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Geology and Mineral Occurrences of the Southern Hogem Batholith

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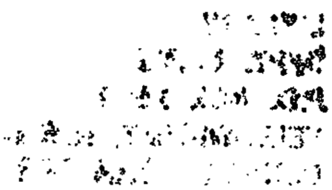

Frontispiece

Landsat I imagery, colour composite of the general area of the southern Hogem batholith (Track 8D, FC5421, NTS 93N, 17 June 1974).

ABSTRACT

The Hogem batholith is the largest intrusive body within the Swannell Ranges, a subdivision of the Omineca Mountains. The batholith is a Mesozoic intrusion located within the island arc environment of the Quesnel Trough. To the west, older, uplifted Cache Creek Group rocks are separated from this belt by the Pinchi fault zone. To the east, the Manson fault zone separates this volcanic belt from the older, uplifted Wolverine Complex. The current structural setting of the Hogem batholith and the intruded Takla Group volcanic rocks is therefore best explained by vertical tectonics associated with graben development.

Detailed mapping in the southern section of the Hogem has documented a complex intrusive history spanning a much larger time interval than previously thought. It is a composite intrusion, containing three, and probably four, partial plutons with distinctive petrographic and chemical compositions.

Geochronologically, emplacement can be separated into three distinct phases. Phase I, chemically divided into the Hogem basic suite and the Hogem granodiorite, yields K/Ar dates within the limits 176 Ma to 212 Ma, and volumetrically represents the main intrusive event. The Phase II Duckling Creek and Chuchi syenite bodies yield K/Ar dates within the limits 162 Ma to 182 Ma and, although there is some age overlap with Phase I, are interpreted as distinctly younger on the basis of field observations. Phase III granite yields K/Ar dates within the limits 108 Ma to 126 Ma, and occurs as relatively small isolated bodies at four localities within the southern Hogem batholith.

The Phase I Hogem granodiorite and the Phase III granite fall within the calc-alkaline (sub-alkaline) petrogenic suite. The Phase I basic suite plots close to the alkaline/sub-alkaline boundary but is predominantly alkaline. The Phase II syenite falls well within the alkaline field.

The Hogem batholith has been subjected to considerable mineral exploration over this century, most recently during the period 1969–1975. Currently, there are no economically viable mineral deposits in the Hogem, although several interesting prospects have been developed. On the basis of field mapping, a clear relationship between the intrusive phases and certain types of mineralization has been established. Only minor pyrite/chalcopyrite/magnetite mineralization is associated with Phase I basic rocks, either as local disseminations or within volcanic contact aureoles adjacent to this phase. With the exception of local pyritized zones, the Phase I Hogem granodiorite is essentially barren of metallic mineralization.

Significant occurrences of copper (chalcopyrite, bornite, chalcocite, malachite, associated with magnetite and minor pyrite) are spatially associated with Phase II syenitic rocks and their related potash feldspar alteration zones. Such mineralization and alteration occurs where syenites intrude Phase I basic intrusive or Takla volcanic rocks. The majority of known copper occurrences in the southern Hogem batholith are in the immediate vicinity of the Duckling Creek Syenite Complex. To a lesser extent, similar copper occurrences have been documented in and near the Chuchi syenite body to the south. Minor gold values are commonly associated with this mineralization.

Copper/molybdenum mineralization is spatially associated with Phase III granitic bodies. Chalcopyrite and/or molybdenite are associated with quartz flooding in altered, fractured zones near contacts and in and near aplitic and alaskitic dykes cutting both intrusive and volcanic rocks.

The best known 'porphyry copper' mineralization within the Hogem is associated with Phase II syenites. However, the environment in which this occurs differs significantly from the major ore deposits in plutonic rocks of the alkaline porphyry suite elsewhere in British Columbia. The Hogem occurrences show little or none of the classic alteration, high level fault control, or porphyry dyke/breccia pipe development common elsewhere. There are no known volcanic equivalents to the Phase II syenites in the general vicinity of the southern Hogem batholith. The tentative conclusion of this study is that erosion has removed the contemporaneous, localized volcanic piles along with their characteristic subvolcanic copper mineralization. The existing syenitic copper occurrences represent lower level, primary intrusive remnants of such deposits. Since there are also no known volcanic equivalents to the Phase III granites, a similar history can be attributed to the existing copper/molybdenum mineralization associated with this calc-alkaline intrusive event.

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INTRODUCTION

The Hogem batholith is the largest intrusive body within the Swannell Ranges, a subdivision of the Omineca Mountains (Holland, 1964). The southern section of this batholith covers the central part of the Manson Creek Topographic Sheet (NTS 93N). The general terrain is mountainous, with high points between 1 800 and 1 980 metres above sea level and valley bottoms between 900 and 1 200 metres. The eastern margin of the batholith can be reached by road from Fort St. James through Germansen Landing, and the road from Manson Creek to Takla Landing crosses the batholith near Kwanika Creek. The specific outline of the southern Hogem batholith is shown relative to major regional features on Figure 1.

Regional mapping of this section of the batholith was carried out during the field seasons of 1971, 1972, and 1973. The major field aspects of this program have been published previously (Garnett, 1972, 1974a, 1974b). Subsequent to the completion of the field mapping, additional information has been developed, especially detailed chemical, petrographic, and radiometric analyses; most of it collected by the spring of 1975. As a result, the geology has been further refined and modified. Much of this additional data has not yet been placed in the public domain, and the intention of this report is to consolidate all the basic geological information, supply an upgraded, large-scale geological map of the area, and evaluate the chemical and radiometric data.

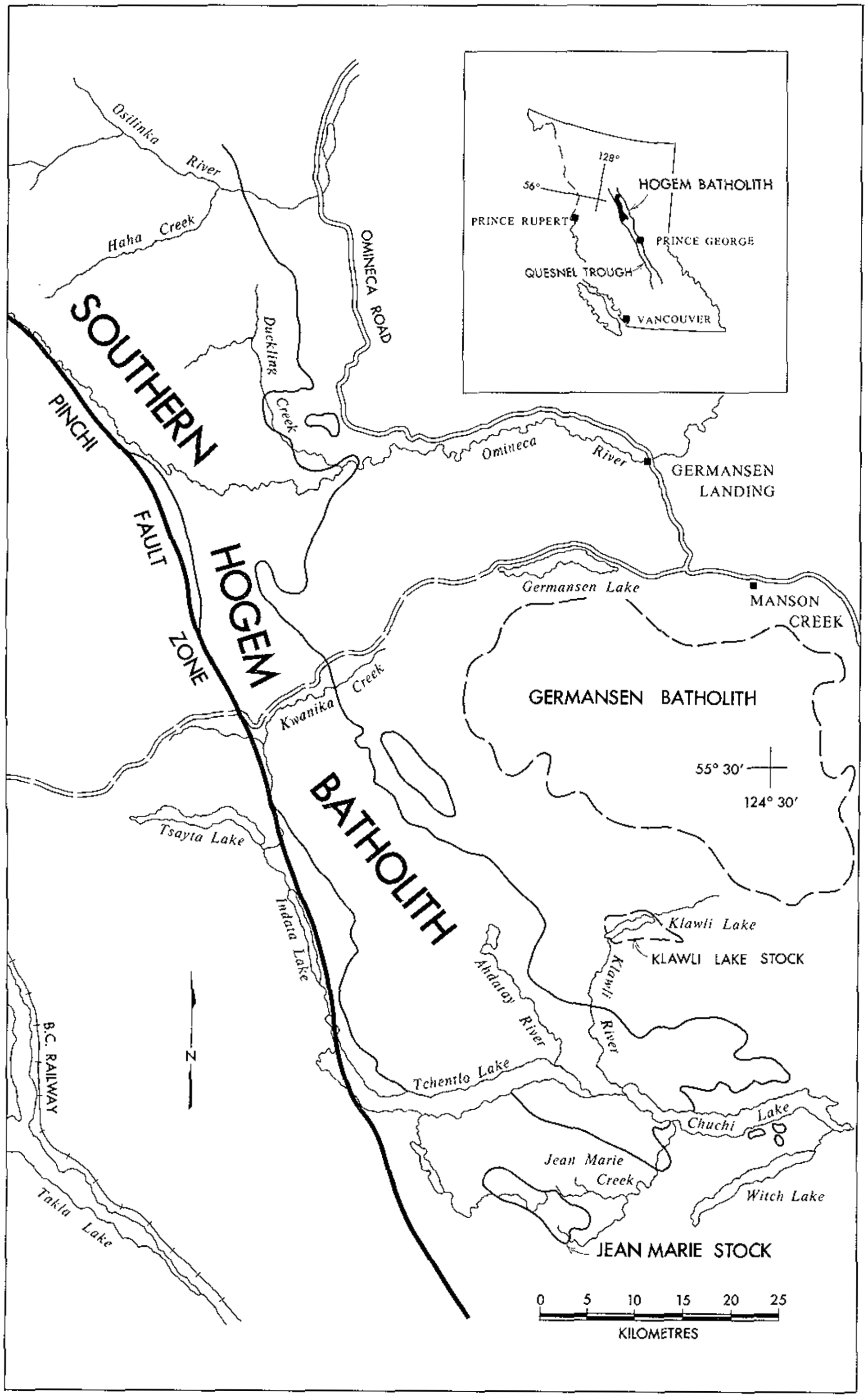


Figure 1. Southern Hogem batholith and vicinity, general location.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the excellent independent mapping carried out by Messrs. J. Franzen, D. Lefebure, and H. Meade as senior assistants during intervals of the field component of this study.

It is a pleasure to gratefully acknowledge both the geological and logistical assistance received from a number of mining companies active in this area over the 1971-1973 period; notably, Amoco Canada, the LUC and NBC Syndicates, Cominco, Granby, Noranda, Falconbridge, Bow River Resources, Dolmage-Campbell, Union Miniere, and Pechiney.

I would also like to acknowledge the hospitality extended to myself and my crew over the years by Mr. Gene Jack of Rosemont and Don and Irene Gilliland of Germansen Landing.

With respect to the analytical aspects of this study, I would like to thank the following members of this Ministry's Analytical Laboratory: Messrs. W. Johnson and P. Ralph for their time and concern in completing the silicate analyses, Mr. F. Karpick for specific gravity analyses, and Mr. L. Sheppard for mineral separations. Special thanks are also extended to Mr. J. Harakal of the University of British Columbia Geochronology Laboratory.

TECTONIC SETTING

The Hogem batholith occurs within a narrow belt of Lower Mesozoic volcanic rocks lying between highly deformed Proterozoic and Paleozoic strata to the east, and deformed Upper Paleozoic strata to the west. The term Quesnel Trough (Roddick *et al., 1967*) has been applied to this belt, which continues both northwest and southeast of the Hogem area (Fig. 1). The characteristic geological features of the trough are continuous through the eastern Cariboo district, with its significant mineral deposits, into the Kamloops-Merritt-Princeton copper-producing region (Campbell and Tipper, 1970). The Quesnel Trough is primarily a Lower Mesozoic basin of deposition, the boundaries of which are regional faults in some areas. In the Hogem area, the Pinchi fault zone marks the western border and the Manson fault zone (immediately east of the map-area) marks the eastern border of this belt, which lies between older uplifted blocks and is therefore a graben.

REGIONAL GEOLOGY

The Pinchi fault zone is the main structural feature of the Hogem area (Fig. 1), separating Permian rocks (Cache Creek Group) on the southwest from Upper Triassic rocks (Takla

Group) on the northeast. The Cache Creek Group adjacent to the southern Hogem batholith has been mapped by Paterson (1974). Cache Creek rocks were not mapped during the Hogem project. Takla Group rocks between the Hogem and Germansen batholiths have been mapped recently by Meade (1977). The petrography and chemistry of the Takla rocks immediately adjacent to the southern Hogem batholith were examined during the Hogem project and are reported on in detail in later sections.

The Pinchi fault trace lies mainly under drift-covered subsequent river valleys, but it is expressed along the banks of Kwanika Creek by outcrops exhibiting intense fracturing, brecciation, and numerous minor faults. It is further described on page 53. Several major fault lineaments have been defined by a combination of air-photo interpretation and field mapping. The greatest density of faulting was noted in the vicinity of the Duckling Creek Syenite Complex. Major eastward-trending faults were also mapped south of Kwanika Creek, and one of these, through Tchentlo Lake, shows apparent left-lateral offset of intrusive units and the western border of the batholith.

Although the Hogem batholith is bounded to the west by the Pinchi fault zone, rocks of the Takla Group occur as wedges between the intrusion and the fault trace. These are predominantly interbedded black argillites and brown siltstones and shales which exhibit slaty cleavage and brittle, concentric folding close to the Pinchi fault trace. The Upper Triassic pelecypod *Halobia* has been reported in similar strata interbedded with limestone on Halobia Creek (Armstrong, 1942, 1944). Andesitic tuffs and breccias occur along the western boundary in the Tchentlo Lake area. Conglomerates and sandstones mapped by Armstrong (1949) as Lower Cretaceous Uslika Formation occur along Kwanika Creek.

Along the eastern margin of the batholith the Takla Group consists mainly of dark green tuffs and volcanic breccias of andesitic to basaltic composition, interbedded with flow rocks and commonly cut by pyroxene and feldspar porphyry dykes. Moderate fracturing, mild hornfelsing, and local pyritization are common features along this contact zone.

Intrusive outliers adjacent to the eastern boundary have been mapped in the Duckling Creek area and south of Kwanika Creek. Three small related outliers have also been mapped between Chuchi and Witch Lakes. The rough dimensions of the Jean Marie stock south of Tchentlo Lake is based on company mapping.

Despite the topographic variations within this region, aeromagnetic maps are very useful in distinguishing outlines of outliers and particular units within the batholith. The basic phases (Units 1 to 4) correspond to distinct magnetic highs, and some leucocratic granitic units (for example, Unit 9) correspond to distinct lows.

The general outline of the Hogem batholith was first documented in Geological Survey of Canada Memoirs 252 (Armstrong, 1949) and 274 (Roots, 1954). Armstrong mapped the southern 2 070 square kilometres of the batholith, the same area discussed in this report. Roots mapped the northern 1 035 square kilometres. Part of the northern section had been mapped previously and called the Omineca batholith in the McConnell Creek map-area (Lord, 1948). Most recently, the northern section of the Hogem has been mapped in more detail (Woodsworth, 1976). In all but the latter case, the mapping of the batholith was part of much larger regional mapping projects, and systematic documentation of Hogem intrusive variation was not attempted. Nevertheless, the detailed mapping which constitutes this study has altered the established outline of the southern part of this body only in minor detail, and many of the original observations made on the nature of the batholith have been confirmed.

SOUTHERN HOGEM BATHOLITH INTRUSIVE PHASES

The rocks of the southern Hogem batholith can be separated into three phases (Garnett, 1974c), in the sense that these 'intrusive phases' represent separate and distinct chapters in the igneous history of this region. Figure 2 illustrates the modal classification used for all Hogem intrusive rock nomenclature (I.U.G.S. Geological Newsletter, 1973) and the division of these rock types into three major phases. As well as the modal distinctions indicated, these phases can also be separated chemically and geochronologically.

