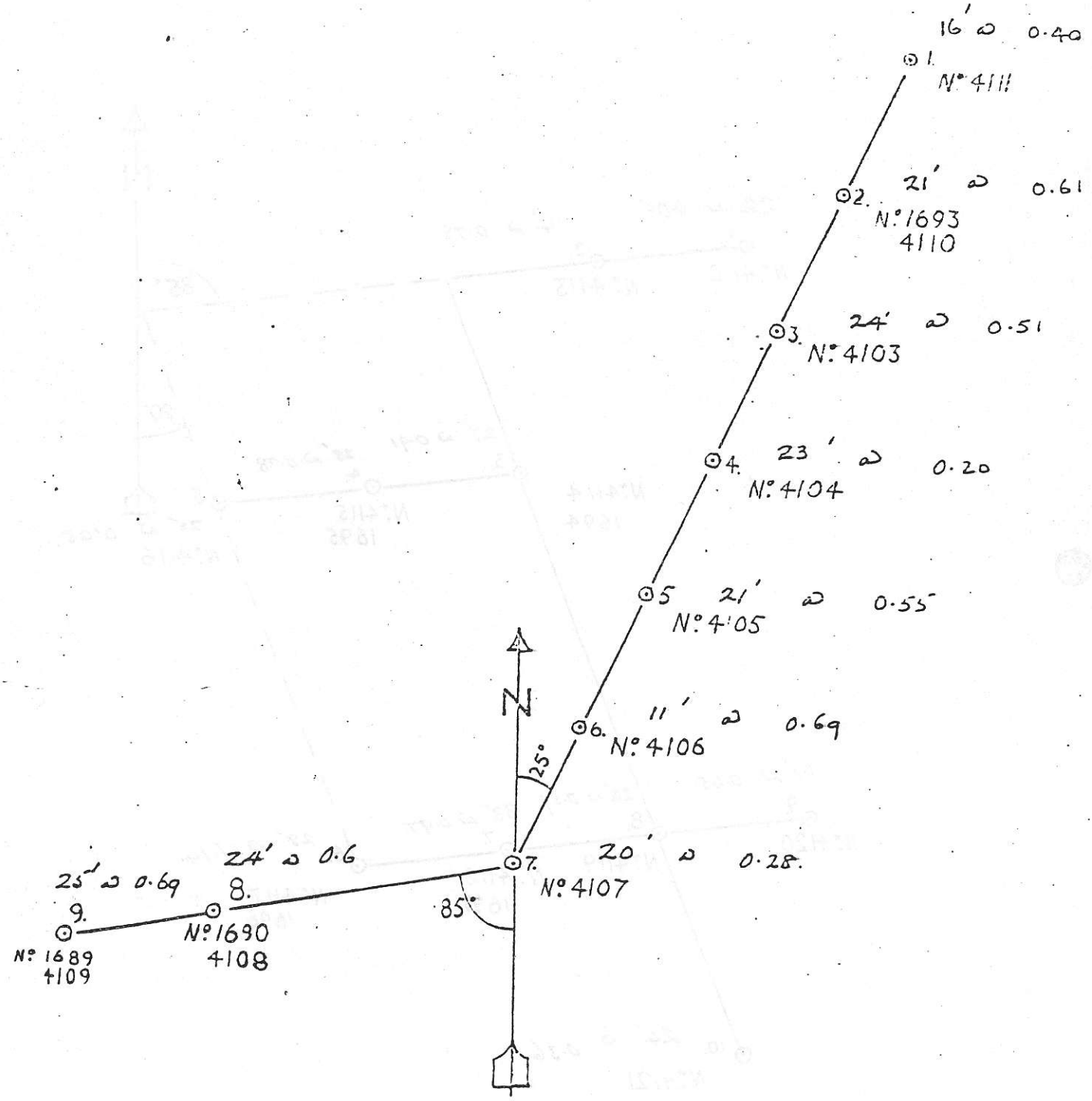
A prospecting team of two men should be employed to trace the gold found in gravels along Sulphurets Creek to its source. They should also prospect the Sulphurets fault south and west of the claims for copper, to track down samples of massive chalcopyrite that were found near the toe of the Sulphurets Glacier in 1961. They should also prospect the south half of the property for copper and high-grade silver gold vein matter.

The cost of exploration in 1962, to get a better valuation of Granduc's Unuk River (magnetite) and Sulphurets properties, is estimated to be $72,000. Drilling should start as soon as snow conditions permit on the Unuk River in April and begin on the Sulphurets Property by mid-July to be completed by September 30th. Prospecting can commence on Sulphurets Creek by mid-May, and continue until October.

G.W.H. Norman
2nd January 1962

Plot D.D. 8.10 E.

Scale: 1" = 50'

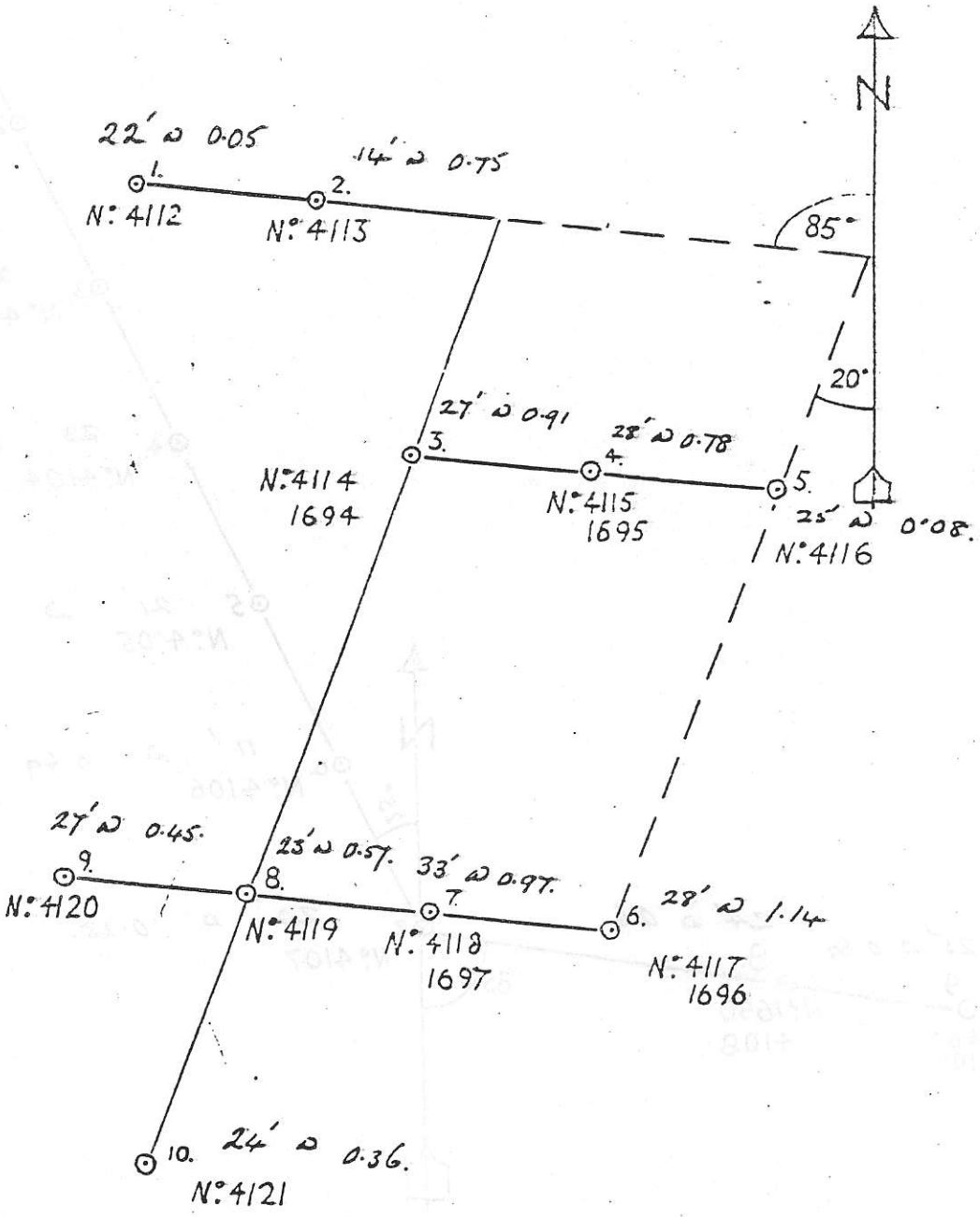


Length of Section 450 feet.

185 feet of Core average 0.50 Cwt.

Plot: D.D. Site # 2.