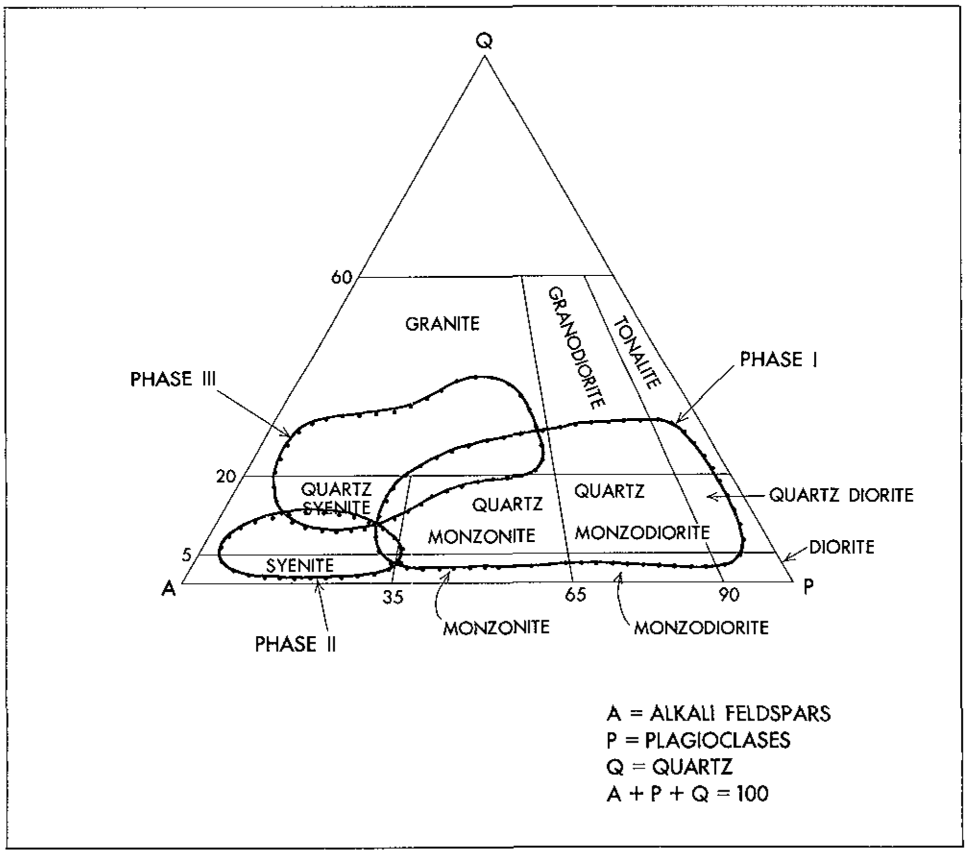


Figure 2. Hogem batholith intrusive phases in relation to general plutonic rock classification (after I.U.G.S., 1973).

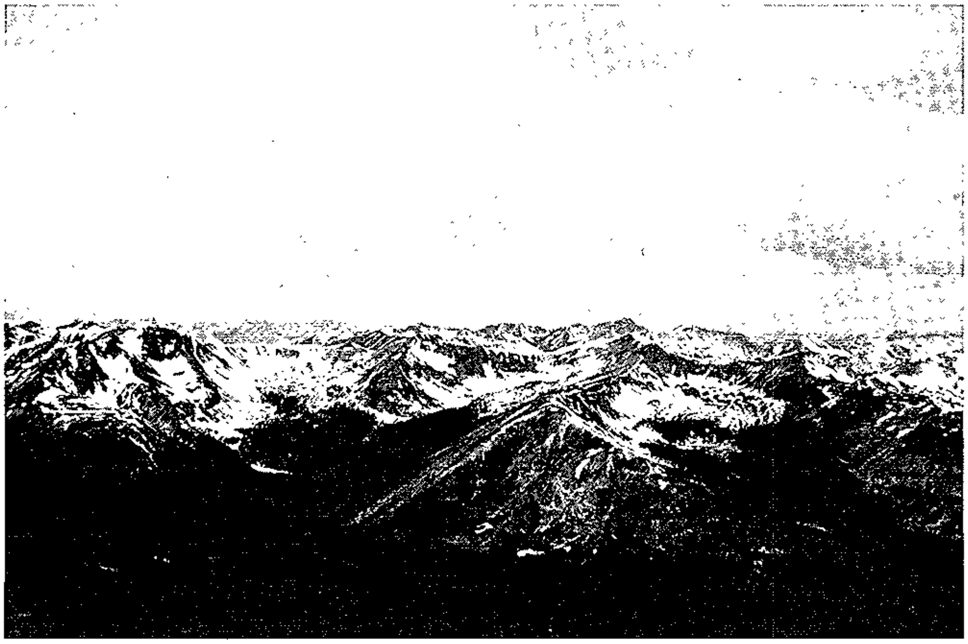


Plate IA. THE HOGEM BATHOLITH: looking west across the Duckling Creek Syenite Complex.

Plate IB. THE HOGEM BATHOLITH: the Swannell Range south of Kwanika Creek.

TABLE 1.
SOUTHERN HOGEM BATHOLITH: INTRUSIVE ROCK DIVISIONS

INTRUSIVE PHASES	PHASE DIVISIONS	UNIT	ROCK VARIETIES
PHASE III LOWER CRETACEOUS		9	LEUCOCRATIC GRANITE, Alaskite
PHASE II MIDDLE JURASSIC TO LOWER JURASSIC	CHUCHI SYENITE	8	LEUCOCRATIC SYENITE, Quartz Syenite
	DUCKLING CREEK SYENITE COMPLEX	7	LEUCOCRATIC SYENITE
		6	FOLIATED SYENITE
PHASE I LOWER JURASSIC TO UPPER TRIASSIC	HOGEM GRANODIORITE	5	GRANODIORITE, QUARTZ MONZONITE, minor Tonalite, Quartz Diorite, Quartz Monzonite, Granite
	HOGEM BASIC SUITE	4	MONZONITE to Quartz Monzonite
		3	MONZODIORITE to Quartz Monzodiorite
		2	NATION LAKES PLAGIOCLASE PORPHYRY (a) Monzonite (b) Monzodiorite
		1	DIORITE, minor Gabbro, Pyroxenite, Hornblendite

Table 1 shows the differentiation of intrusive rock types associated with the three phases. Figure 3 (in pocket) shows the detailed geology of the southern Hogem batholith. **Phase I** accounts for approximately two-thirds of all intrusive varieties mapped. This phase can be subdivided into two divisions, the **Hogem basic suite** and the **Hogem granodiorite,** each division accounting for approximately one-third of this part of the batholith.

The Hogem basic suite is the oldest intrusive division recognized and contains the compositional varieties pyroxenite, gabbro, diorite, monzodiorite, monzonite, and some of their more quartz-bearing equivalents. In general, this suite occupies the east and west borders of the southern half of the batholith.

The Hogem granodiorite is a distinctive leucocratic felsic division predominantly granodioritic in composition but also containing the rock varieties quartz monzodiorite, quartz monzonite, and, more rarely, quartz diorite, tonalite, and granite. In general, it occupies the central portion of the batholith within the study area.

The field relationships between the Hogem granodiorite and the Hogem basic suite are equivocal. Along the central axis of the batholith, granodiorites north of the Omineca

River grade into quartz monzodiorites to the south. Similarly, these quartz monzodiorites appear to grade into quartz monzonites and monzonites south of Kwanika Creek and in this sense, gradational changes can be traced from the basic division into the acidic division of Phase I. However, sharp contacts can be found between these two divisions as well. In the Mount Nation area north of Tchentlo Lake, Hogem granodiorite displays relatively sharp borders against monzodioritic varieties of the basic suite, and Stock (1974) has concluded that, in this area, monzodiorite was intruded by a chemically distinct granodioritic magma.

Phase II syenites clearly intrude Phase I rocks in two widely separated areas. North of the Omineca River, the northwesterly elongated **Duckling Creek Syenite Complex** cuts both Phase I divisions. This complex contains both intrusive and foliated migmatitic varieties of considerable compositional diversity. North of Chuchi Lake, the **Chuchi syenite** intrudes Phase I basic rocks, again along a narrow northwesterly trending belt. The Chuchi syenite is exclusively a leucocratic, granitic textured rock, with none of the complexity of its northern equivalent.

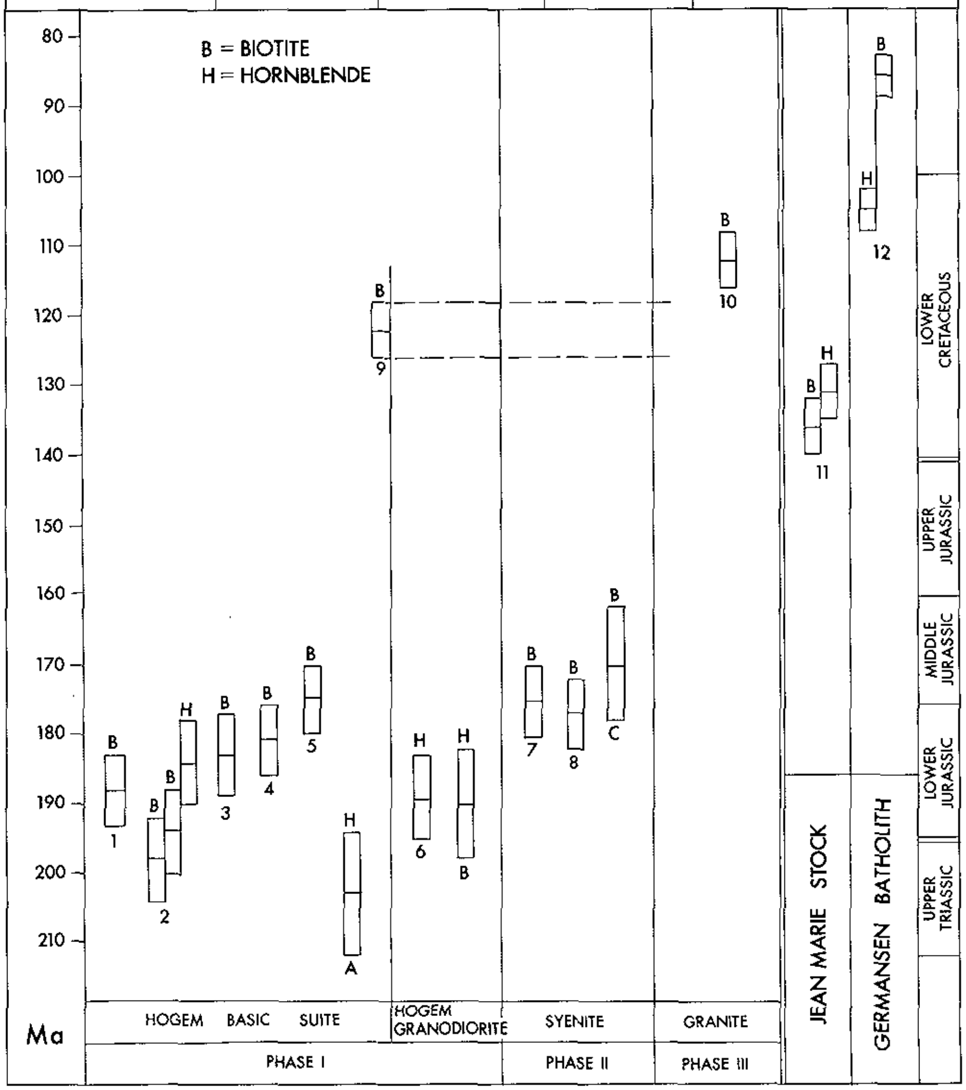
Phase III granites cut all other intrusive rocks in three main localities: west of Duckling Creek, south of Kwanika Creek, and in the Chuchi Mountain area. The main bodies of this phase are leucocratic to holofelsic, medium-grained granites, but locally there are pegmatitic varieties, and aplitic dykes are common as late crosscutting features throughout the map-area.

GEOCHRONOLOGY OF THE INTRUSIVE PHASES

Thirteen samples of southern Hogem intrusive rocks have been dated by the K/Ar method, and are illustrated on Figure 4. Twelve dates have been obtained from 10 representative bulk samples selected during the course of this study, and three dates have been incorporated from other sources. All samples reported were dated by the Geochronological Laboratory of the University of British Columbia, and analytical data, petrographic descriptions, and accurate locations of those collected during this study are compiled in Appendix I. Geographic locations of all dated samples are also shown on Figure 5 (in pocket). Samples 1 to 3 date varieties within the Phase I basic suite. Sample 6 dates Phase I granodiorite. Samples 7 and 8 date Phase II syenites. Sample 10 dates Phase III granite.

Sample 4 was taken from a Phase I monzonite porphyry, potash feldspathized by Phase III granitic intrusion in the Chuchi Mountain area. Sample 5 was taken from Phase I monzonites in close proximity to, and altered by, the Duckling Creek Syenite Complex. Sample 9 was taken from Phase I diorite in close proximity to dyking from an adjacent linear body of Phase III granite. These three specimens are interpreted as being reset to varying degrees by the intrusion of the younger phases.

SAMPLE NUMBER	FIELD NUMBER	K/Ar DATE (U B C)*	COLLECTOR	REMARKS
1	G - 73 - 25	188 ± 5	MMPR	BIOTITE
2	M - 73 - 100	184 ± 6	MMPR	HORNBLENDE
		194 ± 6	—	BROWN BIOTITE
		198 ± 6	—	BLACK BIOTITE
3	L - 73 - 90	183 ± 6	MMPR	BIOTITE
4	G - 72 - 36	181 ± 5	MMPR	BIOTITE, (RESET)
5	FOX - 13	175 ± 5	MMPR	BIOTITE, (RESET)
6	195 - 38	189 ± 6	MMPR	HORNBLENDE
7	LORRAINE	175 ± 5	MMPR	HORNBLENDE
8	COL - 12	177 ± 5	MMPR	BIOTITE
9	KWANIKA	121 ± 4	MMPR	PHLOGOPITE,(RESET)
10	G - 73 - 87	112 ± 4	MMPR	BIOTITE
11	G - 74 - 4	131 ± 4	MMPR	HORNBLENDE
		136 ± 4	—	BIOTITE
12	G - 74 - 1	86 ± 3	MMPR	BIOTITE,(RESET)
		106 ± 3	—	HORNBLENDE
A	-	203 ± 9	STOCK (1974)	HORNBLENDE
B	-	190 ± 8	STOCK (1974)	HORNBLENDE
C	-	170 ± 8	KOO (1968)	BIOTITE



*Complete analytical sample data in Appendix 1; sample locations 1-11 on Figure 5 (in pocket).

Figure 4. Radiometric dates, southern Hogem batholith and vicinity.

Phase I K/Ar dates fall within the limits 176 Ma to 212 Ma, a 36-Ma interval spanning the Late Triassic/Early Jurassic epochs. The six dates from the basic suite of this phase range over this entire interval, whereas the two dates from the Hogem granodiorite have narrower limits, 182 Ma to 198 Ma. Therefore, geochronologically, the granodiorites fall well within the Phase I limits, as defined. [Two dates from another study (Stock, 1974) are included in this interpretation.]

Phase II K/Ar dates fall within the limits 162 Ma to 182 Ma, a 20-Ma interval straddling the Early/Middle Jurassic boundary. Although there is an overlap in the age range of Phase I and Phase II, the syenites clearly intrude and alter Phase I rocks and are interpreted as a separate younger pulse. Sample 7 establishes a Middle Jurassic age for the Duckling Creek Syenite Complex. The Chuchi syenite has been established as equivalent in age to its more complex northern counterpart on the basis of sample 8.

The age of Phase III granites is based on the dating of one fresh sample (10) from the granitic body near Halobia Creek. The sample 9 date had been previously determined, and sample 10 was collected to test the suspicion that the previous date was a result of resetting due to this adjacent granite intrusion. This confirmation is considered to document an Early Cretaceous age for the emplacement of Phase III granite.

It has been suggested previously (Garnett, 1974c) that the first date published by the Geological Survey of Canada in the northern section of the batholith (122±6 Ma, Irvine, 1971) was probably also from a similar intrusion of Phase III granite into Phase I rocks. This suggestion has been confirmed by recent mapping and dating by Woodsworth (1976).

Armstrong (p. 77, 1949) believed that the Hogem batholith was Late Jurassic to Early Cretaceous in age, and speculated that the obviously younger Duckling Creek and Chuchi syenites might be Eocene or Oligocene in age. Roots (p. 187, 1954), grouping the Hogem within the Omineca intrusions of the Omineca and Cassiar Mountain ranges, bracketed their emplacement 'between late Triassic and late Cretaceous time, and probably between the late Jurassic and early Cretaceous time' (sic).

The first radiometric dating of the Hogem batholith was from the Duckling Creek Syenite Complex (170±8 Ma, Koo, 1967), but it was recorded in an unpublished thesis and was not widely known.

Consequently, when the Geological Survey of Canada published its first Hogem date (Irvine, 1971), it was reported that 'the age date is, to the writers knowledge, the first obtained from the Hogem Batholith. It falls within the range of the many dates available for the Cassiar Batholith, which lies to the north in the same tectonic belt.'

The systematic dating that followed these two isolated reports established that the bulk of Hogem rocks were emplaced in Late Triassic to Early Jurassic time. It confirmed Koo's dating by establishing the intrusion of syenite into Phase I rocks during a period encompassing the Early/Middle Jurassic boundary. After an intrusive hiatus covering the Middle and Late Jurassic periods, Phase I and II rocks were intruded by isolated granitic bodies of Early Cretaceous age.

Partially as a result of this dating, the concept of the Hogem and Cassiar batholiths occupying the same tectonic belt has been revised. Gabrielse and Reesor (1974) now group the Hogem batholith mainly within a belt of Upper Triassic/Lower Jurassic granitic rocks and associated volcanic rocks extending northwesterly along the eastern side of the Intermontane Belt. North of the Hogem, the belt appears to swing westerly into the eastern Coast Crystalline Belt. The Cassiar batholith has been placed within a separate Lower and Middle Cretaceous group of granitic rocks occurring in northern British Columbia along the western border of the adjacent Omineca Crystalline Belt. Because of the isolated Lower Cretaceous bodies distributed throughout the Hogem, a clear cut distinction between the two batholiths cannot be established. However, the absence of Late Jurassic intrusive activity suggested by the Hogem dates agrees with the lack of documentation of granitic rocks of this age in the northern cordillera shown in Gabrielse and Reesor's compilation.

Two other dates from intrusive rocks adjacent to the southern Hogem batholith were determined during this study and should be mentioned at this time. Mineral pair dates were obtained from a granodiorite in the Germansen batholith [106±3 Ma (hornblende); 86±3 Ma (biotite), Meade 1975]. Mineral pair dates were also obtained from the Jean Marie stock immediately south of the Hogem batholith, where a sample of fresh granodiorite yielded 136±4 Ma (biotite); 131±4 Ma (hornblende) (Garnett, 1974b). The Germansen dates indicate a time relationship of this batholith, at least in part, with the Phase III Hogem event. The Jean Marie dates suggest either a new intrusive event or an extension of the already documented Early Cretaceous event. In any case, it documents intrusive activity in this area similar in age to the Francois Lake intrusions of the Endako area.

These dates are completely documented in Appendix I.

PETROGRAPHY OF THE INTRUSIVE PHASES

During systematic traversing of the batholith, approximately 1 470 samples were slabbed, stained by hydrofluoric acid and sodium cobaltinitrite solution, and catalogued. Locations of all catalogued specimens are shown on Figure 5. Modal estimates were then recorded, and the calculated ratios of quartz, potassic, and plagioclase feldspar, along with identity and amount of mafic constituents, were combined to name each specimen based on the classification in Figure 2. Thin section investigation of representative specimens confirmed the field nomenclature and provided details of texture and more specific composition of constituents. Table 1 represents the final amalgamation of petrographic divisions, units, and rock varieties, determined using this technique.

Plate IIA. Reconnaissance geological mapping north of Haha Creek.

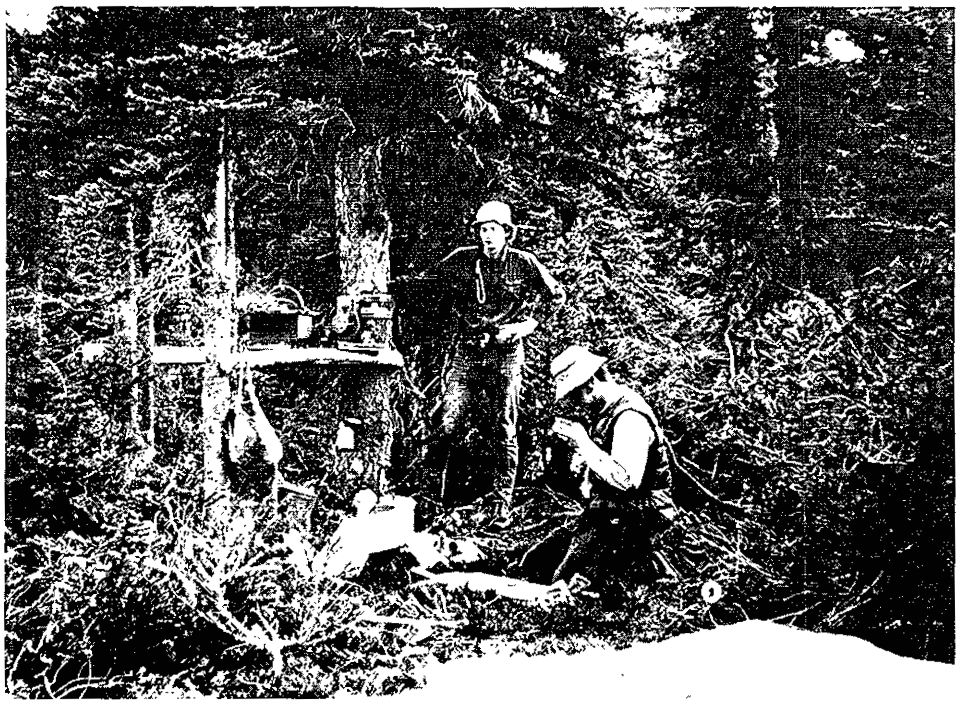


Plate IIB. Portable rock slabbing and staining apparatus, Chuchi Mountain camp.

PHASE I INTRUSIVE ROCKS

HOGEM BASIC SUITE

Unit 1 – Diorite: Unit 1 diorites occur along the eastern and western border of the batholith at various localities throughout the map-area. These rocks are dark grey, medium to coarse grained, and generally have hypidiomorphic granular textures, although they do exhibit flow foliation and mafic streaking close to the batholithic border. Unit 1 rocks contain more than 50 per cent euhedral to subhedral plagioclase which ranges in composition from An_{40} to An_{60}. On this basis, some specimens may be better named gabbro. Orthoclase and quartz are minor interstitial components. Mafic content, dominantly clinopyroxene, is typically greater than 30 per cent. In fresh specimens, biotite is a common associate, but in many cases, alteration is well developed, and hornblende rimming pyroxene is common. Uralite is a common alteration product along with pervasive saussuritization of plagioclase. Magnetite may amount to 5 per cent, thus accounting for the strong magnetic character of the unit. Sphene, apatite, epidote, and chlorite are common accessories.

In the Mount Nation area, local irregular pods of pyroxenite and hornblendite are present in Unit 1. These pods are coarse grained to pegmatitic in texture, and are composed of 90 per cent pyroxene and/or hornblende and up to 10 per cent magnetite.

In the Duckling Creek area, sill-like lenses of pyroxenite occur within basic rocks bordering the Duckling Creek Syenite Complex, and both are enveloped by syenite in some cases. The pyroxenites are black, medium-grained rocks containing up to 90 per cent euhedral clinopyroxene, with accessory biotite, magnetite, and interstitial plagioclase. The Duckling Creek pyroxenites are not differentiated on Figure 3, but have been documented in more detailed reports elsewhere (Garnett, 1972a, 1973; Wilkinson *et al.*, 1976). Within the Complex, porphyroblasts of potash feldspar are present, and there is an increase in biotite content and interstitial orthoclase.

Unit 2 – Nation Lakes Plagioclase Porphyry: The Nation Lakes plagioclase porphyry occurs in the vicinity of Tchentlo and Chuchi Lakes. It is distinguished texturally from other units of the Hogem basic suite by the recognition in hand specimens of diagnostic euhedral plagioclase phenocrysts from 2 to 5 centimetres in long dimension. The laths of plagioclase are enveloped in a vitreous matrix of orthoclase. These rocks range in composition from monzodiorite to monzonite. The porphyritic character which distinguishes this unit from Units 1 and 3 is gradational, and the diffuse boundaries are arbitrarily designated.

Plagioclase is typically twinned and ranges in composition from An_{35} to An_{55}. Some specimens show pervasive sericitization of plagioclase, especially close to boundaries with other units. Mafic minerals constitute from 15 to 30 per cent of these rocks. Clinopyroxene is the dominant mafic with biotite varying from an equally abundant to a minor associate. Amphibole (commonly hornblende) is generally only an accessory constituent, but locally may replace clinopyroxene as the dominant mafic. Uralitization of pyroxene is present in the more altered specimens. Magnetite is a ubiquitous accessory, imparting the moderate to strong magnetic character diagnostic of this unit. In the vicinity of the Chuchi syenite body, rocks of this unit have increased potash feldspar content, which has been interpreted as potash metasomatism due to the younger syenite intrusion.

Units 3 and 4 — Monzodiorite to Monzonite: Monzodiorite (Unit 3) and monzonite (Unit 4) and related quartz-bearing varieties are gradational between the more basic units and the granodiorites of Unit 5. In general, these units occur between the basic borders of the batholith and its granodioritic core.

In both units, euhedral and subhedral plagioclase laths are enveloped in an anhedral matrix of orthoclase and quartz. Quartz content ranges from trace to greater than 5 per cent. Plagioclase is commonly twinned, occasionally zoned, and has a compositional range between An_{35} and An_{45}. Although variations in mafic content are not diagnostic, the dominant mafic mineral in Unit 3 is clinopyroxene, commonly accompanied by biotite. Uralite is present in altered specimens, and hornblende is generally a minor constituent. In Unit 4, hornblende is the dominant mafic mineral, generally accompanied by biotite. Clinopyroxene is rare. Sphene, apatite, and magnetite are common accessories in both units.

HOGEM GRANODIORITE (UNIT 5)

The Hogem granodiorite is a formal name for a group of distinctive leucocratic, quartz-bearing felsic rock varieties which occupy the central axis of the southern Hogem batholith. All Unit 5 rock specimens in the cluster analysis on Figure 10 fall within a restricted range of chemical composition. This chemical similarity is also demonstrated on Figures 6 and 9. For purposes of documentation, the type locality is situated on the main ridge immediately west of Duckling Creek (specimen 109, Fig. 5). Chemical analysis of this specimen is shown in Appendix II and a representative K/Ar date for this specimen is given in Appendix I (Field No. 195-38 — CUESTA). The rocks in this locality are granodiorites representing the median composition of the Hogem granodiorite. Throughout the southern Hogem batholith, granodiorite and quartz monzodiorite are the predominant Unit 5 varieties, but locally, tonalite, quartz diorite, quartz monzonite, and granite are present. Rocks of this unit are light grey, medium to coarse grained, and are generally hypidiomorphic granular in texture, although large areas of microcline porphyry are present and a primary foliation due to feldspar alignment is locally prominent. Euhedral to subhedral, zoned, and twinned plagioclase (An_{34-45}) constitutes 50 to 60 per cent of the rock, with orthoclase and microcline-perthite forming 15 to 20 per cent either as phenocrysts or subhedral grains. Hornblende is the dominant mafic constituent making up approximately 20 per cent of all specimens examined and biotite occurs in amounts ranging from 5 per cent to accessory. Quartz is a ubiquitous interstitial mineral, ranging from 10 to over 20 per cent of the volume of all specimens. Sphene and apatite are very common accessories. Another common diagnostic feature is the presence, locally, of grey, fine-grained, fibrous xenoliths exhibiting sharp to diffuse boundaries with the enveloping material. Alteration is not extensive in this unit, but epidote, chlorite, and sericite are common minor accessories.

SUMMARY

Phase I of the southern Hogem batholith represents the major intrusive event in this area. In a regional sense, the Hogem basic suite forms an envelope around a felsic core of Hogem granodiorite. In more detail, this zoning is complicated by the later intrusions, and in certain areas along the eastern margin, granodiorite is in direct contact with Takla volcanic rocks. However, a combination of aeromagnetic data and the existence of basic outliers suggests that, in general, there is a basic border, in places with shallow volcanic rock cover, along both the eastern and western margins. The zoned nature of the Hogem batholith was first suggested by Armstrong (p. 98, 1949) and will be discussed further in this report.

Although extensive petrographic analysis was not attempted, preliminary conclusions are that Units 1 through 5 show a progressive range of plagioclase compositions from calcic to sodic, and a progressive change in mafic composition from predominantly clinopyroxene with minor biotite in the most basic varieties of Unit 1 to predominantly hornblende with minor biotite in Unit 5.

PHASE II SYENITES

DUCKLING CREEK SYENITE COMPLEX (UNITS 6 AND 7)

The Duckling Creek Syenite Complex displays a roughly elliptical shape trending northwest across the northern part of the map-area. Rocks of the complex vary considerably in grain size, texture, mafic content, and specific mineralogy, but can be subdivided into two main units: dark grey to pink, fine to medium-grained, foliated syenite (Unit 6) and pink leucocratic syenite, varying in texture from aplitic to pegmatitic, with potash feldspar porphyries common (Unit 7).

In both units, microcline/perthite amounts to 50 to 80 per cent of all rocks. Plagioclase (generally An_{10-20}) ranges from 5 to 30 per cent. Clinopyroxene is the dominant mafic forming 5 to 40 per cent of the specimens investigated. Biotite and hornblende are present in amounts up to 5 per cent in some specimens. Apatite, sphene, magnetite, and garnet are common accessories.

The Duckling Creek Syenite Complex intrudes rocks of the Hogem basic suite and envelopes lenses of pyroxenite. The intrusion of Unit 6 syenite through these pyroxenite remnants, and the presence of stringers and dykelets of Unit 6 syenite cutting both these varieties, import a streaky 'migmatitic' appearance to many specimens. This migmatite defines zones of strong northwesterly trending foliation within the Unit 6 syenite. Rocks best described as amphibole/biotite/potash feldspar gneisses and schists are enveloped within the migmatite zones. A more detailed description and interpretation of Unit 6 and these associated lenses of possible paragneiss have been published previously (Garnett, 1972a, 1973). Intrusion of Unit 6 syenite into the bordering Phase I basic rocks produced an orange-bleached, potash-enriched hybrid zone. Pervasive potash feldspathization and sericitization of plagioclases are easily recognized in thin sections of these contact rocks. Similar alteration zones can also be recognized adjacent to Unit 7 and 8 syenites. Further petrographic studies of this complex have been the subject of two University of British Columbia undergraduate theses (Harivel, 1971; Meade, 1972) and one Master's thesis (Koo, 1968).

CHUCHI SYENITE (UNIT 8)

The Chuchi syenite occurs as an elongated mass trending northwesterly from the flanks of Chuchi Mountain to the Klawli River. Its contact zone with the Nation Lakes plagioclase porphyry (Unit 2) is poorly exposed and not well defined along most of its length, and although it could be interpreted as gradational on a regional scale, it is more likely due to potash metasomatism of Unit 2 rocks. The best documentation of a separate syenite intrusion can be seen in the Klawli River area, where numerous leucocratic syenite dykes crosscut Unit 2 monzonites.

In places the contact zone between Units 8 and 9 also appears gradational. Based on sporadic sampling across this poorly exposed zone, there is a possibility of a gradation from syenite to quartz syenite to granite. However, it is considered that any apparent gradation is again due to contact effects. There has been no dating to confirm the Cretaceous age for Unit 9 in this area.