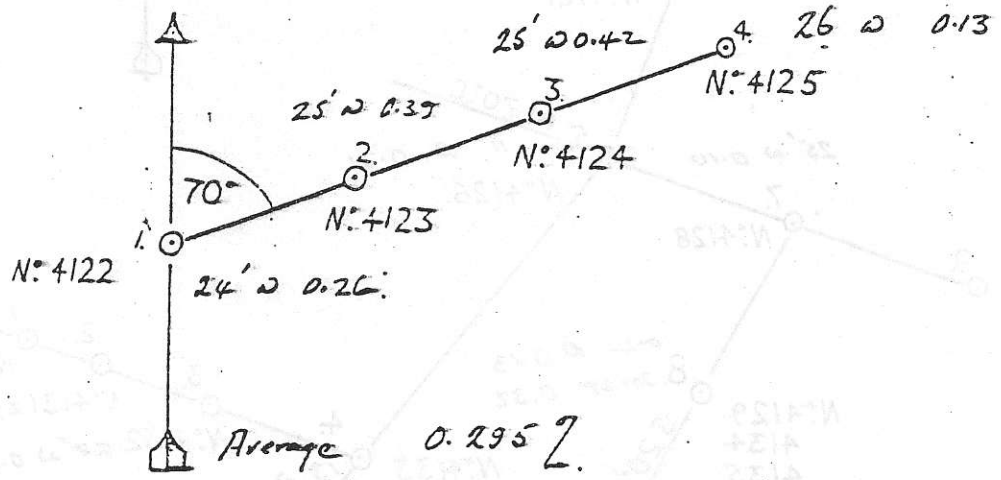
Scale: 1" = 50'.



251 feet of core in 10 holes average 0.63

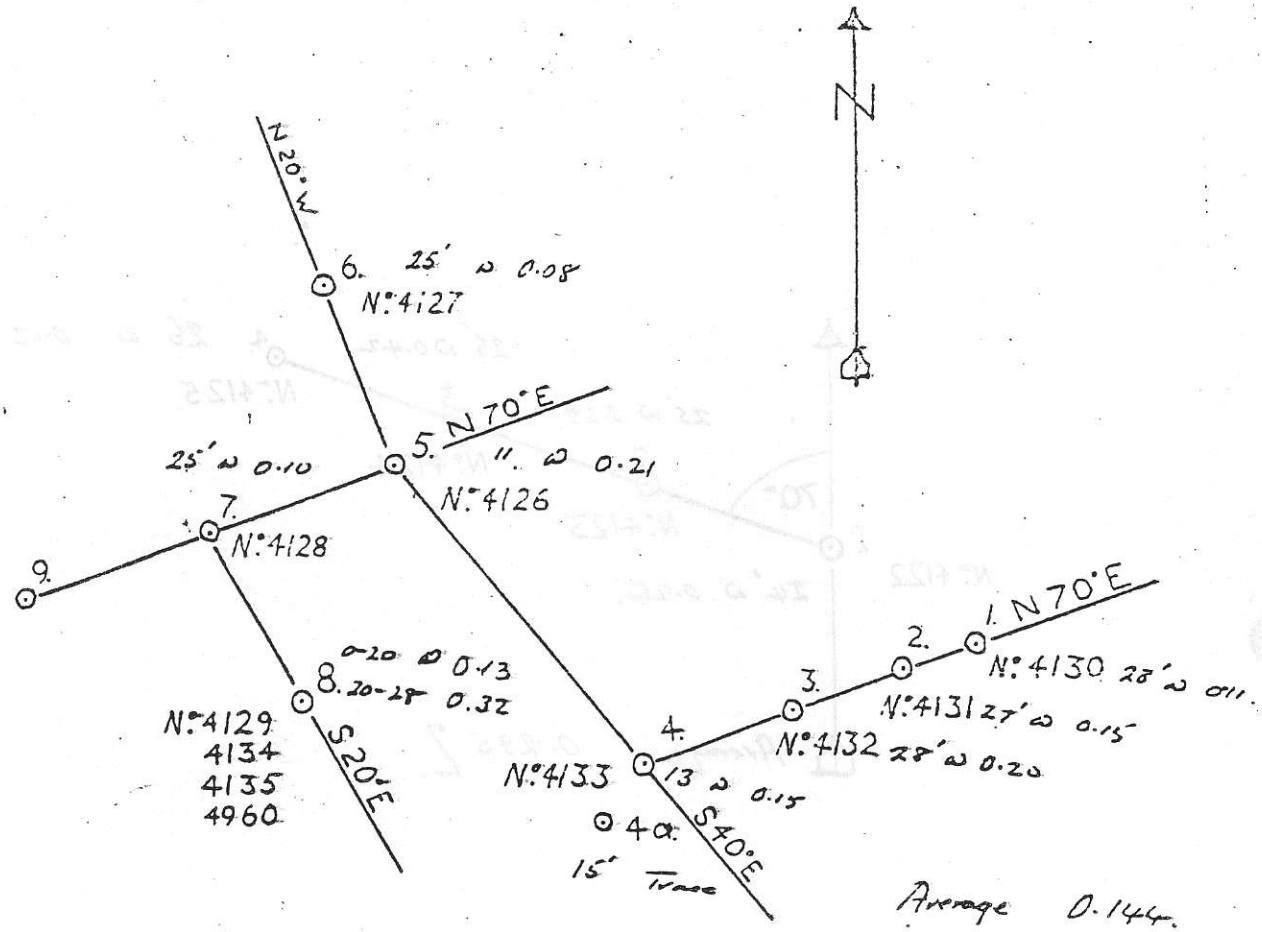
Plot: D.D Site # 3.

Scale: 1" = 50'.



Plot: D.? Site # 4.

Scale: 1" = 50'.



Average 0.144.

APPENDIX IB

1963, Memorandum Report to John Drybrough from G.W.H. Norman, Sulphurets-Mitchell Area Claims

Vancouver 1, B. C.

October 24, 1963.

MEMORANDUM TO : John Drybrough

FROM: G. W. H. Norman

Re: Sulphurets-Mitchell Area Claims

SUMMARY

Grandue's Sulphurets claims cover low grade copper deposits of the "Porphyry Copper" type. The accompanying geological map gives the distribution and alteration of the rock types and illustrates some of the complex structures present on the claims. The most favourable rocks for copper are syenite, quartz syenite, and granite whose exposed limits are indicated on the map. The area underlain by these rocks varies from 3000 to 7000 feet wide easterly, and 12000 feet northerly. The favourable host rocks for ore probably have extensions north and west beneath faults, are concealed in part by ice, snow and glacial deposits, and may in places be obscured by rock alteration.

RECOMMENDATIONS

The size of the favourable area, the rough topography and the complex nature of the geology, makes systematic drilling an expensive project. The outcome of a drilling project, unless the holes were deep and closely spaced, could be misleading, inconclusive, or disappointing. An I.P geophysical survey of the favourable area to show the distribution of sulphide concentrations is recommended as a precaution prior to setting up a drilling project for the claims. The I.P survey would take about two months, and cost approximately $20,000.00. A systematic drilling project, requiring fewer holes, could then be laid out and the final cost of testing the large favourable area adequately should be considerably less than a drilling project without a geophysical guidance on the distribution of sulphide.

PREVIOUS WORK 1930(?)-1957

Gold was found in the gravels along Unuk River below Sulphurets Creek and in gravels and benches along Sulphurets Creek above the canyon, in the early eighties, according to F. E. Wright's 1905 Report, published in the 1906 B. C. Minister of Mines Report. Interest in the region appears to have died down by 1910 and did not revive until the early thirties.

During the early thirties, the MacKay Lake shear zone, which contains local high values in gold and silver, was found 12 miles north of the mouth of Sulphurets Creek, and the Leduc River was prospected for gold by Wendal Dawson and partner, to its source near Granduc. In 1935, a Keystone drill was taken to the placer ground above the canyon on Sulphurets Creek, where it can still be seen, and 18 test holes were drilled below the junction of Mitchell and Sulphurets Creek. In the same year, Bruce and Jack Johnstone staked the Big showing Nos. 1-15, and a few other claims to cover the copper showings on the ridge between Sulphurets and Mitchell Creek and are reported to have located a barite deposit near Bruce Jack Lake. Work on their claims is not recorded, but an assay of a 50 foot chip sample is stated to be gold trace, silver 1.6 oz., chalcopyrite and arsenopyrite were listed as present in the samples, but the amount of copper is not given. Exploration geologists for Granby made brief inspections close to Sulphurets Glacier in 1953 and 1957, described the rock as rhyolite, and reported adversely on the area. The occurrence of high grade copper float along Sulphurets Creek is mentioned. A rough sketch made in 1953 shows copper assays ranging from 0.15 to 2.2% over 5 to 10 foot widths, on the north side of Sulphurets Glacier, 7000 feet east of the Glacier's toe.

RECENT WORK.

1960 Surveys

Present interest in the area dates from April, 1960, when Granduc's airborne magnetometer survey with helicopter was made of the Unuk River drainage area. Approximately 600 claims were staked in May, 1960, to hold ground with magnetic anomalies. 74 of these claims are held by valid certificates of work for periods ranging from 7 to 14 years. The balance (*) are in the Sulphurets region and will be void, without further work, in the Spring and early Summer of 1965.

* Still held

The attached map shows the outline of the claim group staked for Granduc in the Sulphurets area in May, 1960, in relation to geology and to the magnetic anomalies. The entire Unuk River drainage basin was covered by heavy snow in the spring of 1960. The region was completely white with practically all rock covered and only trees visible above the snow as aids in navigation. This prevented flights above timberline because such flights lines could not be identified by strip photography and plotted. This was particularly true of the high, snow covered, ridge between Sulphurets and Mitchell Glaciers where a strip 5000 feet wide along the ridge was not flown. The syenite along this ridge contains parts well impregnated with magnetite that would have given large aero-magnetic anomalies.