Unit 8 shows none of the variability of its Duckling Creek counterpart. The rocks are pink, fine to medium grained, allotriomorphic granular with euhedral, twinned plagioclase laths, subordinate to interstitial and subhedral orthoclase and microcline-perthite. Clinopyroxene, biotite, and minor hornblende are the dominant mafic minerals, with accessory apatite.

PHASE III GRANITE (UNIT 9)

Intrusive masses of granite and alaskite occur in the following localities: Chuchi Mountain, southeast of Ahdatay Lake, south of Kwanika Creek, and west of the headwaters of Duckling Creek; alaskitic and aplitic dykes are common throughout the southern Hogem batholith. These rocks are pink to orange, fine to medium grained with

Plate IIIA. Steeply dipping rhythmic banding in syenites north of Haha Creek.

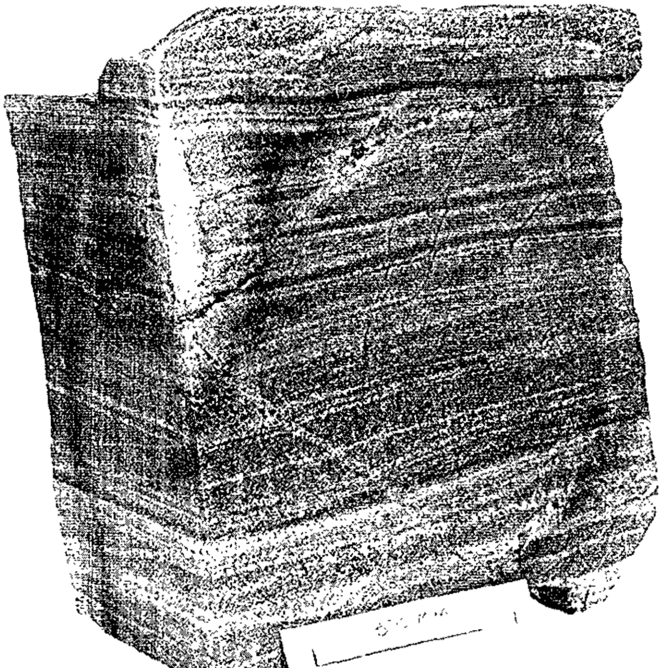


Plate IIIB. Slab of banded syenite (paragneiss ?) from above locality.

occasional miarolitic cavities, leucocratic to holofelsic, with microcline-perthite and quartz making up 90 per cent of their volume. Mafic content is always less than 15 per cent and is mainly biotite with minor hornblende. Sphene and apatite are common accessories and sericite and calcite are common alteration minerals. Some specimens show incipient cataclastic strain features and broken feldspar laths.

SILICATE CHEMISTRY OF HOGEM AND TAKLA ROCKS

One hundred and twenty-nine representative samples were chosen from the 1 470 samples catalogued during this study, and were analysed for the following oxides: SiO_2, Al_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, MnO, FeO, Fe_2O_3, P_2O_5, H_2O+, H_2O-, CO_2, S, BaO, SrO. The complete analyses and details of the methods of analysis used are contained in Appendix II. One hundred and eight of these samples represent Hogem intrusive varieties, whereas 21 were selected from Takla volcanic rocks adjacent to the batholith. With respect to intrusive samples, only fresh, equigranular varieties determined as typical of the main rock types by detailed field and laboratory-oriented procedures (slabbing, staining, point counting, petrography) were selected. With respect to volcanic samples, only fresh, mainly equigranular rocks showing no noticeable contact effects were selected.

Figure 6 is a silica versus total alkalis plot of 108 Hogem intrusive rocks. The dividing line separating alkaline from sub-alkaline chemical fields is from Irvine and Baragar (1971). The plots differentiate Phase I Hogem basic suite, Phase I Hogem granodiorite, Phase II syenite, and Phase III granite. Phase I basic rocks fall close to the dividing line and predominantly in the alkaline field wereas Phase I granodiorite plots completely in the sub-alkaline field, again close to the dividing line. Phase II syenites plot high in the alkaline field, and Phase III granites cluster in the high silica sub-alkaline field.

The data presented on Figure 6 requires further discussion. The trends exhibited can be interpreted as demonstrating a bifurcation in the intermediate range of the Hogem basic suite. Within the alkaline field, the basic suite trends directly into the Phase II syenite, whereas it also appears to trend into the Hogem granodiorite in the sub-alkaline domain. This sub-alkaline trend could also be interpreted as continuing into the Phase III granite domain as well. With respect to Phase III, the clearly separated Early Cretaceous ages (Fig. 4) and the predominant crosscutting field relationships exhibited by these granitic rocks clarify a separate and distinct Phase III intrusive relationship.

The decision to separate the syenites into a distinct phase was based initially on their observed predominance of crosscutting features relative to Phase I rocks. As previously discussed, Figure 6 offers no decisive evidence, and, although radiometric dates for Phase II syenites show younger average ages than most Phase I samples, there is an overlap that could be interpreted as representing a uniform differentiation sequence (Fig. 4). The author admits that a chemical argument can be presented for one continuous differentiation trend into the syenite field, but endorses a separate, younger syenite phase on the basis of unequivocal field observations. Such observations not only include the *numerous readily identifiable textural, mineralogical, and contact characteristics* previously outlined (p. 26), but is also based on the unique metallic mineral association of chalcopyrite and bornite with the two geographically isolated syenite bodies. Further, it is felt that the radiometric dates do confirm a younger age for the syenites, and that the chemical separation of these phases is obscured by the sampling of some hybrid rocks of original Phase I affinity that were contaminated by the documented pervasive metasomatism accompanying Phase II syenite intrusion.

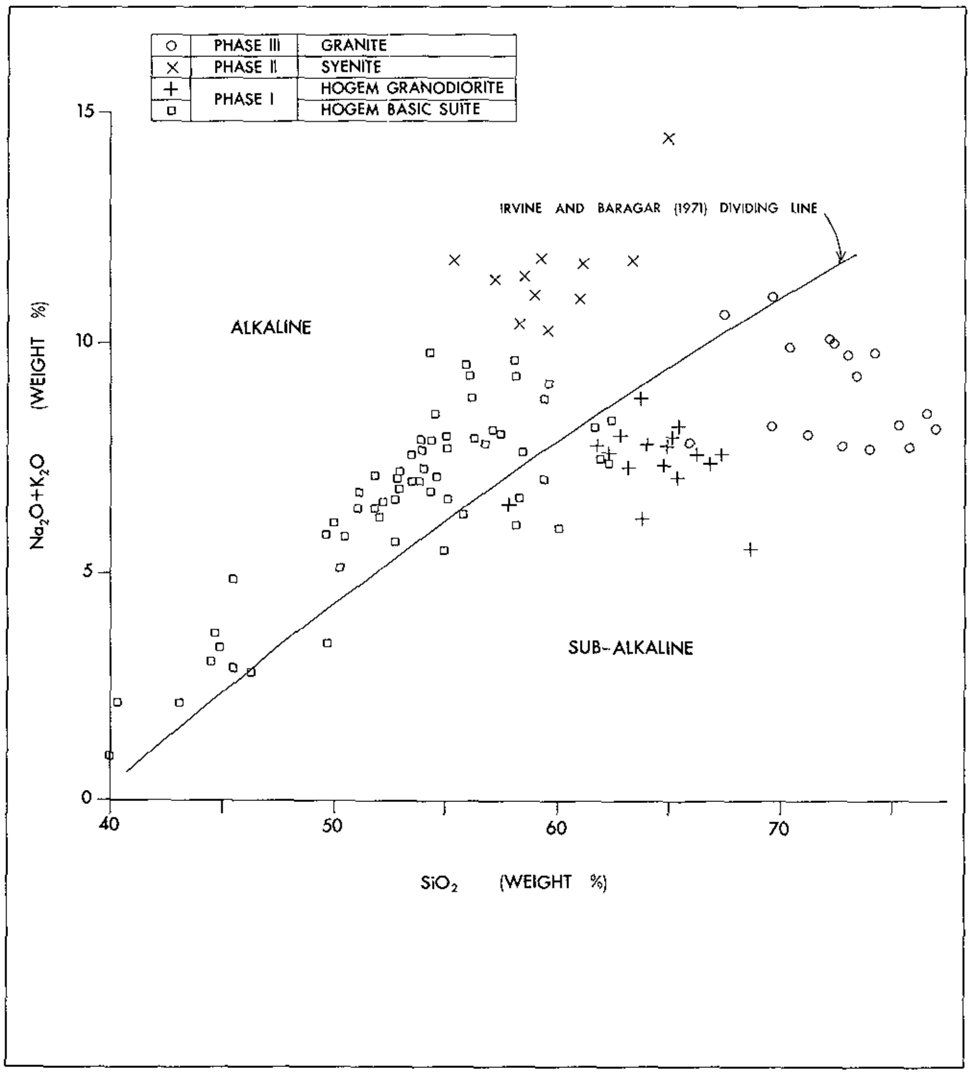


Figure 6. Silica/total alkalis plot, southern Hogem intrusive rocks.

Figure 7 is a similar plot of 21 Takla volcanic rocks. Although a more random distribution is evident, the majority of these rocks fall within the alkaline field close to the dividing line and parallel to the trend of the Phase I intrusive rocks.

Figure 8 is a triaxial plot designed to illustrate the fields of variation of the most common volcanic rocks (Church, 1975); the oxide ratios defined as the orthogonal axes of this plot were calculated for the Takla volcanic rock samples. Figure 9 is a modification of this plot to illustrate fields of variation for equivalent common plutonic rocks.

Some liberties must be taken in such a modification, since there is no simple direct correlation between Church's original volcanic variation diagram and the plutonic domain. The most obvious example is the andesite field, which is a broader domain chemically than its simplistically considered plutonic counterpart, diorite. Therefore, the andesite field has been converted to a diorite/monzonite equivalent for illustrative

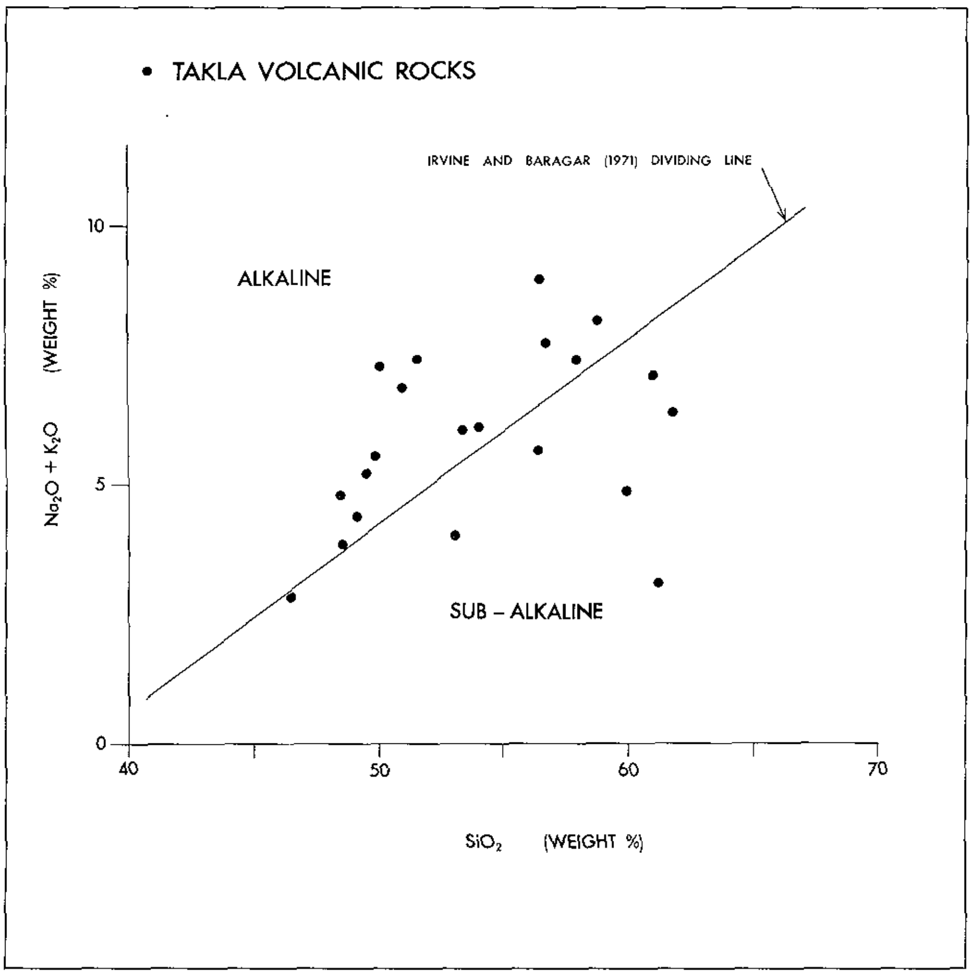


Figure 7. Silica/total alkalis plot, Takla volcanic rocks near the southern Hogem batholith.

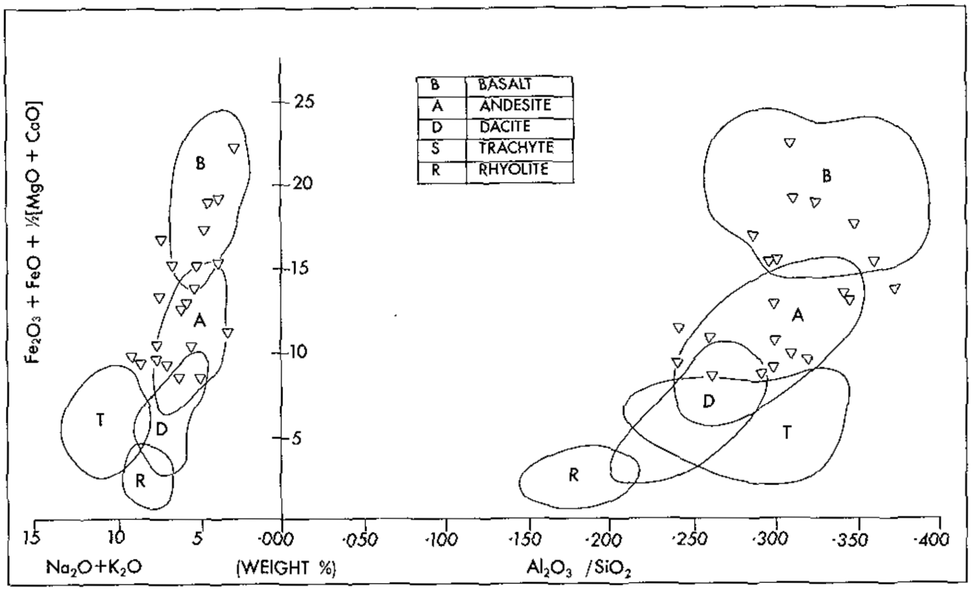


Figure 8. Triaxial plot showing fields of variation of the most common volcanic rocks in relation to chemical variation of Takla volcanic rocks near Hogem contact (after Church, 1975).