The area north of Sulphurets glacier is marked as unmapped on maps by the Canadian Geological Survey. Granby geologists thought this area was underlain by rhyolite. The magnetic anomalies are concentrated along the copper bearing syenite and guided the staking to cover a copper prospect completely concealed by snow.

Ross and Bishop, of Ketchikan, blanketed the Mitchell Creek area with claims early in June without noticing Granduc's claim stakes that had been erected one week earlier. They had heard that a Granduc party would be working in the area and intended to stake copper showings known to the Bishop family for many years. Granduc's claims lie in the centre of the area staked by Ross and Bishop. Kendall Dawson has staked additional claims east of the original 1960 Ross-Bishop claims to cover scattered small showings of molybdenite.

By September 15, 1960, sufficient geological and ground magnetic traverses were completed to show that many of the anomalies were due to concentration of magnetite disseminated in the rock with associated chalcopyrite and pyrite, and to verify locations indicated from the air. Geological work, plotted on a scale 1 inch to one-half mile, in 1960, roughly outlined the syenite intrusive, the general trend and attitude of the bedded and sheared volcanic and sedimentary rocks and the sericite, chlorite, carbonate, silica alteration. The work indicated extensive low grade copper mineralization in and near the syenite in a belt several thousand feet wide easterly and 20,000 feet northerly.

Ground magnetometer traverses checked the location of the 300 gamma anomaly on the south side of Mitchell Glacier and showed that the magnetic highs trended south toward an area of copper staining visible higher up the mountain. A magnetic survey east of

Sulphurets Glacier confirmed anomalies there and indicated that they trended N.W., closely parallel to the strike of the formation.

Work in 1961

The work recommended and carried out in 1961 consisted in more detail mapping of the rocks, alteration and mineralization and 738 feet of packsack drilling. The geological mapping was carried out by F. V. Kirkham, with an arrangement that a study of the alteration, mineralization and mineral composition of the syenite would be done as a thesis for an M.A. degree at the University of B. C.

The location of the packsack drill holes is shown on the map on the south slope of the ridge between the two glaciers. The 738 feet of packsack holes averaged 0.417% Cu. The average for 436 feet drilled at sites 1 and 2 is 0.574 %. The holes average 20 feet in depth and did not pass out of the mineralization. The few assays for molybdenite indicated an average content 0.017% MoS_2.

At the end of the 1961 field season, a map (1 inch to 1000 feet) prepared from Kirkham's field work, was submitted with a brief account of the 1961 work. The microscopic study of the rocks was not completed until the spring of 1963, and Kirkham's report and final map were not finished and accepted by the University until 1 September, 1963.

Work in 1962

The field mapping in 1961 showed that the claims were crossed by one or more large faults. A few holes were laid out in 1962 to test the possible relationship of the mineralization to these faults as a guide for future drilling. Only two holes were drilled as located on the map, and these suggested that the mineralization was probably not related directly to major faults.

Hole No. 1 was drilled vertically to a depth of 1012 feet. The syenite in the uppermost 90 feet in this hole was sericitized and carbonatized and in the initial 30 feet orthoclase was introduced also. The altered syenite 0-90 feet, assayed 0.36% Cu. and the first 30 feet with orthoclase alteration, assayed 0.49%. The syenite from 90-624 feet was very slightly altered except for intermittent short sections which contained disseminated pyrite, chalcopyrite and some magnetite. The unaltered syenite ended at

624 against a fault zone 624-636, consisting of clay gouge 2 feet or more wide and sheared calcareous schist with a little pyrite. The rocks below the fault to the bottom of the hole, at 1014, consisted of light grey to green, fine grained altered types, high in albite, sericite, chlorite, carbonate, and quartz with 0 to 5% pyrite and traces of chalcopyrite.

Hole No. 2 was drilled 504 feet at minus 60 degrees south. It was collared a short distance below the fault and remained in altered rocks similar to those below the fault in Hole No. 1. Assays of the altered rock in the bottom of Hole No. 1, gave 0.01 oz. gold and .07 to 0.19% copper.

The drilling in 1962 was recorded for work certificates that will hold the most northern 14 claims for 10 years and the balance until the spring of 1965.

Recommendations for work since 1962 on the Sulphurets claims have been stalled pending receipt of Kirkham's final maps and report. These were received in late September, 1963, and a copy of his geological map with claims and drill holes added and an alteration map are herewith appended.

Kirkham's report contributes information regarding the mineralogy and types of syenite, the alterations and the fault patterns. The study of alteration is based on specimens from localities indicated on the alteration map. The unequal spacing of the specimens shows that an accurate mapping of alteration will require further work.

Kirkham divides the "syenite group" into three main types, albite syenite or hornblende plagioclase porphyry; syenite and quartz syenite, grading into granite; and granite. The albite syenite is the most basic and earliest phase and occurs as elongate sheets or sills extending N.N.W. from Sulphurets Glacier in the southern part of the area. The youngest granite phase is crosscutting according to Kirkham, and was found by him north of Mitchell Glacier only in the northern part of the area. The syenite and quartz syenite phases with some granite occur in the centre of the area, separated from the other types in places by a flat thrust (?) fault dipping 30 degrees west.

The important distinctions between the three types are the orthoclase (potash feldspar) and the quartz content. Orthoclase occurs as a sparse constituent in the albite syenite; as an essential constituent with albite in the syenite, quartz syenite, and the part

of the granite phase that is gradational into quartz syenite. It occurs in the form of microperthite as the only feldspar constituent of the crosscutting granite. Quartz behaves similarly and is present in greatest amounts in the granite.

The increase in potash feldspar content of the syenite has been produced in part by progressive differentiation. If the copper mineralization is an end product of the differentiation, it would be most closely related to the rocks with the highest potash feldspar content. The association of copper with a high potash feldspar content in syenites and related rock types, occurs in other parts of B. C., according to J. E. Armstrong of the Canadian Geological Survey, and at Ajo, Arizona, according to Hopo of Phelps Dodge.

Although an association occurs between copper and the orthoclase content of the rock in the Sulphurets-Mitchell deposit, it is not established whether the association is with petrogenic orthoclase or with hydrothermal orthoclase introduced after rock consolidation. The evidence from other deposits favours, perhaps, an association of copper with orthoclase introduced by hydrothermal mineralizing processes. The association of copper with hydrothermal orthoclase would rule out concentrating drilling in the area of the granite phase as a safe and sure way of properly testing the prospect.

Another unresolved problem, in attempting to cut down the drilling footage required, is the manner or place in which the various phases of the syenite were differentiated from one another. Differentiation probably continued after the syenite bodies were introduced into the spaces they now occupy. The regional distribution of the syenite and affiliated intrusives, rocks in the Unuk River area, rather clearly indicates that the major part of the differentiation occurred at depth and that the various phases were injected into their present positions in successive invasions. The crosscutting granite phase, which is the latest phase of the syenite group recognized by Kirkham, occurs only north of Mitchell Glacier. The copper content of this rock is neither greater nor more evenly distributed than in rocks in the area tested by packsack holes on the north side of Sulphurets Glacier. The syenite in this area is mapped by Kirkham as syenite, quartz syenite, and contact facies of these rocks.

It is not possible from the geological mapping to select any particular syenite phase or any part of the favourable area as being either representative or superior to any other part for a drilling test and thereby reducing the exploratory drilling footage required.

The problem of making an adequate test of the copper possibilities of the Sulphurets claims is complicated by faulting. The uppermost fault which crosses the Sulphurets-Mitchell ridge and extends north across the Mitchell valley, dips west at about 30 degrees at D.D.H. No. 1. Syenite on the hanging wall side of the fault strikes N.E. nearly at right angles to the albite syenite sheets farther south. The changes in strike and lithology indicate a large throw on this fault with a strong S.E. component. It is uncertain what is concealed under the fault on both sides of the Mitchell Glacier. A copper zone which outcrops south of the fault at the packsack drilling site No. 1, on the south side of Sulphurets-Mitchell Ridge, should extend northward under the fault.

Ice conceals most of the rocks for several miles above the fault northeast of Mitchell Glacier. There are indications that a belt of syenite sheets or dikes extend for several miles across this ice covered area to a syenite plug, six miles N.N.E. of the Sulphurets claims. This plug gave the only aeromagnetic anomaly found in the headwaters of the Unuk River and locally contains traces of copper. It is highly probable that the granite and associated phases of the syenite on the north side of Mitchell Glacier will extend northward under the fault. The copper content of some of the granite north of Mitchell Glacier is between 1 and 2 percent and the fault may conceal copper bearing rocks.

The alteration study did not bring any particular association of secondary silicates with sulphides that could be used as a guide to drilling. Colours have been added on the accompanying alteration map to bring out distribution patterns of the secondary minerals. The colours suggest very crudely that chlorite is an important alteration mineral in the area tested for copper between the two glaciers, and that sericite is associated with molybdenite. The area of greatest chlorite concentration indicated, is on the Sulphurets-Mitchell ridge. The distribution of specimens studied is a little too erratic for convincing statistical conclusions, however.