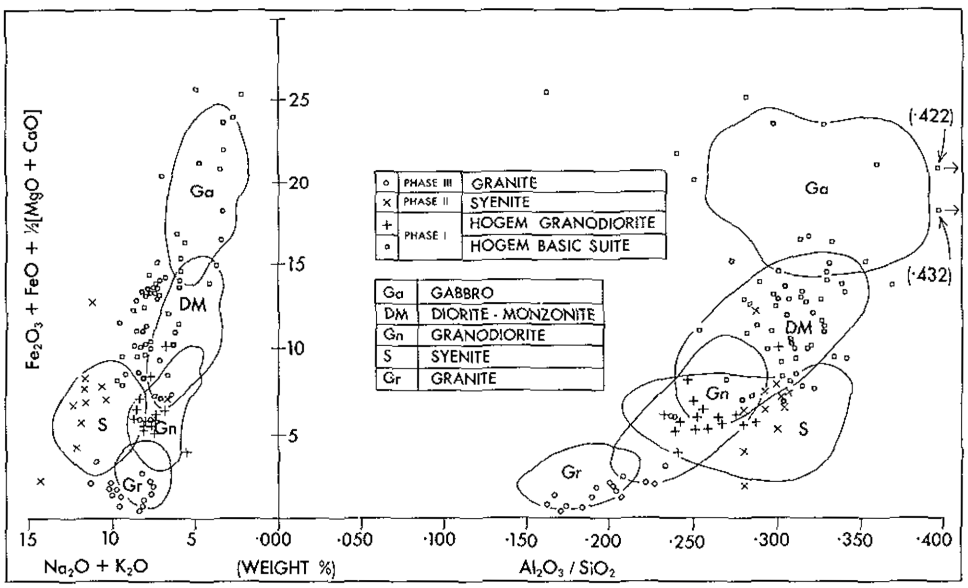


Figure 9. Triaxial plot showing fields of variation of equivalent common plutonic rocks in relation to chemical variation of Hogem intrusive rocks (modified after Church, 1975).

purposes, recognizing that volcanic/plutonic equivalence is far more complex than implied by the modifications shown on Figure 9. However, it is felt that there is some value in comparing these plots, and some tentative conclusions are drawn as a result.

(1) Volcanic rocks plot along the same trend exhibited by the Phase I intrusive varieties.

(2) Comparing Figures 8 and 9, there are no volcanic equivalents plotted to match either the later syenitic (trachyte) or granitic (rhyolite) phases, whereas there is a direct equivalence documented in the gabbro (basalt), diorite to monzonite (andesite), and granodiorite (dacite) fields, all representative of the initial major intrusive phase of the Hogem batholith in this area. Additional corroborative evidence of this relationship is discussed in the next section.

In evaluating these observations, it must be reiterated that all volcanic specimens analysed were collected adjacent to the batholith. However, a more representative sampling of volcanic rocks between the Germansen and Hogem batholiths was conducted by Meade, and his identical plots of volcanic rocks of the Takla Group (1976, figure 5, p. 52 and figure 11, p. 59) reinforce this author's conclusion that there are no corresponding volcanic equivalents to the Phase II syenite or the Phase III granite fields in this area.

In general, Meade concludes that the basic batholithic rocks (gabbro, diorite, monzodiorite, monzonite, and syenite), which he designates as 'the Alkalic Suite of Late Triassic to Early Jurassic Age,' are comagmatic with alkali basalts and trachyandesite lavas of the Takla Group. Meade's Alkalic Suite compares in part with this report's Phase I rocks, but this author has delineated the syenites as a distinct and separate intrusive event (Phase II). Granodiorites and quartz monzodiorites designated by Meade as 'the Granitic Suite of Early Jurassic age' are considered by him to be comagmatic with porphyritic andesites of the Takla Group. This intrusive suite can be directly compared to the author's Phase I Hogem granodiorite. Meade's 'Cretaceous Granitic Suite' compares directly to the author's Phase III granite, and he does state that 'there are no apparent extrusive equivalents of [his] Cretaceous Granitic Suite' (p. 154). In this author's opinion, there is an equally apparent absence of extrusive equivalents of the syenitic rocks of the 'Alkalic Suite of Late Triassic to Early Jurassic Age.'

STATISTICAL (CLUSTER) ANALYSIS OF HOGEM AND TAKLA ROCKS

Eleven of the 17 analysed oxides (SiO_2, Al_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, MnO, FeO, Fe_2O_3, P_2O_5) were chosen as variables, and all 129 samples were then subjected to this unbiased form of correlation analysis. The procedure for cluster analysis is described

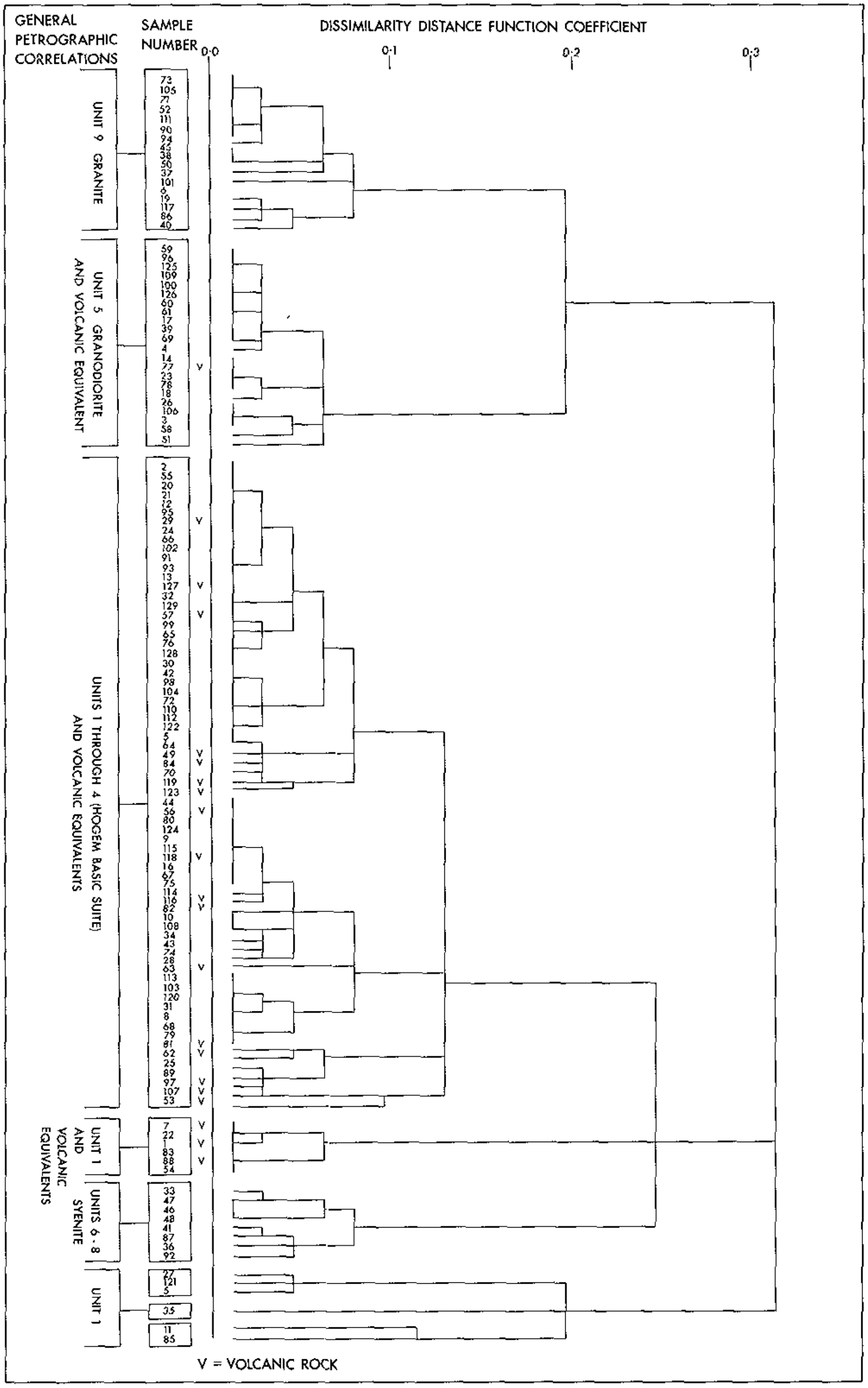


Figure 10. Cluster analysis dendogram of intrusive and volcanic rocks, southern Hogem batholith.

in detail by Parks (1966, 1970) and a computerized program was set up in this Division by A. F. Bowman. An R-mode principal components analysis is performed on the matrix of correlation coefficients and distance function values. In simpler terms, each sample is compared on a pair by pair basis with all other samples. Factors are statistically determined to represent most of the total variance within the sample population (three factors cumulatively representing 90 per cent in this particular analysis).

The final result is a print-out dendrogram clustering the samples in groups according to similarities, these groups being joined in broad associations by an array of stems and lateral connecting bars (Fig. 10). The differences between the groups correspond to the relative lengths of the stems, long stems indicating large differences. The abscissa on the dendrogram is the value of the distance function, ranging from 0.0 (complete similarity) to +1.0 (complete dissimilarity).

As indicated to the left of the dendrogram, this unbiased sorting of the raw oxide data clearly separated the rocks of the three intrusive phases into chemically distinct domains. The Hogem basic suite and its volcanic equivalents represent the largest clustered domain, and the one with the highest internal degree of dissimilarity, as might be expected. Attempts were made to further separate the rock varieties within this suite, but chemical dissimilarities were apparently not significant enough to allow further definition by cluster analysis.

It must also be pointed out that cluster analysis statistically separated the Hogem granodiorite (Unit 5) from all other units, including the synchronous Hogem basic suite. The equivocal field relationships between Units 4 and 5 have been discussed previously (*see* p. 17). This statistical separation tends to support Stock's (1974) interpretation of a chemically distinct granodioritic magma.

The cluster analysis, combined with the previously discussed petrographic, radiometric, and chemical studies, clearly documents the composite nature of the Hogem batholith. Three and possibly four partial plutons of varying chemical compositions are indicated: Hogem basic suite, (Hogem granodiorite), Phase II syenite, and Phase III granite. Although there are occasional discrepancies between field and petrographic determinations and chemically clustered domains, these were surprisingly rare, and in very positive terms, the cluster analysis chemically and statistically confirmed the generally established field nomenclature.

All 21 volcanic samples are clustered within the Phase I units (20 with Units 1 through 4 and 1 with Unit 5). Therefore, statistical analysis confirmed the previously documented singular chemical affinity between the volcanic rocks adjacent to the Hogem batholith and the intrusive varieties associated with its oldest and most dominant phase.

Plate IV. The Omineca River valley cutting through the Hogem batholith; the deserted settlement of Old Hogem in middle ground.

THREE–DIMENSIONAL GRAVITY MODEL OF THE SOUTHERN HOGEM BATHOLITH

During the summer of 1972, C. A. Ager, as part of a University of British Columbia Ph.D. thesis project partially supported by this Ministry (Ager, 1974), conducted a gravity survey in conjunction with the field mapping of the central portion of the batholith. Three east/west traverses were completed across terrain underlain respectively by Cache Creek Group rocks, Pinchi fault zone, Hogem batholith, and Takla volcanic rocks (Fig. 11). Four hundred and ninety-five gravity observations were taken at 0.4-kilometre (0.25-mile) intervals. Both four-wheel drive and helicopter access were used.

Simultaneously, 750 representative samples were selected from outcrops along and around the survey routes, and their bulk densities were measured directly. Based on these measurements, the following major divisions were determined by Ager:

(1) Cache Creek rocks – $\rho = 2.67$ g/cm^3
(2) Takla volcanic rocks – $\rho = 2.87 - 2.92$ g/cm^3
(3) Hogem batholith
   (a) syenitic units – $\rho = 2.57 - 2.58$ g/cm^3
   (b) granitic units – $\rho = 2.62 - 2.63$ g/cm^3
   (c) dioritic units – $\rho = 2.80 - 2.85$ g/cm^3

ρ = mean density

Sophisticated computer analysis combining geological, density, and aeromagnetic data produced an initial surface division of the batholith and adjacent rocks into separate density units (Fig. 12). Three-dimensional modelling was limited to the three profiles where specific density data was available, allowing suitable fit calculations between surface density subdivisions and the vertical component of the gravitational effect. The suggested models along the three gravity profiles are reproduced in Figure 13 (Profiles AA′, BB′, CC′).

Ager's thesis suggested the following three-dimensional interpretation:

(1) The Hogem batholith has a funnel-like gross shape across its central section.
(2) The Pinchi fault, which bounds the batholith to the west, dips 40 degrees toward the west-southwest (250 degrees).
(3) In general, the batholith maintains the established basic fringe, felsic core zonation at depth. Gravity data also indicates that, in part, the eastern basic fringe is buried under a thin layer of volcanic rocks.
(4) The entire mass of the central portion of the Hogem batholith appears to be tilted about 5 to 10 degrees toward the west-southwest.
(5) Less dense (Cache Creek ?) rocks appear to underlie Takla volcanic rocks along the eastern fringe of the batholith.

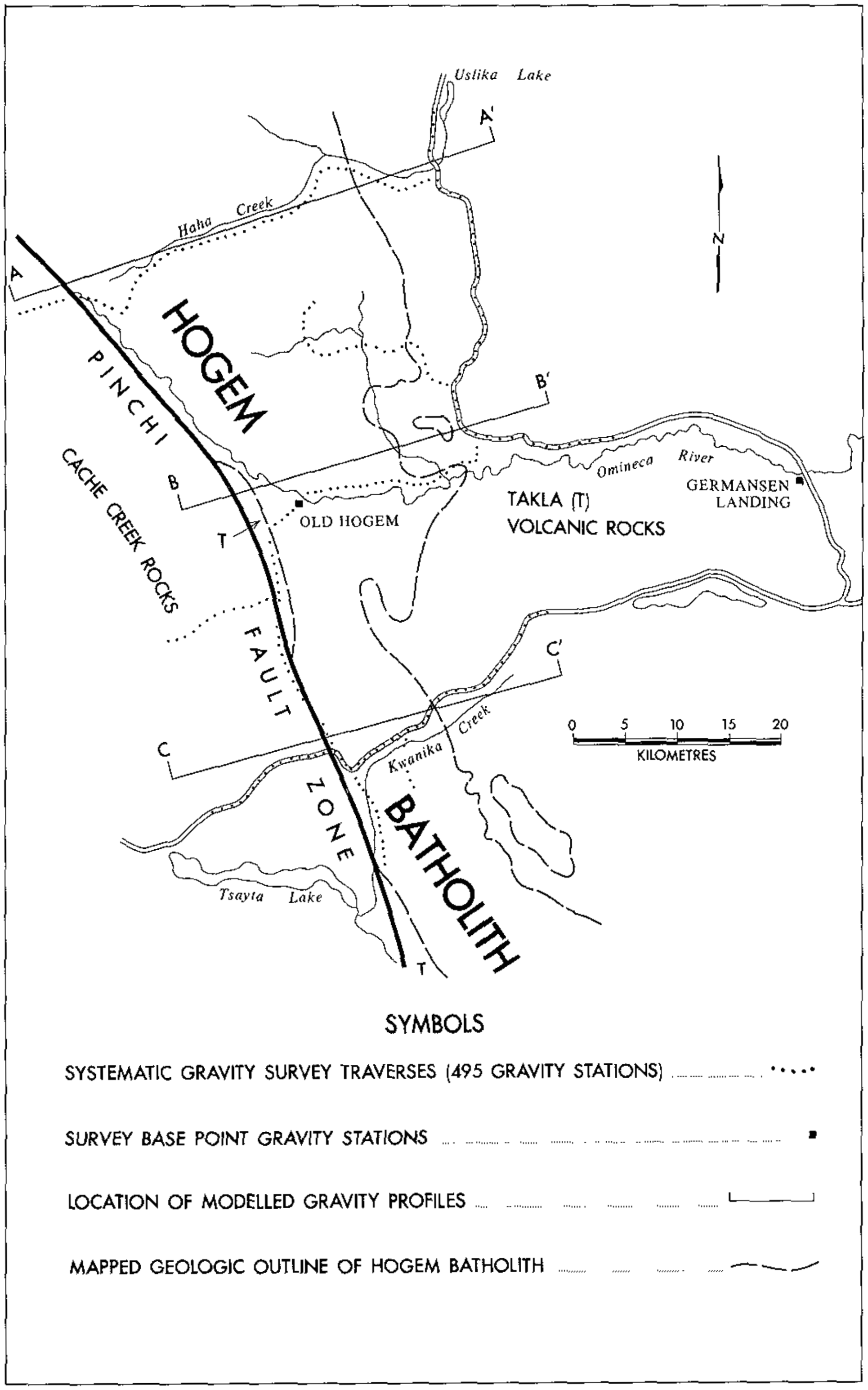


Figure 11. Gravity survey traverses and profile locations, southern Hogem batholith.