There is a suggestion, obscured by faulting, of a swing in structure from N.N.W. in the southern part of the area to N.N.E. in the northern half. This swing in the structure is a major regional flexing from N.N.W. to N.N.E. whose axis extends from the Sulphurets-Mitchell ridge, 12 miles westward, to the mouth of Sulphurets Creek. The area of probable maximum flexing is concealed beneath faults on the ridge between the glaciers. The flexing may exercise a control on ore concentration, but the maximum flexion point cannot be pinpointed for a drilling test.

Kirkham's study indicates that the exploration for copper should be confined to the Syenite Area north of Packsack drill site No. 1. The favourable area for copper is 12000 feet long northward and 3000 to 6000 feet wide. Copper may occur also in rocks beneath the west dipping fault and some deep holes may be required eventually to test these concealed blocks. A systematic drilling programme of the favourable area, with holes averaging 500 feet deep at 200 foot centres, would amount to about 375,000 feet of drilling. Holes 200 feet apart could miss deposits of considerable size or give poor results like the initial drilling of Hudson Bay Mining at Galore Creek, or Newmont's initial drilling at the Atlas property in the Philippines.

Recommendations - Copper Prospect.

There is a great danger that the problems and costs of attempting to test the large copper area at the Sulphurets claim without some clear guides to the most favourable sections would lead to disappointment and wasted effort. A method which offers hope of giving guidance to drilling would be a survey of the distribution of sulphide concentration with I.P. equipment. This should also help to indicate the location of valuable ground which should be acquired before a systematic programme of drilling is started. An I.P. survey of the copper bearing syenite could be made with lines 1000 feet apart. Even the snow covered ridge between the two glaciers contains sufficient outcrop that much could be learned regarding concealed mineralization there.

The minimum footage of lines required would amount to 100,000 feet, and would consist of three lines north of Mitchell Glacier, 10,000 feet long, and eleven lines, 6,000 feet long south of this Glacier. About 5,000 feet of line can normally be run in one day, and at this rate the work would take 20 days. Under the conditions of weather and topography at Sulphurets, the time required would probably be two months.

The approximate cost would be:

1	Engineer and equipment rented from Danbury, travel time and expense included ($5,000.00 per month - A. A. Brants estimate)	$ 10,000.00
1	Engineer @ $500.00	1,000.00
2	Assistants @ $300.00	1,200.00
1	Cook @ $400.00	800.00
	Supplies @ $4.00 per man day	1,200.00
	Camp Equipment	500.00
	Beaver 20 hours	1,500.00
	Helicopter 30 hours (Crandus Helicopter)	1,650.00
		17,850.00
	Plus 10 percent	1,785.00
	Labour overhead	600.00
		$ 20,235.00

An option on Ross and Bishops claim will be required before an I.P. survey is carried out.

Recommendations Gold-Silver Prospects.

Just below the hanging glacier on the east side of Sulphurets Glacier is an area with small barite veins. Kirkham traversed this area in 1961 and reported that the veins occurred at intervals in a zone 400 feet wide. He collected representative rock samples for an alteration study and brought in small pieces from one of the veins. These were not a true sample and it was not realized for some time that they contained visible electrum. A few pieces were selected with no visible electrum and these gave 12 oz. gold and 333 oz. silver.

During the summer of 1962, Ole Olson spent about half a day at the hanging glacier but failed to find the gold bearing veins or anything of interest. He was anxious to get out of the Sulphurets area and I suspect did not give the area a good check.

In 1959 Barclay and Wright found a small high grade gold and silver showing, three miles south east of the hanging glacier. The Johnstones in 1935 found barite at Bruce Jack Lake, not far from Barclay's showing. Barclay is very interested in this section of the area and I recommend that he should be given six weeks there next summer.

He should be equipped with a cobra drill and should systematically sample some of the silicified sections for large lower grade gold zones, as well as look for high grade veins.

G. W. H. Norman.

APPENDIX IC

Abstract of 1963 M.Sc. Thesis by R.V. Kirkham, The Geology and Mineral Deposits in the Vicinity of the Mitchell and Sulphurets Glaciers, Northwest British Columbia

Abstract

The Mitchell-Sulphurets region is in the heart of the Coast Mountains of northwest British Columbia. Geologically it is situated on the western edge of the Bowser basin approximately 12 miles east of the main Coast Mountains plutonic complex. The map-area is underlain by partly or wholly metasomatized sedimentary, volcanic, and intrusive rocks. The volcanic and sedimentary rocks are tentatively dated as Lower Jurassic. They probably belong to Lower Hazelton and/or possibly Upper Takla group. The sediments are typical of a greywacke, turbidite suite. The volcanics belong to a marine sequence chiefly comprising pyroclastic members.

Possibly in Jurassic time, the sedimentary and volcanic rocks of the area were invaded by the Mitchell Intrusions. The earlier members of the Mitchell Intrusions were injected as [illegible]s and dykes predominantly into the well-bedded sediments. The later members formed larger, more irregular bodies. There are marked mineralogical changes within the intrusions. Differentiation by fractional crystallization and composite intrusion account for original variations in mineral composition, but post-crystallization changes are the cause of unusual rock types. Spilitized diabase, syenodiorite, albite syenite, syenite, quartz syenite, and some granite have resulted from the "doliming" or albitization of the original plagioclases.

Immense quantities of trapped volatiles, which were concentrated by differentiation processes, resulted in phenomenal amounts of rock alteration during the dying stages of the magmatic period. They have had a profound effect on an area of rock about three times that of the intrusions. During the period of rock alteration the area approached an equilibrium environment probably somewhere below 400° C. and probably at moderate pressures. Throughout the area altering fluids probably contained moderate concentrations of Na, K, SiO_2, and H_2S, high concentrations of CO_2 and H_2O, and in the Mitchell Valley trace amounts of HF. The end of the alteration period was sharp, possibly being terminated by the development of major faults which could have permitted the release of the fluids. The chief types of alteration - albitization, carbonatization, sericitization, silicification, chloritization, and pyritization - have affected the rocks in a similar manner throughout most of the area. In most areas secondary minerals in highly altered rocks are the same as those in the slightly altered rocks.

The mineral deposits, which are of the "Porphyry Copper" type, were formed during the alteration period. The presence of large volumes of volatiles at an elevated temperature allowed extensive migration of the metal-bearing solutions from their magmatic source. Disseminated copper and molybdenum mineralization is found in porphyritic, granitic intrusions

and in altered volcanic, sedimentary, and intrusive rocks. The large quantities of fluids have also resulted in the separation of the copper and molybdenum sulphides into distinct deposits. The formation of distinct deposits was probably dependent upon the physical-chemical properties of the environment at the time of alteration.

Major faulting occurred late in the alteration period. This marked the end of the Mitchell epoch of magmatic activity. Somewhat later in the history of the area, possibly in Tertiary time, a few keratophyre (basaltic (?)) dykes were emplaced. Extensive erosion by glaciers in Pleistocene and Recent times has sculptured the landforms into their present shapes.

APPENDIX ID

Chapter IV, Rock Alteration from R.V. Kirkham's M.Sc. Thesis

CHAPTER IV - ROCK ALTERATION

Introduction

Alteration is widespread in the rocks of the Mitchell-Sulphurets Region. If the Mitchell Intrusions are considered to be the source of the altering fluids, it is interesting to note that the visible portion of the alteration halo is greater than three times the area of the intrusive bodies. All rocks of the area, even the ones that megascopically appear to be fresh, have been affected to some extent (Photographs 9 and 10). Rock propylitization is the most common type of alteration throughout the area. Regional albitization of the plagioclase feldspar has also taken place but it is questionable if this phenomenon is directly related to the main period of alteration or whether it is related to a more widespread spilitic province. Albite, calcite, sericite, quartz, chlorite, and pyrite are the most common secondary minerals. The distribution of these and other secondary minerals, determined from thin-section analyses, is shown in Figure 15. The preservation of pseudomorphs with increasing alteration indicates that a major portion if not all of the alteration has taken place at constant volume.

Time of Alteration

The major period of rock alteration must have followed the consolidation of most of the Mitchell Intrusions. Possibly it was synchronous with or closely followed the crystallization

of the cross-cutting granite. Large portions of the plagioclase-hornblende porphyry and moderately large portions of the syenite and quartz syenite have been altered. In contrast, the areas of cross-cutting granite that have been examined, although they show much evidence of veining by quartz and calcite, do not contain much rock alteration. The inference follows, that since the cross-cutting granite is the youngest of the Mitchell Intrusions, alteration may have been continuous with crystallization. Although this might well have been true, it should be noted that the minerals in the cross-cutting granite are not as susceptible to alteration as those in other rocks. This leads to another inference that the minerals in the granite were closer to being in equilibrium in the alteration environment than those in the other members of the Mitchell Intrusions.

The field relations make it difficult to fix the relative time of the periods of faulting and alteration. Large alteration zones have been offset by major faults. The sharp upper limit of alteration on the north slopes of the Mitchell Valley is a result of its being mainly a fault contact. On the other hand, many major faults have been revealed and obliterated by alteration and have also controlled the development of some alteration zones. Moreover, the mylonite zones that were examined have been affected by alteration. These faults with their associated mylonite zones are definitely post intrusion.

The only simple explanation would be that the major periods of faulting and rock alteration were very close in time.