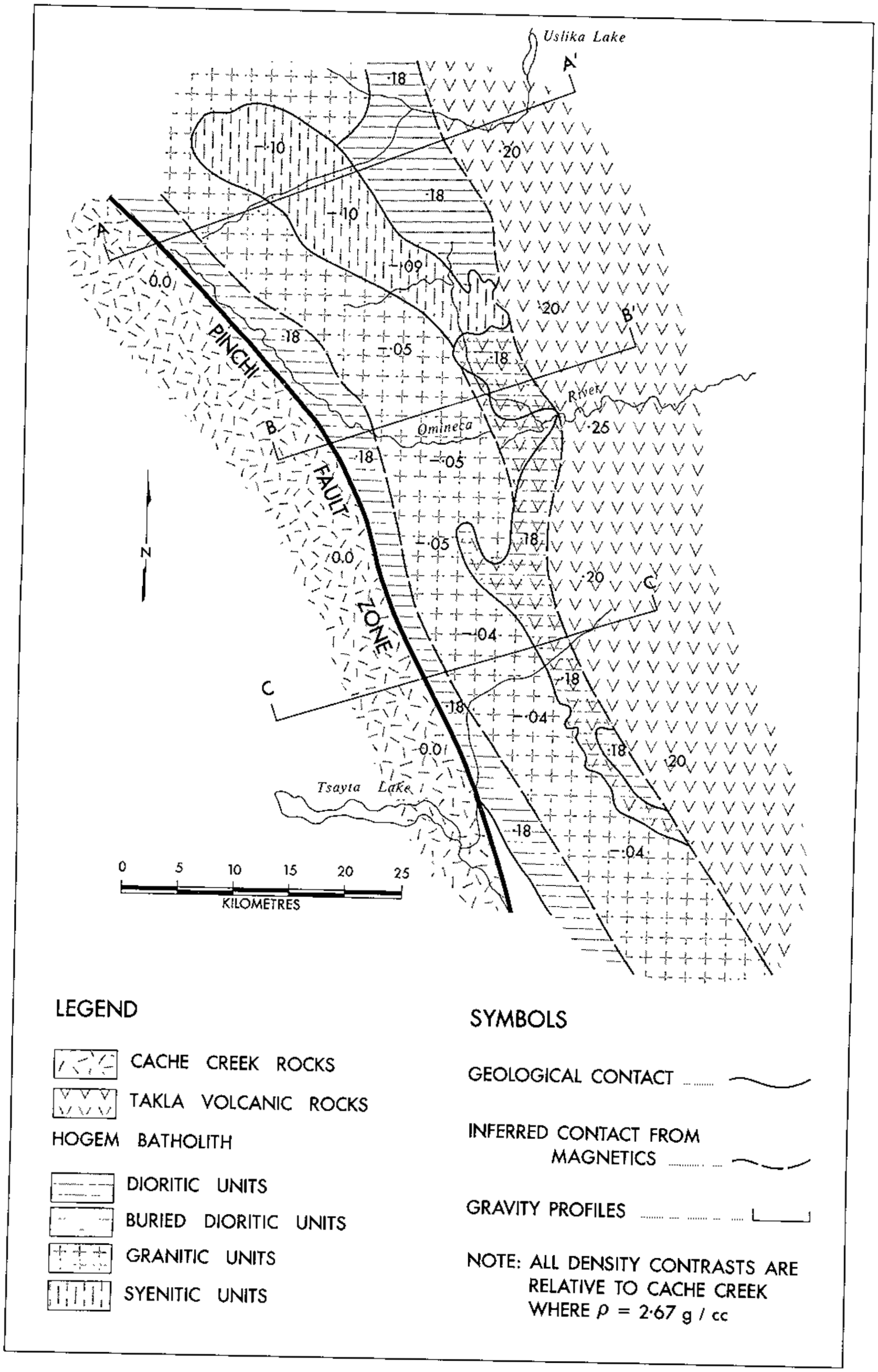


Figure 12. Density subdivisions of Hogem and adjoining rocks (from Ager, 1974).

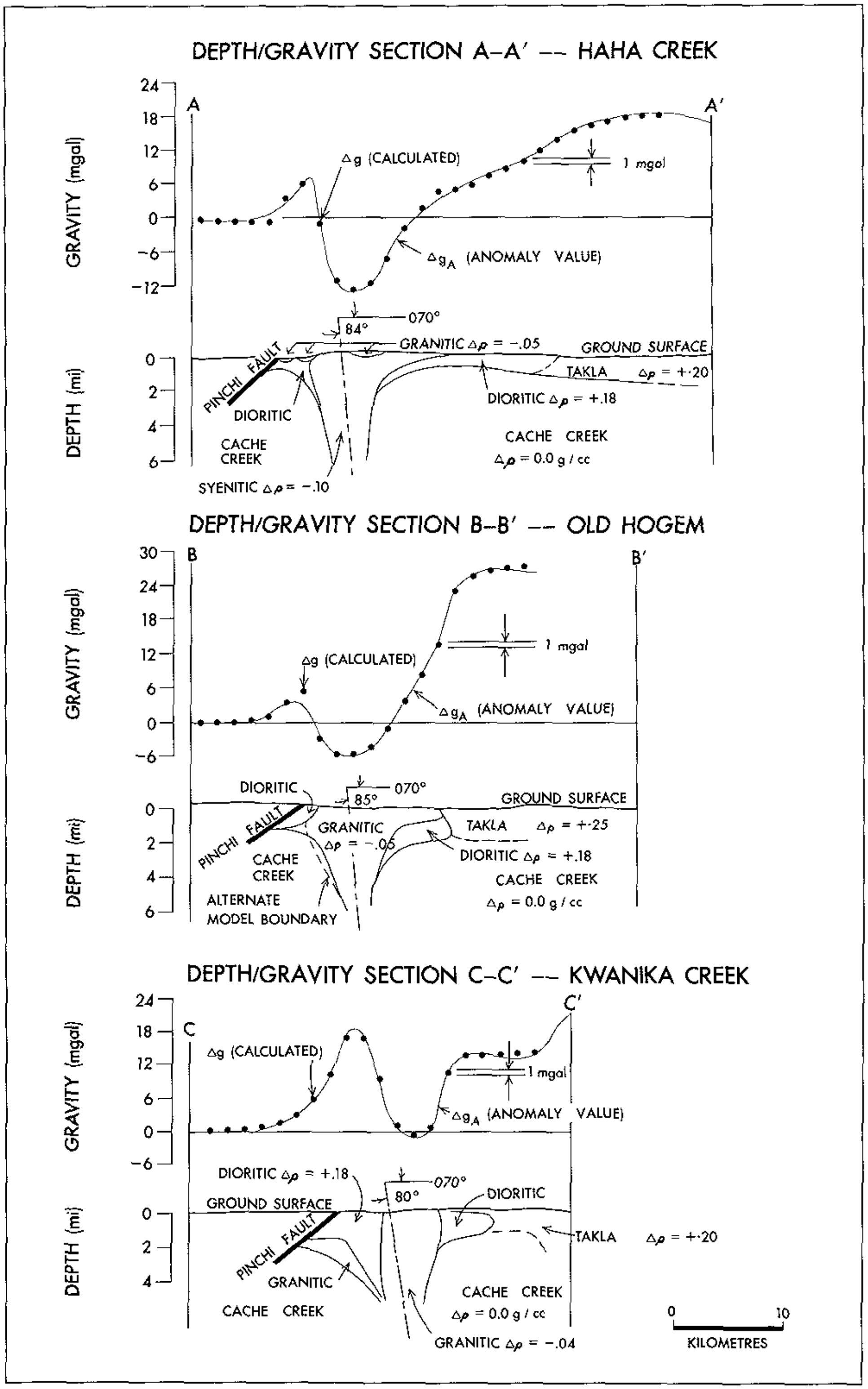


Figure 13. Gravity profiles and models of the Hogem batholith (from Ager, 1974).

ECONOMIC MINERALIZATION

The Hogem batholith has attracted considerable mineral exploration over the years, beginning with the influx of prospectors into the Omineca placer gold fields in 1868. Many mineral occurrences associated with the batholith were discovered over the ensuing period. The success of large, low-grade mineral deposits developed in the Guichon batholith during the 1960's led to a renewed interest in the potential of the similarly aged Hogem. Consequently, during the period of this study (1970–75), numerous mining companies were actively investigating this area. These investigations consisted of systematic helicopter-supported reconnaissance surveys and re-evaluation and additional development of known occurrences. Although several interesting prospects were determined, no major ore deposits have yet been established within the batholith.

As part of this study, most of the known mineral occurrences of the southern Hogem batholith were investigated. Numerous of these occurrences were reported in more or less detail in the annual publications *Geology, Exploration and Mining in British Columbia, 1972, 1973, 1974.* All known occurrences are located and identified by British Columbia Mineral Inventory Numbers on Figure 5 (in pocket).

Although no detailed metallogenic study was conducted by the author, a clear field relationship was established between the intrusive phases defined and certain types of mineralization. The most significant mineralization is associated with Phases 6 to 9 and will be discussed in detail in the following sections. Minor chalcopyrite mineralization occurs in association with mafic constituents and magnetite within Units 1, 2, and 3 of the Hogem basic suite and locally within dykes and volcanic rocks along the commonly pyritized Takla/Hogem contact. Accessory molybdenite is sometimes associated with these Phase I occurrences. Although some pyrite is encountered locally within the Unit 5 Hogem granodiorite, this unit is essentially barren of economic mineralization.

COPPER IN SYENITES

Copper (chalcopyrite, bornite, chalcocite, malachite, minor pyrite) is spatially associated with Phase II syenitic rocks and their related potash feldspar alteration zones. The majority of known copper occurrences in the southern Hogem batholith are clustered within or near the Duckling Creek Syenite Complex (Unit 6). To a lesser extent, similar copper occurrences have also been documented in the immediate vicinity of the Chuchi syenite (Unit 8). In all cases, sulphides occur as disseminations within migmatitic and/or foliated portions of syenite and in potash feldspar-rich dykes, stringers, and fracture fillings cutting adjacent intrusive and volcanic rocks. Minor gold values are commonly associated with this mineralization.

The significant occurrences of this type within the Duckling Creek Syenite Complex have been described previously (Garnett, 1971). The major known prospects are listed below,

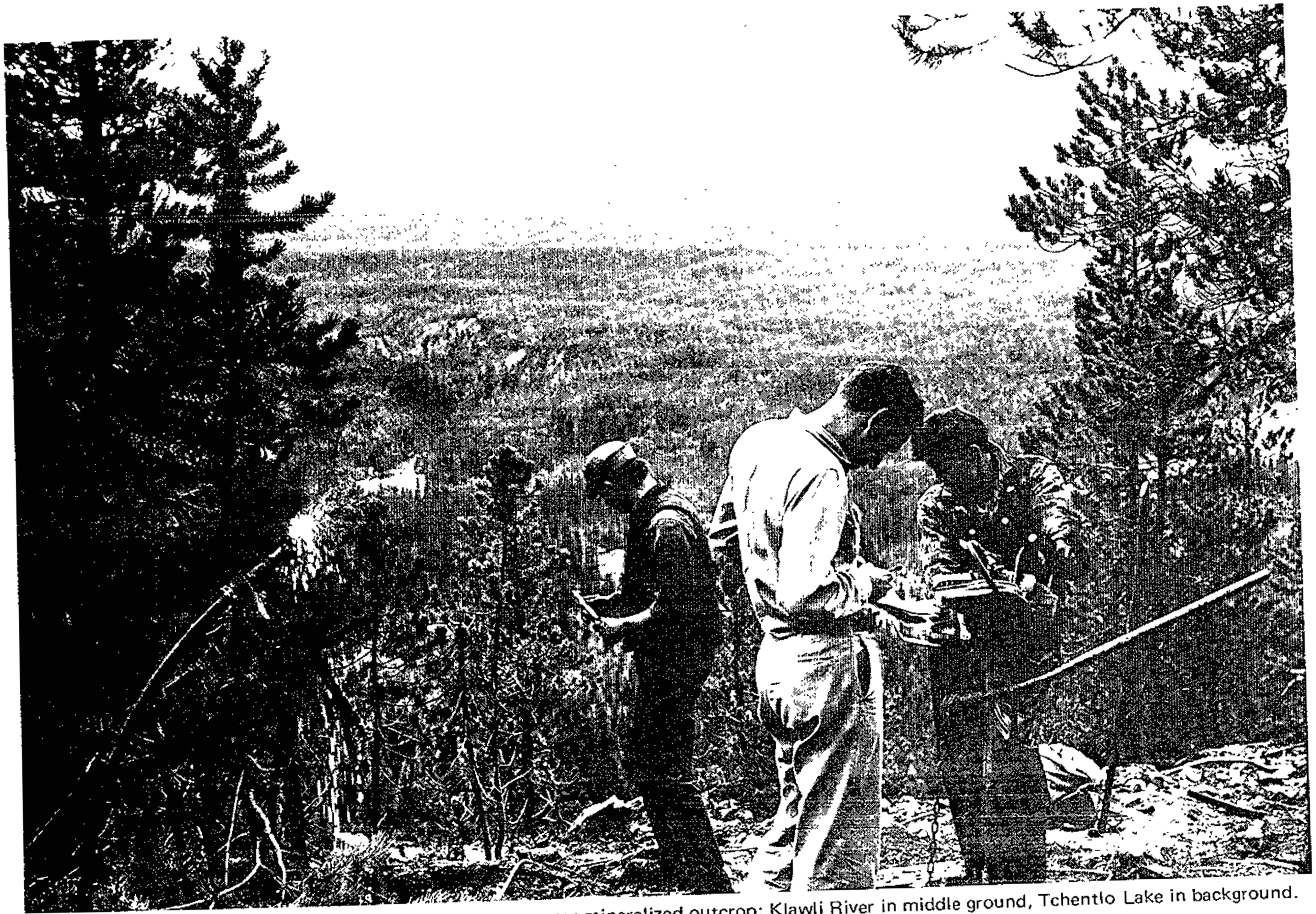


Plate V. COL: geologist and drill crew working on a copper mineralized outcrop; Klawli River in middle ground, Tchentlo Lake in background.

and revised versions of previously published descriptions of the first two are reproduced here for reference.

(1) **LORRAINE**; Duckling Creek Syenite Complex; Garnett, 1972a, 1973; Wilkinson *et al.*, 1976

(2) **TAM, REM**; Duckling Creek Syenite Complex; Garnett 1972a, 1974a

(3) **COL**; Chuchi syenite; GEM, 1972

LORRAINE, LORREX (MI 93N-2)

LOCATION: Lat. 55° 55′ Long. 125° 27′ (93N/14W)
OMINECA M.D. Thirty-five miles northeast of Germansen Landing, 2.5 miles north of the headwaters of Duckling Creek, at approximately 5,500 feet elevation (Fig. 14).

CLAIMS: LORRAINE 1 to 12, LORREX 1 and 2, GK 1 to 112, LORRAINE 1 to 3 Fractions.