Nature and Temperature of the Altering Fluids

A study of the products of alteration gives some indication as to the nature and temperature of the altering fluids. As stated before, the main alteration minerals in the Mitchell-Sulphurets region are albite, calcite, sericite, quartz, chlorite, and pyrite (?). Chlorite and pyrite are less abundant than the others. It is known that the alkali content governs the formation of zeolites, sericite, and kaolin in alteration zones at temperatures below 400° C. Turner and Verhoogen in discussing experimental work done by Noll (p. 577) state:

> At lower temperatures (below 400° C.) it depends upon the alkali concentration of the active solutions whether zeolites, sericite, or kaolin are formed.....
>
> Kaolin originates from SiO_2- or Al_2O_3-gels in neutral solutions free of alkali metals or in acid solutions containing alkali metals, at temperatures below 400° C.; on the other hand, montmorillonite forms in alkaline solutions of the alkali metals, and at higher concentrations of potash, sericite appears. At very high concentrations of alkali, zeolites, especially analcite appear.

If, as the writer believes, alteration in the Mitchell-Sulphurets region is predominantly a low-temperature phenomenon (below 400° C.), then from Noll's experimental work it would seem that the altering fluids contained moderate concentrations of the

alkali metals. These conditions could possibly account for the extensive albitization as well as for the sericitization. These concentrations were probably relatively uniform over large areas since there is no evidence of strong zonation.

Besides the alkali metal content, the solutions must also have carried considerable carbon dioxide or soluble carbonate to facilitate the extensive formation of calcite. In the case of the map-area silica would have been displaced from lime silicates and calcite would have formed. Turner and Verhoogen (p. 578) state:

> Whereas silica readily displaces carbon dioxide from carbonates at moderate and high temperatures, many silicates are converted with equal ease to carbonates by hydrothermal reaction with solutions containing carbon dioxide or soluble carbonates, at low temperatures. Autometasomatic replacement of such minerals as feldspars, augite, and olivine by carbonates is a common deuteric process illustrated by igneous rocks of widely different composition.

This feature also explains why no skarn zones are found near the intrusions even though there are many limy rocks in the vicinity. Besides the liberating of the silica from the silicates by the carbon dioxide or soluble carbonate, quartz was probably added to the solutions at their source. Many quartz veinlets are found in the granites and syenitic rocks, some of which are relatively unaltered.

The presence of hydrogen sulphide or some such sulphur-bearing compound in the altering fluids would be the

easiest way to account for the formation of pyrite in the altered rocks. The ferromagnesian minerals such as hornblende, pyroxene, and biotite would be replaced by a magnesium-rich chlorite and by iron sulphide. The reason for believing that this type of chlorite may be relatively rich in magnesia is discussed later.

Many of the hand specimens, examined in this study, contain inconspicuous quartz, calcite, chlorite, and in a few from Mitchell Valley, fluorite veinlets. These minerals at many places form a network of criss-crossing veinlets, which average from 1/32- to 1/4 of an inch in width. In some areas fractures containing these veinlets may have been the only channel-ways for the altering fluids.

There are several reasons for believing that alteration throughout the area is uniformly a low-temperature variety. First, there is no evidence of steep thermal gradients. Alteration varies in intensity but there is no significant change in the types of secondary minerals from place to place (Figure 15). Secondly, high-temperature alteration minerals, such as calc-silicates, potash feldspar (except metastably), pyrophyllite, tourmaline, etc., have not been found. Thirdly, all secondary minerals that have been identified, except the potash feldspar, are compatible with and support a low-temperature origin. The potash feldspar, which is thought

to be secondary, is found only adjacent to some intrusive contacts in high-temperature zones where low-temperature metasomatism has been superimposed. The potash feldspar is possibly a metastable relic of the earlier high-temperature metasomatism. The ubiquitous nature of secondary calcite probably signifies a widespread, relatively uniform low-temperature environment of alteration. Turner and Verhoogen (p. 576) state that secondary hydrothermal calcite is a product of low-temperature metasomatism rather than moderate or high temperature.

In summation the active fluids at the time of metasomatism probably contained moderate concentrations of Na, K, SiO_2, and H_2S, high concentrations of CO_2 and H_2O, in the Mitchell Valley trace amounts of F, and were at some elevated temperature probably below 400° C. for a considerable period of time.

Degree of Alteration

The altered rocks can be subdivided into two groups depending on the degree of alteration. The first group includes those rocks in which relics of original high-temperature constituents are in all stages of replacement by low-temperature minerals. With continuing alteration the primary minerals that were susceptible to replacement became more and more altered until a point was reached that all the minerals susceptible to alteration had been completely destroyed. This point

marks the start of the second group of altered rocks. Now with continuing alteration the secondary minerals increased in size and developed better or what might be described as "fresher" crystals (Photograph 34). Photographs 29 to 33 illustrate the first group and Photographs 34 and 35 illustrate the second group. Such a subdivision may be of primary importance in distinguishing the alteration zones that make the best host rocks for the ore minerals. From this preliminary study of the Mitchell-Sulphurets region it seems that the deposits that have the best chance of being ore grade are in the second group and that the less promising deposits may occur in either group.

Judging from the varying degrees of alteration of rocks over large areas, the writer believes that there were probably many "centers" of alteration. Unless such minerals as sericite and calcite can form over an extremely wide range of temperatures, there was probably not significant temperature variations from the highly altered rocks to the outlying areas. Also, as shown by results of Noll's experiments in the previous section, the concentrations are important for governing the formation of alteration minerals in an environment of low temperature. That sericite is widespread, and kaolin, other clay minerals, and zeolites are negligible, mean that the concentrations in the altering fluids probably did not vary greatly from the highly altered rocks to the less

altered rocks. This leaves one critical variable; that is, the degree of cooking or the amount of altering solutions to which the rock was exposed.

The quartz-sericite schist probably represents the highest grade of alteration. Bateman (p. 104) states:

> With most rocks, except limestone and quartzite, the end product of alteration is a rock composed mostly of sericite and quartz. The original feldspars, ferromagnesian minerals, and micas are all changed to sericite, and silica is generally added.

Since the greatest development of quartz-sericite rocks is in the Mitchell Valley (there are also considerable quantities of quartz-sericite schist about where the legend is in Figure 4) the main center of alteration was probably near the cross-cutting granite.

Susceptibility of Minerals to Alteration

In general ferromagnesian minerals and plagioclase feldspar were by far the most susceptible to alteration, and apatite, potash feldspar, and quartz resisted alteration.

A general alteration series can be established by using the pseudomorphs in the altered plagioclase-hornblende porphyry. Photographs 30 to 33A illustrate increasing alteration in these rocks. Photograph 29 shows a relatively unaltered microcline phenocryst in an otherwise highly altered porphyry. In these rocks the hornblende is most commonly replaced by chlorite, calcite, pyrite, and trace amounts of silica. In some of the least altered rocks it is replaced

Photograph 29: (K-167) Photomicrograph illustrating a relatively unaffected microcline phenocryst in an otherwise highly altered albite syenite porphyry (X25; polarized light).

by epidote and perhaps actinolite (?). In the more highly altered rocks sericite has accompanied the chlorite, calcite, and pyrite in replacing hornblende. The plagioclase in all these rocks, whether the hornblende is altered or not, is albitized (some oligoclase). This feature leads one to believe that the albitization could be independent of the rest of the alteration. Calcite and sericite are the main secondary minerals that replace plagioclase. Occasionally minor clinozoicite is present. Even though the plagioclase and hornblende are equally altered in the lowest zones, relics of plagioclase are present in rocks where nearly all vestiges of

hornblende have been destroyed. The potash feldspar resisted alteration until most of the plagioclase had been destroyed.

Alteration Minerals

Alteration minerals will be discussed in an approximate order of decreasing abundance. The distribution of alteration minerals is shown in Figure 15.

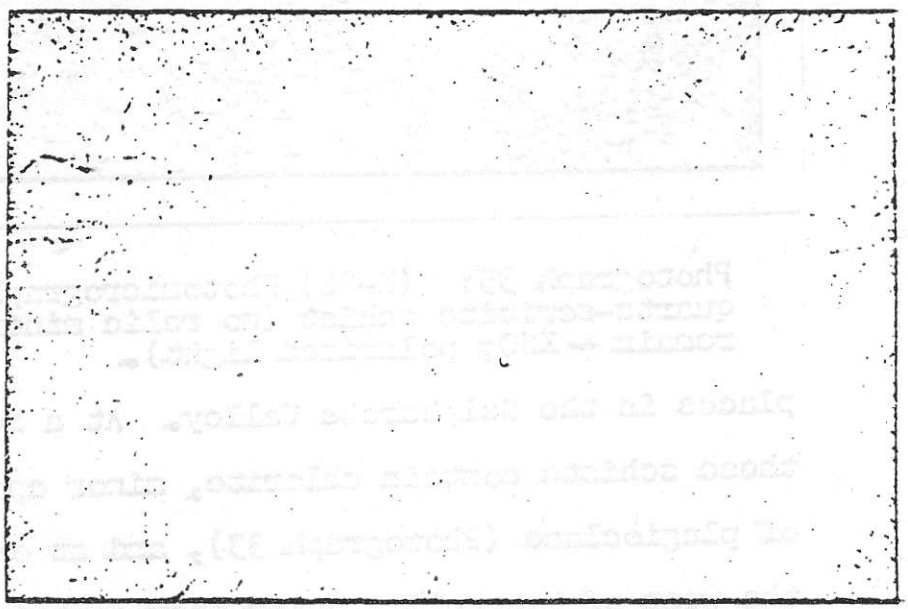
Albite - Albitization is ubiquitous in the area. Plagioclase, a common mineral in the region, everywhere is either albite or oligoclase. Besides the main occurrences described throughout the thesis, minor amounts of albite are also found lining veinlets, both in mylonites and in some syenitic rocks. This type of albite appears to have grown in place of other minerals, whereas most of the secondary albite is replacement of pre-existing plagioclases.

Some of the sedimentary rocks and mylonites, which are rich in albite, have developed a silicified appearance. This appearance results from the rock breaking through grains instead of around them. This type of fracture results from the interlocking nature of grains in these microcrystalline rocks.

The evidence for albitization has been discussed in the section on the genesis of the Mitchell Intrusions.

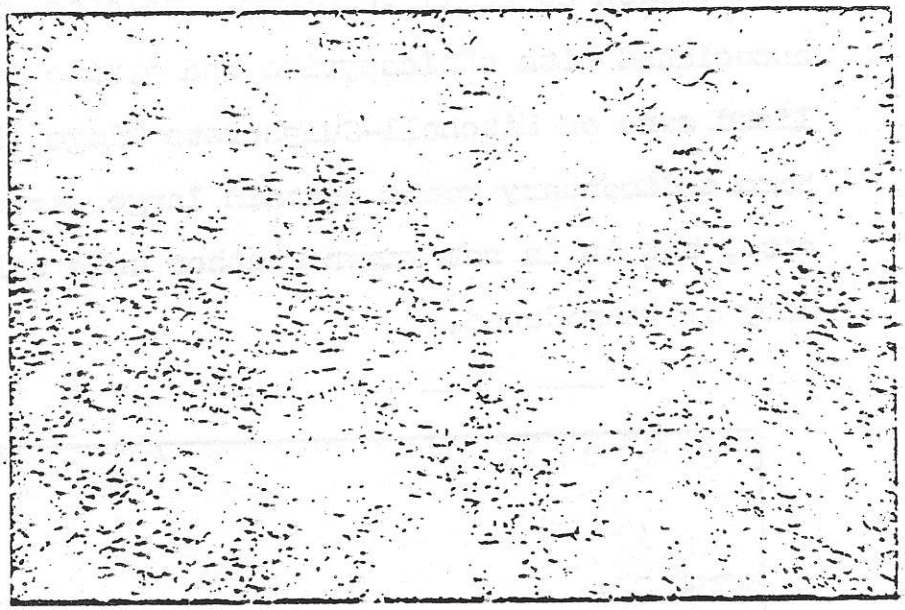
Calcite - Secondary calcite, usually in minor amounts, is found in most rocks of the area. It typically replaces lime-bearing silicates. With or without quartz it is

also common as small veinlets. Calcite and chlorite are associated with chalcopyrite and pyrite in a main mineralised zone on Mitchell-Sulphurets Ridge (Photograph 34). Some sedimentary rocks contain large percentages of calcite, but it is not known whether this calcite is primary or introduced.



Photograph 34: (K-205) Photomicrograph illustrating calcite-chlorite host rock of a mineral deposit on Mitchell-Sulphurets Ridge (X80; plain light).

Sericite - Sericitic alteration is one of the most widespread types developed in the area. Most commonly sericite is found as an alteration product of plagioclase, but in more highly metasomatised zones it has also replaced other silicate minerals. Well-developed quartz-sericite schists are found in the Mitchell Valley and in some



Photograph 35: (K-76) Photomicrograph of quartz-sericite schist (no relic minerals remain - X80; polarized light).

places in the Sulphurets Valley. At a few localities these schists contain chlorite, minor apatite, rare relics of plagioclase (Photograph 33), and at one locality - to the west of Mitchell Glacier they contain minor biotite. The presence of sericite in these schists from six widely separated localities in the Mitchell Valley has been confirmed by X-ray powder photographs (the localities are shown in Figure 15). In a mineralized mylonite zone on the upper northern slopes of Sulphurets Valley sericite occurs with relatively abundant fine-grained hydrothermal biotite.

The styles of replacement by sericite are many. In

some specimens minute flakes of sericite have formed uniform grids throughout host minerals. In some, the flakes are randomly scattered throughout the host; while in others, they have formed alteration zones in the host. In a few specimens the sericite flakes have formed single train-like veinlets. A few of the highly altered rocks contain pseudomorphic clots of sericite after plagioclase.

Quartz - Secondary quartz is abundant in the quartz-sericite schists, massive silicified rocks, and in veinlets which mainly occur in the schists, syenitic rocks, and granites but also in other rocks throughout the area. In the low grade altered rocks it is difficult to separate the primary quartz from the secondary quartz.

Two distinct generations of quartz veinlets have been found in the quartz-sericite schist. The first generation is by far the most abundant and is closely connected to the formation of the schist itself. These veinlets usually average about 1 inch in width and may comprise over 50 per cent of the rock. In all places they parallel the schistocity and are usually separated by areas of granular quartz, sericite, chlorite, and pyrite. They may have been formed by metamorphic differentiation. These veins are invariably barren. The second system of veins usually cuts the first at high angles. These generally

do not comprise more than 2 per cent of the rock. At many localities they contain coarse chalcopyrite and, in a few rare cases, galena, sphalerite, and tetrahedrite. In one area small amounts of chalcopyrite had migrated considerable distances from these veins into the country rock.

Chlorite - Chlorite is common as a minor constituent throughout the region, but in a few places it occurs in abundance. Where it is subordinate to quartz, sericite, and calcite, the altered rocks in most places are pale buff or some shade of grey, but where it is abundant the rocks are some shade of green. Only the rocks that contain greater than 5 per cent finely disseminated chlorite have a greenish tint. In a few specimens the sericite as well as the chlorite is green.

Variations in the types of chlorite have been noted in thin section. Chlorite found as a widespread alteration product is pale green approaching colourless, is weakly pleochroic, and has anomalous blue or brown birefringence. Chlorite found locally in some mineralized areas is a much darker green, is strongly pleochroic, and commonly displays anomalous royal purple birefringence.

W. G. Jeffery, in his work on the Campbell Chibougamau Mine in Quebec, has described a similar phenomenon

(unpublished thesis, 1959, pp. 149 and 158). He was able to divide the chlorites in that area into two groups: Chlorite I and chlorite II. Chlorite I has a high magnesium content and chlorite II is rich in iron. These two groups were distinguished by their optical properties. The main diagnostic properties are as follows (after Jeffery, p. 149):

Type I	Type II
Usually colourless or pale green	Green
Pleochroism - nil to faint	Pleochroism - strong
Length fast - negative elongation	Length slow - positive elongation

He states:

> Between the two variations the optic angle passes through zero, the chlorite is isotropic, and the birefringence is nil. As the birefringence decreases from that of types I and II they can be termed respectively low chlorite I and low chlorite II.

At the Campbell Chibougamau Mine chlorite II is found chiefly as wall rock alteration associated with sulphide mineralization, whereas, type I is not associated with mineralization. He cautions against using the chlorites as a guide to ore since chlorite II is also found in shear zones that are not mineralized.

Following Jeffery's distinction of the two varieties, the writer believes that the dark green, more strongly pleochroic chlorite which is found in some of the copper mineralized areas, could be richer in iron

than the chlorite found as a widespread alteration product. The elongation of most of the chlorites in the map-area is negative (length fast) and only a few have positive elongation even in the ore zones. Possibly this means that all the chlorites of the area contain considerable magnesia. Hey (1954) in his review on chlorites has noted that the optical properties do not vary proportionally to changes in the Fe total/ Fe+Mg ratio. From his charts it can be seen that variations in the optical properties are also dependent upon the amount of silicon present, but still optical variation reflect a general variation in iron and magnesium content. In the "ore" zones it is quite possible that the copper, upon entering the rock, replaced the iron of the pyrite which then entered the chlorite. The writer has no proof for this hypothesis but offers it as feasible explanation for the observed phenomena.

Pyrite - Small amounts of disseminated pyrite are widespread throughout the area. Pyrite is included with the alteration minerals because the formation of the bulk of it was probably more closely connected with the alteration processes than with other sulphide deposition. Wherever observed, it is older than the other sulphides. Pyrite associated with magnesian (?) chlorite and calcite in most areas has formed as a replacement product of pri-

mary ferromagnesian minerals. The pyrite in the regionally altered rocks constitutes typically less than 5 per cent of the total rock. Amounts greater than this are rare and have undoubtedly resulted from the addition of iron to the rock.

Clay Minerals - Clay minerals have been noted in a few specimens, especially from rocks of low grade alteration. A clay mineral (or minerals) has been recognized selectively replacing certain zones of plagioclase crystals in the syenitic rocks. This mineral (or minerals) could not be resolved in X-ray powder photographs. Although the possibility that they may have been overlooked or mistaken for sericite is still considered, clay minerals do not appear in great abundance in the map-area. Large kaolinized zones or any "chalky" type altered rocks have not been observed.