OWNER: Kennco Explorations, (Western) Limited.

OPERATOR: THE GRANBY MINING COMPANY LIMITED, 2000, 1055 West Hastings Street, Vancouver.

METAL: Copper.

DESCRIPTION:

HISTORY: The malachite-stained cliffs of the Lorraine property are the most visible and best known indication of copper mineralization in the Duckling Creek area. Its presence was known for many years by local Indians, and was shown to prospectors during World War I. Claims were located by The Consolidated Mining and Smelting

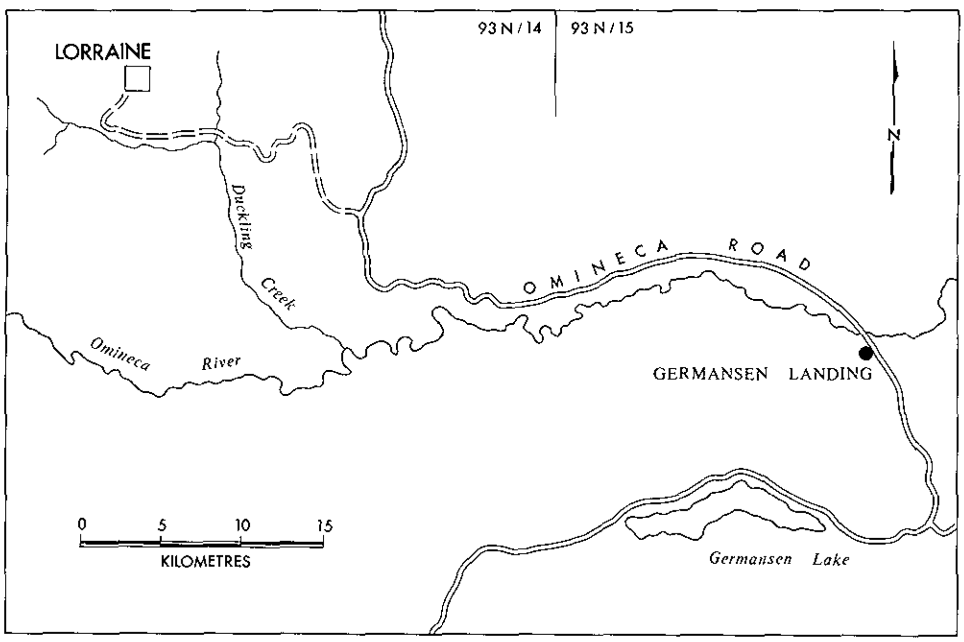


Figure 14. Lorraine property, general location.

Company of Canada, Limited in 1943. In 1947, Kennco Explorations, (Western) Limited again located claims on the showings and have worked intermittently on the property since that time. In 1970, The Granby Mining Company Limited obtained an option on the Lorraine from Kennco, and conducted detailed geological mapping, extensive trenching, and diamond and percussion drilling on the ore zone over the period 1970–1974. Numerous descriptions of this occurrence have been published (Armstrong, 1949; Black, 1949; Koo, 1968; Garnett, 1971). During the field season of 1973, the writer, assisted by H. D. Meade and D. V. Lefebure, mapped the Lorraine property in detail.

A comprehensive property description of this deposit was completed in 1976 (Wilkinson *et al.*) in which the indicated potential reserves for an 'Upper Zone' deposit were stated as 4.5 million tonnes grading 0.75 per cent copper and 0.34 ppm gold and for a 'Lower Zone' deposit as 5.5 million tonnes grading 0.6 per cent copper and 0.10 ppm gold. These estimates were based on a cutoff grade of 0.4 per cent copper.

DETAILED GEOLOGY: The Lorraine property lies mainly within the Duckling Creek Syenite Complex. All three intrusive phases documented on the regional scale are represented within the area of the Lorraine property shown on Figure 15 (in pocket). Monzonites and diorites of the Hogem basic suite occur in the north half of the area. These basic rocks contain clinopyroxene as their dominant mafic constituent, with minor amounts of hornblende and biotite. Quartz, apatite, sphene, and magnetite are common accessories. In this vicinity, there are numerous orange patches evident within these outherwise fresh grey-black, medium-grained, hypidiomorphic textured rocks. This 'bleaching' increases near the border with the syenite migmatite, and is attributed to potash metasomatism caused by the later syenite intrusion.

Biotite pyroxenites occur as irregular pods and lenses within the basic rocks There is no similar occurrence of pyroxenite known elsewhere within the southern Hogem batholith, and its abundance in this particular zone is one of the major problems in unravelling the total intrusive evolution of this area. Field evidence indicates that pyroxenite lenses have shallow to moderately inclined dip directions north and south of the main ridges, occupying the main part of the cirque floors. Along the central ridge area, however, and especially in the mineralized zone, pyroxenite lenses parallel well-defined steep migmatitic foliations. The pyroxenites within the basic rocks contain euhedral crystals of clinopyroxene and lesser biotite enclosed by interstitial plagioclase. Within the syenite migmatites, pyroxenite lenses have similar textures, but the interstitial material is K-feldspar. In both cases, these rocks appear to have intrusive, cumulative textures.

The pyroxenite porphyries are mainly mafic-rich borders enveloping pyroxenites, exhibiting coarse porphyroblastic clusters of K-feldspar in a matrix of pyroxene and biotite with interstitial orthoclase. One tentative explanation is that pyroxenite represents sill-like cumulate lenses which developed within the differentiating Hogem basic suite in

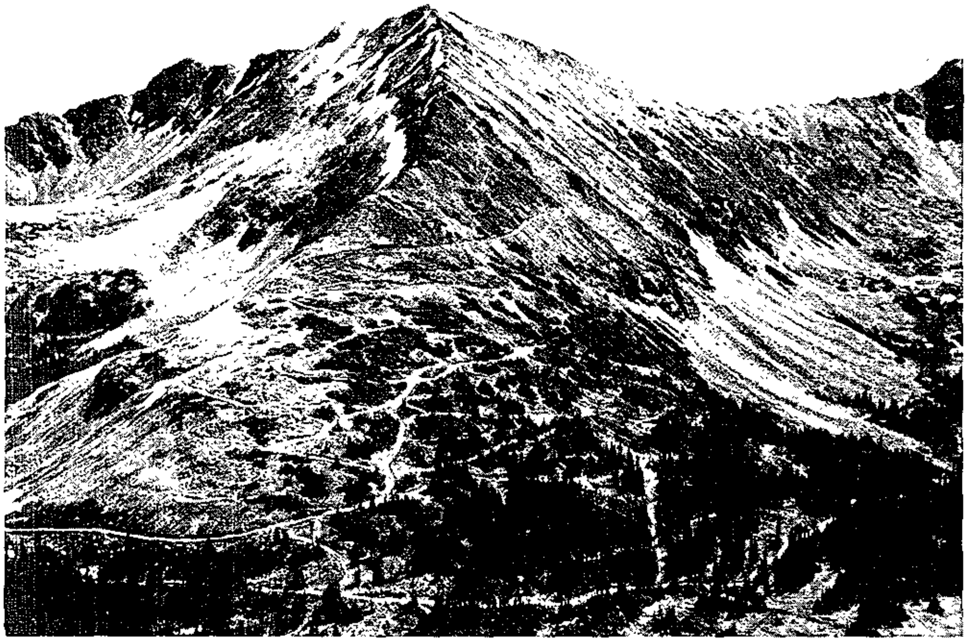


Plate VIA. LORRAINE: looking southeast along core of the deposit; lower mineralized zone is in main area of roads, trenches; upper mineralized zone axis roughly parallels cirque ridge.

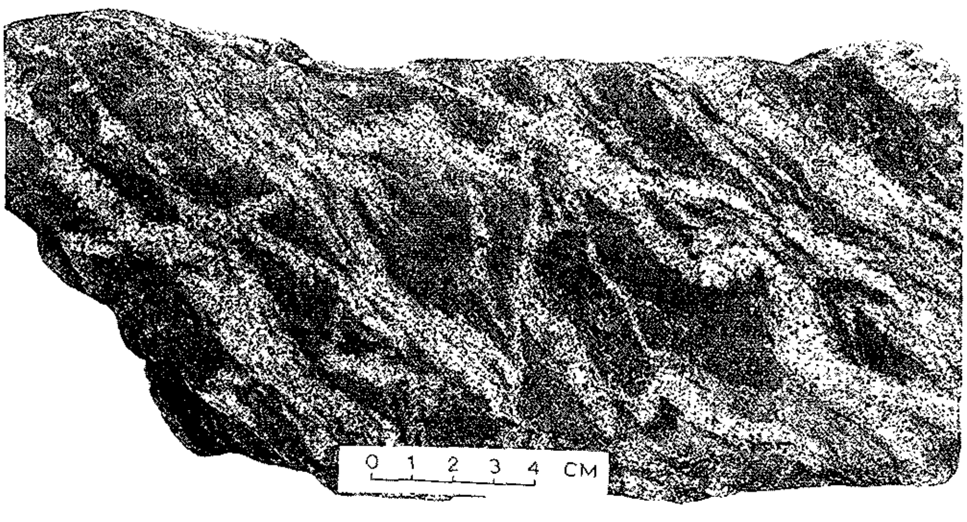


Plate VIB. LORRAINE: syenite migmatite from lower mineralized zone; light areas are pink syenite dykelets, dark areas are fine-grained biotite, pyroxene-rich mafic zones; chalcopyrite and bornite are finely disseminated throughout.

this area (*see* Harivel, 1972), and acted as porous sponges that were easily metasomatized by invading syenite magma, in part creating the K-feldspar pyroxenite porphyries.

There is much variation within the Duckling Creek Syenite Complex, ranging from pink, leucocratic, intrusive textured syenite, to dark grey foliated gneiss. Plate VIB shows the migmatitic character of much of this unit, and the best mineralized sections are in the more mafic portions of similar rocks. The intrusive appearance of parts of this unit suggests that syenite magma intruded and metasomatized a body of layered monzonite/diorite and pyroxenite. Orthoclase, microcline, and perthite are the major felsic constituents with minor twinned plagioclase usually present. In the mafic sections, biotite and clinopyroxene are most common, with accessory amphibole, apatite, sphene, and magnetite. Garnets occur locally as accessory constituents, commonly in light grey migmatites.

All the previously described units are cut by fresh holofelsic syenite dykes and sills, having textures varying from pegmatitic to aplitic. These rocks clearly document a second pulse of syenite intrusion and, although there is rare chalcopyrite associated with this event, by far the bulk of the mineralization is spatially related to the earlier migmatites.

Fresh pink holofelsic granites are common in the vicinity of the Lorraine deposit. These dykes have north to northeasterly trends and may be controlled by the similarly oriented fracture pattern indicated on Figure 16. These fine to medium-grained dykes cut all previous units, but in some localities, dykes with granite cores grade into coarse-grained syenitic borders.

Light grey plagioclase feldspar porphyry dykes appear to be the last pulse of intrusive activity in this area. Minor chalcopyrite mineralization is associated with similar dykes cutting monzonites on the high ridges immediately north of the map-area.

Some of the foliated rocks noted regionally within the Duckling Creek syenite body are schistose and paragneissic in appearance, and suggest that some remnants of pre-existing metasedimentary or volcaniclastic material may be included within the migmatitic complex. Although no compelling evidence for intrusion of 'basement' rocks was noted within this map-area, it still remains a possibility based on evidence elsewhere within the complex (Garnett, 1971).

Three steeply dipping fracture patterns can be distinguished on Figure 16. The strongest pattern is at about 105 degrees and documents the youngest fracture system, crosscutting both the northeast-trending dykes and fractures. These fractures (from 050 degrees to 075 degrees) represent the second strongest fracture set while a weaker maxima occurs at 000 degrees, dipping 60 to 70 degrees to the east.

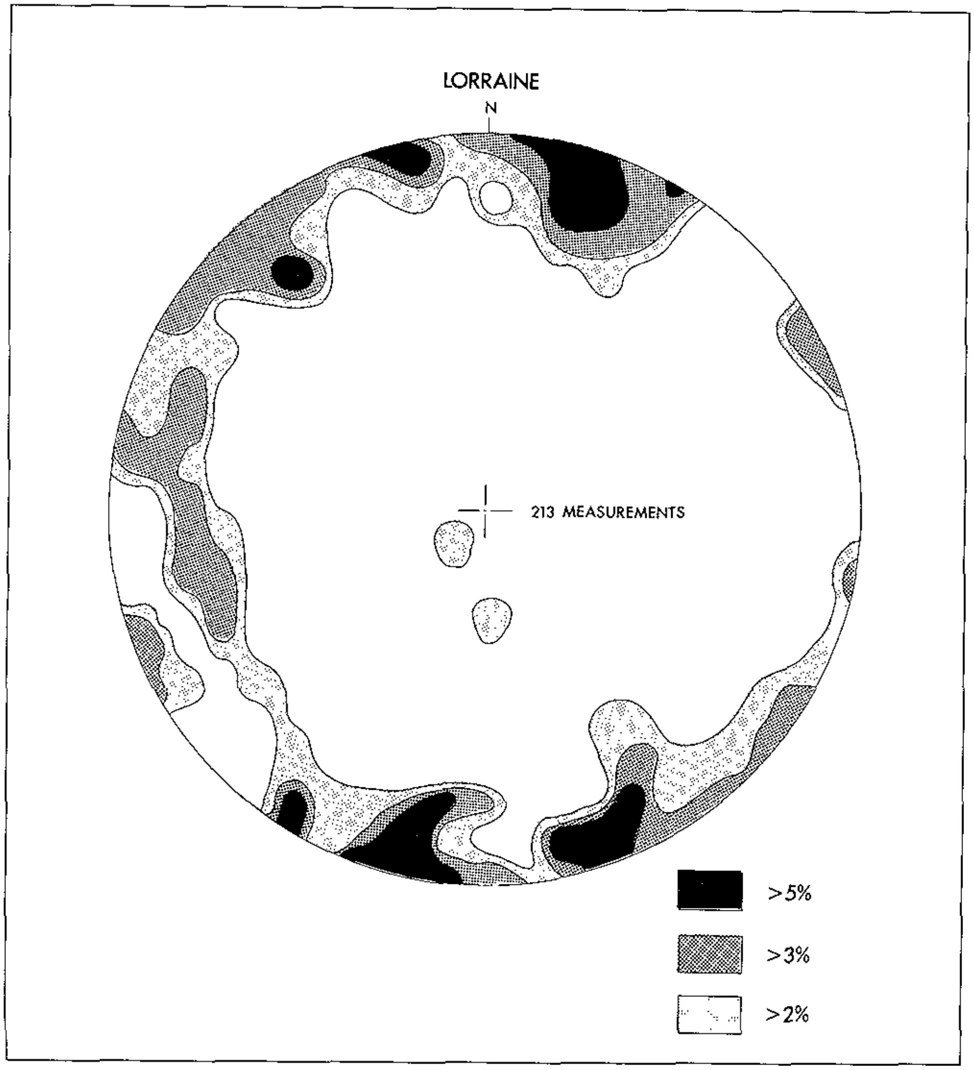


Figure 16. Lorraine and vicinity, poles to measured joints.

Faults have been determined by a combination of airphoto interpretation and brecciation noted during mapping. Numerous highly fractured zones are apparent, especially within the trenched area of the main mineralized zone. The majority of slickensides noted in such localities show shallow dip orientations.

MINERALIZATION AND ALTERATION: The best mineralized sections within the Lorraine orebody have several common criteria.

(1) They occur within the foliated syenitic migmatites.

(2) They occur mainly in the mafic-rich portions of the migmatites.