Epidote - (Usually pistacite, minor clinozoisite). Epidote occasionally occurs in abundance but it is not one of the major alteration minerals of the area. Ferromagnesian minerals in some of the least altered rocks are replaced by pistacite. Clinozoisite was identified in a few thin sections as an alteration product of plagioclase.

Biotite - Minute flakes of hydrothermal biotite exist in a few areas in similar types of occurrences as sericite. The highest concentration of secondary biotite was noted

in a porcelaneous mylonitized rock which occurs on the upper northern slope of Sulphurets Valley. This rock contains minor disseminated chalcopyrite and molybdenite.

Potash Feldspar — Potash feldspar is not a common alteration product in the area but it has been included in this section since it is found intimately associated with chlorite adjacent to some of the intrusive contacts. Moreover it does not seem to be in dyke-like bodies. In these contact areas it is difficult to distinguish between dykes and metasomatized country rock. Potash feldspar has also been found as a constituent of microcrystalline, mosaic aggregates in mylonitized rocks. Here the potash feldspar was probably an original product of the rock that recrystallized upon mylonitization. Photograph 28 illustrates such a mylonite.

APPENDIX IE

1968 Preliminary Summary Report of Sulphurets-Mitchell Creek Ridge by Roy Wares

PRELIMINARY SUMMARY REPORT OF GEOLOGY OF SULPHURETS-MITCHELL CREEK RIDGE

by Roy Wares
October 1, 1968

To accompany Quarterly Progress Report
to September 30, 1968 by E. Ostensoe

The Mitchell Creek-Sulphurets Creek property is structurally complex and consists of a number of thrust faults placing units of different lithology, alteration and mineralization in juxtaposition. The most prominent structure is the Sulphurets Thrust Fault, which carries a sill complex over hydrothermally altered sediments.

The upper thrust unit consists of a series of transgressive sills of monzonitic/syenitic aspect which are intrusive into a sequence of volcanics faulted against arenaceous sediments. The volcanic rocks are predominantly andesitic in character with subordinate dacitic flows, agglomerates and agglomeratic tuffs which are more frequent in the upper part of the volcanic unit. Metasomatic phenomena, particularly potash metasomatism, are widespread but minor, being prominent only along shears that are present in the unit and which are related to the Sulphurets Fault.

The Sulphurets Fault is a zone of movement rather than a discrete discontinuity and comprises a complex interdigitation of andesitic and monzonitic units with siliceous replacement units that are characteristic of the hydrothermal assemblages below the fault. In the movement zone, there is a strong, closely spaced cleavage developed.

By far the largest unit in the property is the regional hydrothermally altered assemblage which exhibits marked but regular variation in alteration type. The rock units are not clearly recognizable in many cases but, where found, comprise siltstones and greywackes with minor pre-alteration siliceous intrusives. There is considerable structural complexity in this unit. A large boss of a fine grained intrusive of syenitic aspect with associated satellitic dykes is cut by a silicified shear zone and is itself cut by a subsidiary thrust which carries part of this intrusive over hydrothermal assemblages. In addition, a wedge of agglomerates, flows and sediments is faulted into the hydrothermal assemblages and only altered along thin arcuate shears.

The regional alteration alluded to above, consists of a sericitic assemblage that is crudely zoned around a dome or core of intense silicification, centred in the vicinity of D.D.H. #68-5 and 6. This comprises a core of aphanitic, cherty material that passes outwards through a dense stockwork of quartz veins into a sparsely veined zone. The sericitic assemblages form a crude envelope to this siliceous dome, despite complications produced by faulting associated with the steepening of a westerly dipping thrust fault. The cleavage in the schists defines a fold structure plunging steeply to the northwest.

The sericitic alteration does not appear, on the scale of mapping, to be related to known intrusives and transects lithological boundaries. Away from the

sericitic alteration there is pervasive silicification but only subordinate chlorite and sericite. Pyrite is ubuiquitous in this unit and will be referred to in a later section.

The third major structural unit present is one comprising sediments and markedly porphyritic intrusives. It is faulted against the hydrothermally altered assemblages but has itself escaped significant alteration except in the vicinity of the fault zone. The sediments are chiefly siltstones, sandy siltstones and argillites that are folded into inclined asymetric folds. The porphyritic intrusives are varied in character and consist of an extensive sill of orthoclase porphyry cut by later hornblende porphyrite.

The three units described have different structural and alteration types. The upper thrust sheet is cut by a number of faults, interpreted as splays associated with the Sulphurets Fault. Potash metasomatism is related to some of these faults which also possess subordinate quartz-pyrite alteration. There is a low grade regional, isochemical, metamorphism present in this sheet.

Within the Sulphurets Fault zone, there is an interdigitation of lithological and alteration types of both the overlying thrust block and the underlying hydrothermal association with a pervasive and multi-directional fracture and cleavage pattern developed.

The hydrothermal assemblage is characterized by the inconsistent development of fractures and cleavage in the silicified replacement units. The exception to this is the sericitic assemblages where there is a pervasive set of cleavages present and some cross fracturing related to folding.

The third tectonic unit shows evidence of fracturing associated with fault patterns but there is little evidence of widespread deformation and metamorphism.

Sulphide mineralization is widespread in the property but over much of the area, it is barren of valuable metals. The upper thrust block carries low, but widespread amounts of copper mineralization averaging about 1/2% to 1% Cu. The area of mineralization is spatially associated with the monzonitic sills and shear zones transecting the sills, hybridised sills and andesites. The depth of the zone is limited by the Sulphurets Fault but the mineralization is sufficiently widespread to perhaps warrant further examination.

The Sulphurets Fault Zone which was drilled in part in 1962, 1968, is characterized by the same type of mineralization as the upper thrust block, though there may be some enrichment from the interdigitation of sills and replacement rocks. It is suggested that this enrichment occurred at elevated temperatures and pressures during the thrust movements.

Molybdenum mineralization rarely occurs in spatial association with copper mineralization. There is, however, a significant MoS_2 showing in the Ross claims. The molybdenite occurs in fractures and thin disseminations in the sericite schist "envelope" around a silicification "dome" or "core". The results of drilling and field mapping appear to indicate that though MoS_2 is widespread, it forms zones

do not possess significant length or breadth. The extensive, and spectacular [illegible] zones (averaging 3% to 5% pyrite) in the hydrothermal zone that carry trace copper mineralization are of no economic significance. They are considered to be due to "sulphurization" of a regional unit in which iron was re-arranged and fixed with sulphur.

Thin fractures occasionally carry appreciable amounts of copper mineralization but are limited in extent and width. A zone of baryte-calcite-quartz veins found in the eastern part of the property is about 400' wide. The vein system is related to cross flexing of a westerly plunging asymetric fold. Wide veins with significant amounts of mineralization are lacking, although previous investigators reported good gold/silver values over narrow widths.

APPENDIX IF

Ted, Ray Property, Unuk River, Skeena Mining Division

by E. W. Grove, in Report of Minister of Mines and Petroleum Resources, 1968

SKEENA MINING DIVISION

UNUK RIVER

Ted, Ray

By E. W. Grove

LOCATION: (56° 130° S.E.) The Sulphurets-Mitchell Creek property is on the east side of the Unuk River, 40 miles northwest of Stewart, and 20 miles north of the Granduc mine.

CLAIMS: The property presently consists of 78 claims, including the Ted, Ray, Ran, Patty, Arbee, John Bull, and Dawson-Ross claim groups.

ACCESS: Men and materials were transported by helicopter from Stewart.

OWNER: Granduc Mines, Limited, and Don Ross and Associates, of Ketchikan, Alaska.

OPERATOR: Granduc Mines, Limited, 2009, 1177 West Hastings Street, Vancouver 1.

METALS: Copper, molybdenum.

WORK DONE: A geological crew of seven men spent 3½ months preparing a topographic and geologic map of the property, which covers about 9 square miles. A geochemical orientation programme was run on the Patty and Ran 40 to 48 mineral claims, and six BQ-size core holes totalling 3,819 feet were drilled by an eight-man crew. The project was supervised by E. Ostensoe, chief geologist, Granduc Mines, Limited.

REFERENCES: *Minister of Mines, B.C.*, Ann. Repts., 1962, p. 8; 1967, p. 31.

DESCRIPTION:

The Sulphurets-Mitchell Creek property is one of three large conspicuous gossan exposures in an area bounded to the north by the confluence of Unuk River and Treaty Creek. All three occurrences appear to be localized within altered Lower Jurassic volcanic and sediments intruded by syenitic plutons and are marked by intense mechanical deformation. Deep valley erosion has removed most of the Bowser Assemblage sediments, which once capped the mineralized complex, and recent glacial action has scoured clear large parts of the area. Since the initial discovery of the deposit in 1935, glacial ablation has exposed extensive outcrop areas below the old trim lines. Investigations at the Sulphurets-Mitchell Creek property in 1967 indicated that a detailed geological mapping programme was required before further evaluations could proceed. As a result, company geologists mapped about 9 square miles by plane-table in 1968 at a scale of 1 inch equals 200 feet.

Structurally, the mineralized zone, which includes pyrite, chalcopyrite, and molybdenite within quartz, carbonate, sericite, and talc alteration, lies near the northwest end of an elongate regional dome. The layered country rocks, which include intercalated volcanic epiclastics, volcanic flows, and marine sediments, have been intruded by a complex of syenite, monzonite, and diorite plutons. So far most of the alteration-mineralization appears to be concentrated within schists developed from certain horizons intruded by syenitic plutons. At least three prime directions of schistosity are visible and post-mineral faulting has been extensive. Thrust faults appear to dominate along the west margin of the intrusive complex, whereas northeasterly tear faults are prominent in the central and eastern sections. Even the glacial moraines in the area are disturbed by the most recent faults.

Three core holes, DDH 68-2, 68-3, 68-4, were drilled at the north edge of Patty No. 1 claim to test the extension of a mineralized zone previously drilled in 1962 near the top of the main ridge which separates the Mitchell and Sulphurets glaciers. Three other holes were drilled at other points to test mineralization and extend geological information.

Figure 8. GENERALIZED GEOLOGY SULPHURETS - MITCHELL CREEK AREA

A generalized geological map of the immediate area surrounding the Sulphurets-Mitchell Creek property is shown on Figure 8. This area was mapped by members of the Mineralogical Branch as part of a regional project directed by the writer in 1966–67 to revise the British Columbia section from Portland Canal to the Iskut River with special reference to mineral-deposit occurrences. The Sulphurets-Mitchell Creek zone lies within rocks forming the western margin of the Bowser Basin and is adjacent to the important Coast Crystalline Complex of intrusive igneous rock which transects the western limits of the main basin (*see* Fig. 7). The granitic La Brant batholith is one of several satellite plutons likely related to the main complex. The syenite-monzonite and related intrusives found in the Sulphurets-Mitchell Creek area are just a few of many such intrusives localized along the exposed basin margin forming a belt which in the Unuk area is approximately 26 miles wide. For convenience these and other plutons found within the basin area have been termed " Skeena Intrusions," and so far age, composition, and genesis are not implied. Within the regional tectonic framework the Sulphurets-Mitchell Creek deposit lies within the Bear River uplift, a major unit found to extend from Alice Arm to the Iskut and east to include the Oweegee Dome-Ritchie anticline area.

Within the confines of the map-area (Fig. 8), general relationships are usually decipherable. The rock units, consisting of intercalated, lenticular members, generally dip steeply and trend north-northwest. These rocks include marine siltstones, greywackes, volcanic epiclastics, and mixed volcanics. Near the La Brant batholith the intruded country rocks have been variously hornfelsed, indurated, or sheared, depending on their composition and competency. In the Mitchell Creek-Sulphurets section, where syenite-monzonite plutons are localized, alteration has been varied and extensive with sericite, K-feldspar, and silica dominant. Sulphide mineralization has been found areally in disseminations and vein-type deposits. Pyrite, chalcopyrite, molybdenite, galena, sphalerite, tetrahedrite, and bornite along with magnetite locally form the most abundant metallic minerals.

PORTLAND CANAL

Tide Lake Flats

Granduc Mine By H. Bapty and L. Wardman

Location: (56° 130° S.E.) The Granduc mine is at the head of the Leduc River, 25 miles north-northwest of Stewart, between elevations of 2,500 and 4,000 feet.

Claims: Sixty-four Crown-granted and 220 recorded mineral claims.

Access: By 28 miles of road from Stewart to Tide Lake and thence by an 11.6-mile tunnel to the mine.

Owner: Granduc Mines, Limited.

Operator: Granduc Operating Company, 520, 890 West Pender Street, Vancouver 1; N. Gritzuk, general manager; mine address, P.O. Box 69, Stewart; D. E. Howard, resident manager.

Metal: Copper, silver.

Work Done:

Leduc Camp

The camp was opened on February 26, 1968, and was closed on December 19, 1968.

On the 2475 level, excavation of the crusher-room was started, the top crusher-room was slashed out and the back rock-bolted using Roc-Loc bolts, and longhole drilling and blasting of the ore bin above the crusher-room was completed.

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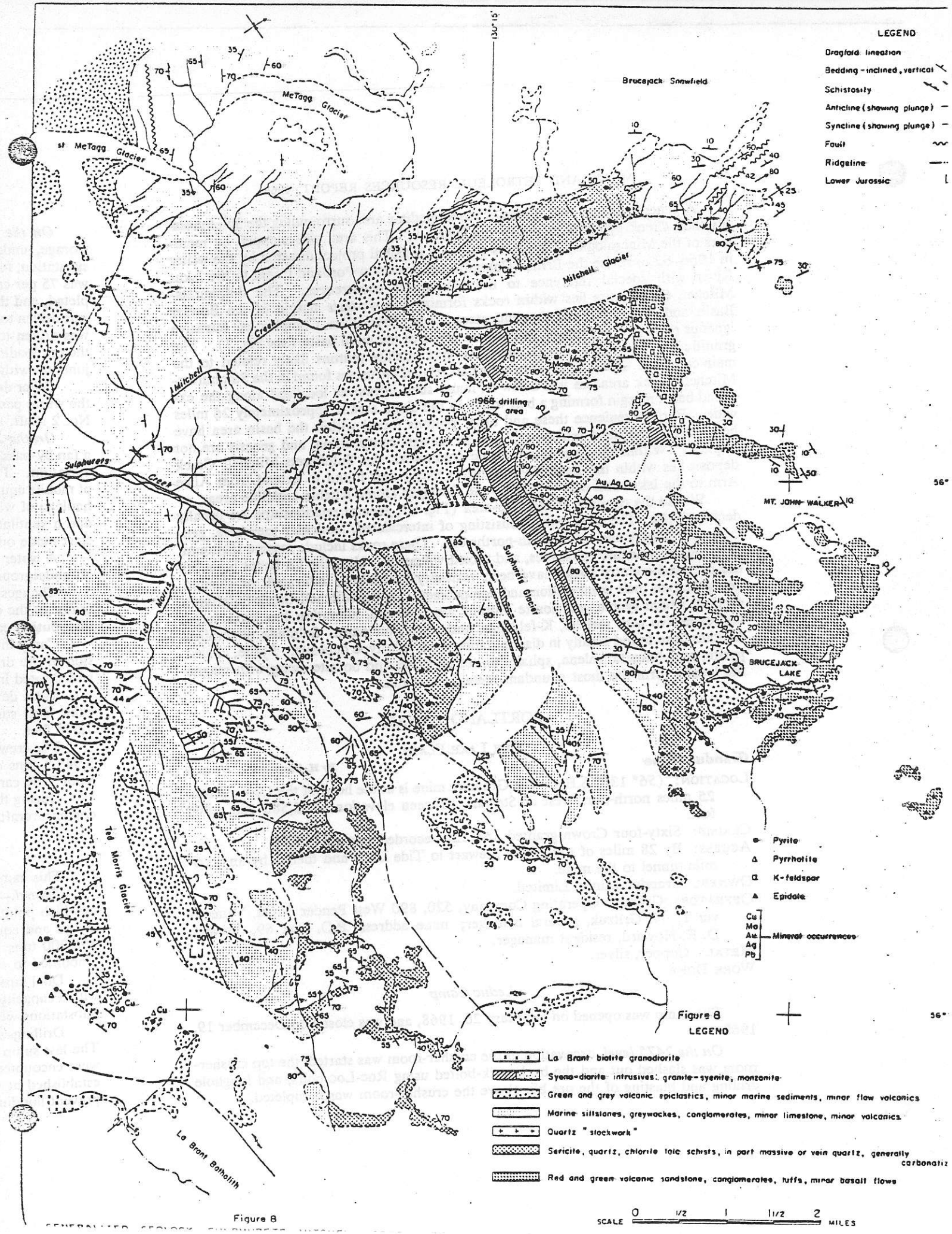
LEGEND
Dragfold lineation
Bedding - inclined, vertical
Schistosity
Anticline (showing plunge)
Syncline (showing plunge)
Fault
Ridgeline
Lower Jurassic
Brucejack Snowfield
McTagg Glacier
Mitchell Glacier
Mitchell Creek
Sulphurets Creek
1968 drilling area
Au, Ag, Cu
MT. JOHN WALKER
Sulphurets Glacier
Ted Morris Glacier
BRUCEJACK LAKE
La Brant Batholith
Pyrite
Pyrrhotite
K-feldspar
Epidote
Cu
Mo
Au
Ag
Pb
Mineral occurrences
Figure 8
LEGEND
La Brant biotite granodiorite
Syenodiorite intrusives: granite-syenite, monzonite
Green and grey volcanic epiclastics, minor marine sediments, minor flow volcanics
Marine siltstones, greywackes, conglomerates, minor limestone, minor volcanics
Quartz "stockwork"
Sericite, quartz, chlorite talc schists, in part massive or vein quartz, generally carbonatiz
Red and green volcanic sandstone, conglomerates, tuffs, minor basalt flows
SCALE 0 1/2 1 1 1/2 2 MILES

Figure 8

APPENDIX II

GEOCHEMICAL REPORTS

APPENDIX IIA

Report on an Orientation Survey for a Rock Geochemistry Survey at Mitchell Creek, B. C., by J.H. Montgomery, Ph.D., P.Eng., 1974