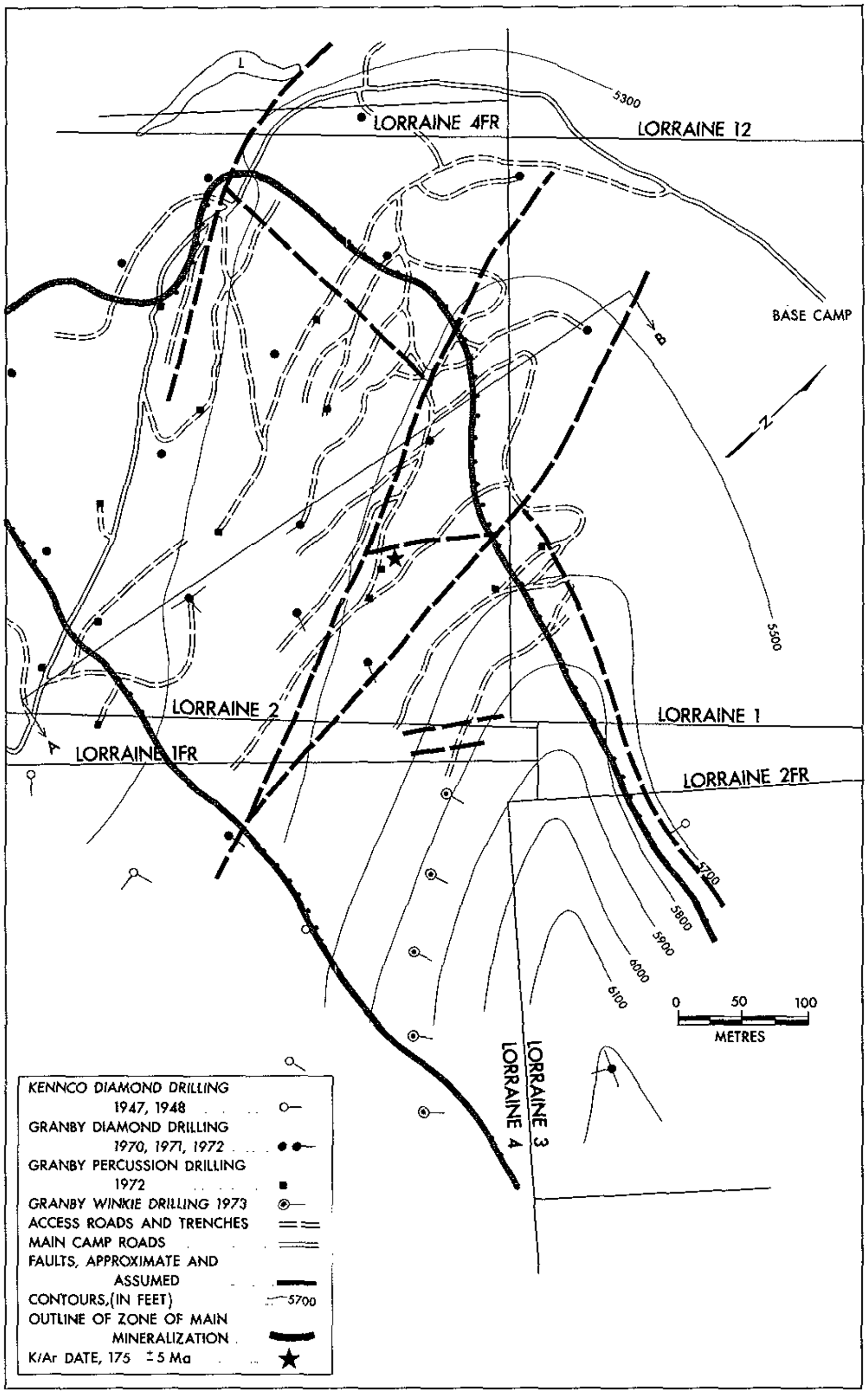


Figure 17. Lorraine, drill sites and trenching, main mineralized zones.

(3) Mineralization within these zones is predominantly disseminated chalcopyrite and bornite, although veinlets and fracture fillings of these primary sulphides are occasionally present.

(4) The significant mineralization is associated with intense secondary biotite and chlorite growth, pervasive potash feldspathization and sericitization of all feldspars, and the presence of accessory epidote and magnetite.

A symmetrical mineral zonation around this orebody has been previously described (Koo, 1968), but the present mapping was not able to confirm any such uniform pattern. Rusty pyritized areas occur within the northeast periphery of the migmatite, but no clear pyrite halo has been mapped. Although some mineral zonation is present within local mineralized zones ranging from bornite-rich cores to pyrite/chalcopyrite peripheries, the predominance of magnetite over pyrite and the presence of bornite on this property indicates a sulphur-poor mineralizing environment. The mineralized sections appear as lenses erratically distributed through otherwise identically appearing, poorly mineralized syenitic migmatites.

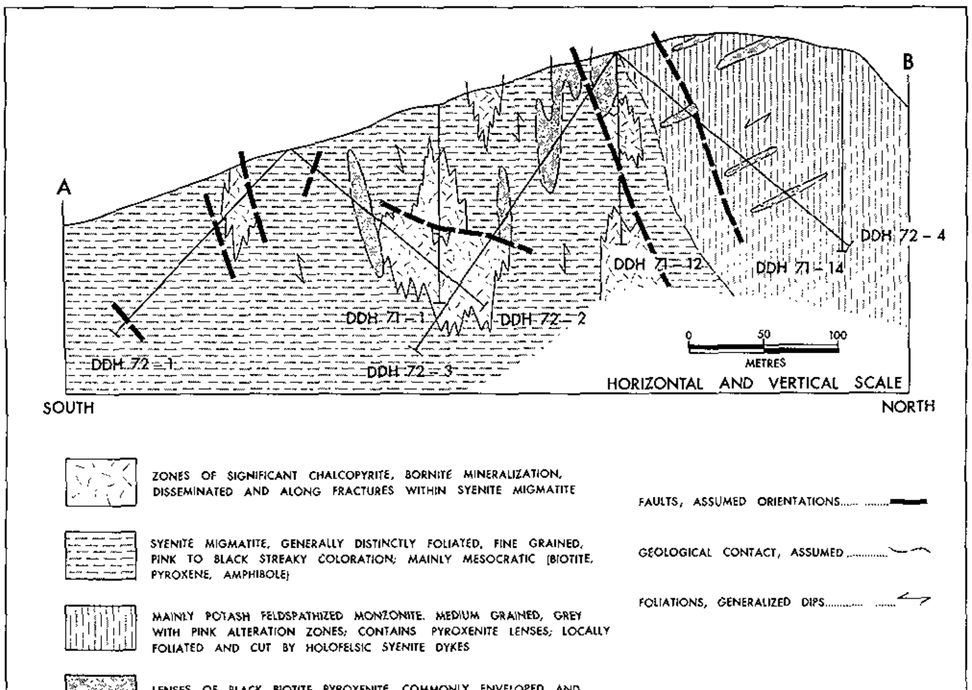


Figure 18. Lorraine, diagrammatic cross-section, lower mineralized zone.

Figure 17 shows the trenching across the main mineralized area and the various drilling programs designed to evaluate this zone. Section A-B (Fig. 18) is a diagrammatic interpretation of the spatial association between significant zones of mineralization and the surrounding migmatitic rocks. The diagram is based on information obtained from examination of drill core of the indicated holes, together with study of existing drill logs and assay results supplied by The Granby Mining Company Limited. The interpretation that mineralized sections (approximate range 0.5 per cent to 1.0 per cent copper) are erratically distributed throughout the zone seems inescapable. The steeply dipping nature of these zones and their corresponding lack of horizontal correlation remains speculative.

The steepening of the pyroxenite lenses within a narrow northwest-trending belt in the vicinity of the central mineralized zone, as indicated on Figure 18, may be more apparent than real. There is no doubt that the migmatitic foliation planes have steep to vertical dips in this area. If these planes represent flow foliations along the core zone of the syenite intrusion, the resulting strong fabric could obscure or obliterate an original shallow pyroxenite layering which it intruded and feldspathized. The steep orientations of foliations measured in trenches at surface are considered by the writer to reflect the overall structural control of the mineralization, whether originating by strong core zone intrusive flow, presence of remnants of steeply dipping basement rocks, or fault rotation.

Malachite-stained fractures are very common within these zones of primary sulphide concentration and contribute to the assay values. However, malachite staining is also common along fractures cutting barren syenites elsewhere on the property. Many of the fractures, which still contain primary sulphides along with malachite, contain fine leucosyenite veins. There must be a distinction made between malachite-filled fractures of altered, *in situ* primary sulphides and malachite-stained fractures due to leaching, transport, and later precipitation on fractures removed from the zones of significant primary sulphide mineralization. The majority of malachite-stained fractures appear to fall into the latter category.

The predominance of disseminated sulphides over fracture-filling primary mineralization and the strong spatial correlation of foliated syenite with copper sulphides have led to the interpretation that copper-bearing solutions were genetically associated with the syenites which intruded basic rocks of the Hogem batholith in lower Middle Jurassic time. A K/Ar age determination on black biotite pyroxenite cut by syenite dykelets yielded a date of 175±5 Ma (*see* location, Fig. 17). This date is considered to indicate the minimum age of the syenitic intrusion and the maximum age of sulphide mineralization at the Lorraine. It substantiates the previous date (170±8 Ma) taken by Koo (1968) on similar material from this general area.

TAM (MI 93N-93)

LOCATION: Lat. 56° 00′ Long. 125° 30′ (93N/13E, 14W; 94C/3W, 4E)
OMINECA M.D. Thirty-five miles northwest of Germansen Landing, 14 miles north-northwest of Old Hogem, at approximately 5,000 feet elevation (Fig. 19).

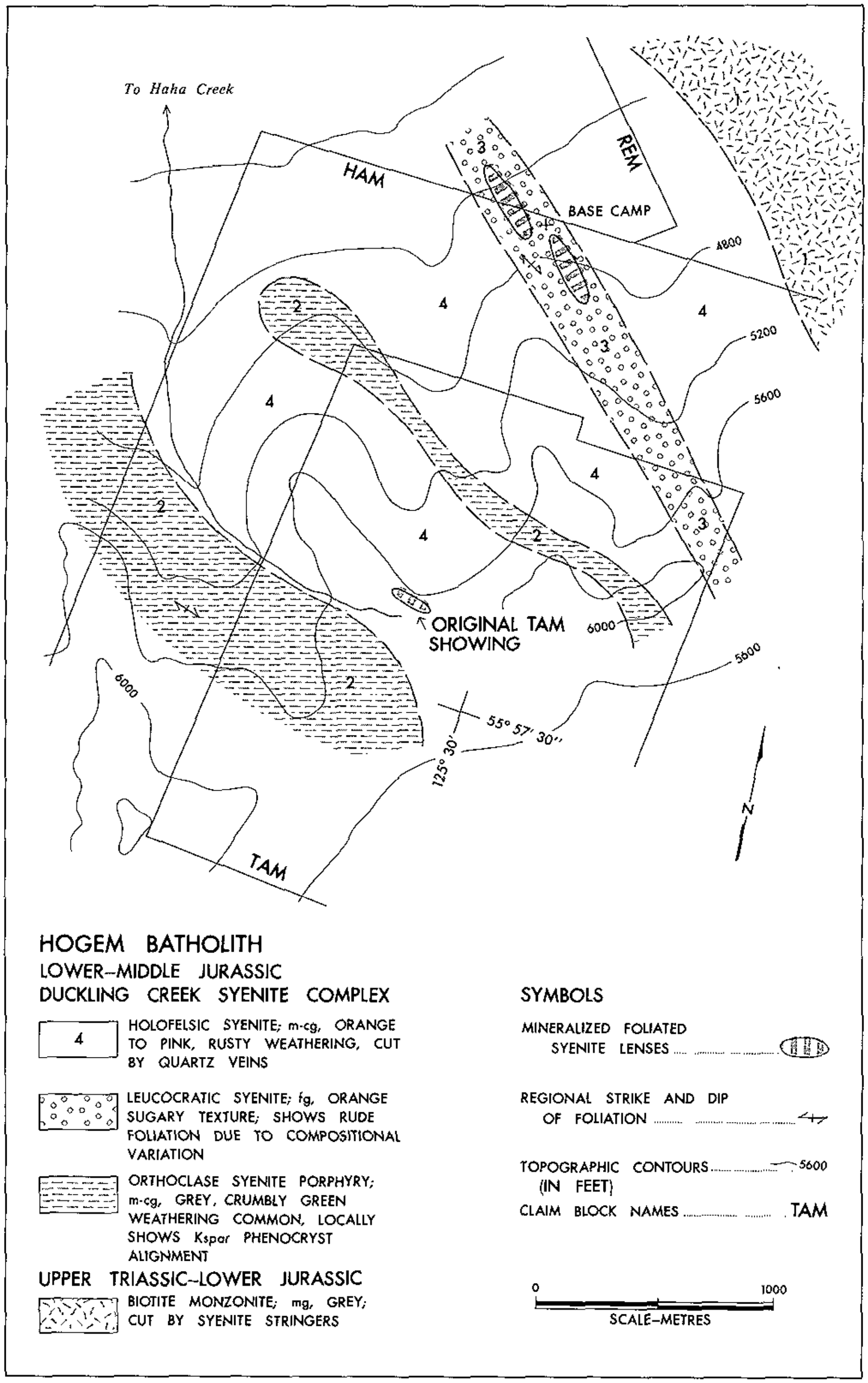


Figure 19. Tam, Ham, and Rem claims, Haha Creek area, general geology.

CLAIMS: TAM 1 to 20, HAM 1 to 52, AMP 1 to 13, SUZANNE 1 to 4, END 1 to 20, NA 1 to 12, 18 to 23, 25, REM 4 to 58, 63 to 66, 68, 70, 72, 74, 76, 78 to 82.

OWNER: UNION MINIERE EXPLORATIONS AND MINING CORPORATION LIMITED, 200, 4299 Canada Way, Burnaby V5G 1H4.

METAL: Copper.

DESCRIPTION:

The claims straddle Haha Creek, a northeast-flowing tributary of the Osilinka River. During the late 1940's, reconnaissance exploration of the Duckling Creek area by Kennco Explorations, (Western) Limited uncovered mineralization along a north-facing cirque wall overlooking the Haha Valley. The original showing was staked in 1968 by Omineca Explorations Ltd., and again by Union Miniere Explorations and Mining Company Limited in 1969. Intermittent work continued around this showing until late 1973, when geological mapping discovered new showings in the forested area below an adjacent cirque valley (Fig. 19). After completing detailed geochemical and IP surveys, a diamond-drilling project was initiated at the beginning of the 1974 field season. Over 7,000 feet (2 100 metres) of drilling was completed. This new showing represents the most significant new discovery in the Duckling Creek area in over 30 years of intermittent exploration.

The property lies entirely within the Duckling Creek Syenite Complex, near its northeastern boundary with biotite monzonites of the older basic sequence of the Hogem batholith. The new mineral occurrences are within lenticular lenses of foliated fine-grained leucocratic syenite. The foliation trends northwesterly with steep to vertical dips, paralleling the long axis of the foliated syenite bodies. The mineralized lenses occur within a belt of fine-grained, orange, sugary textured syenite. Foliation within this unit is defined by sericite and chlorite alignment and streaky colour banding of K-feldspar. Both the mineralized lenses and the surrounding foliated rocks are predominantly K-feldspar with minor sericite, chlorite, and calcite and locally accessory biotite. Magnetite is an erratically distributed accessory, and some specimens show orange-rusted hematite peppered throughout. These rocks are surrounded and cut by coarser grained, non-foliated syenites.

Copper occurs mainly as chalcopyrite disseminations erratically distributed throughout the fine-grained syenites. Examination of drill core clearly illustrates the control of disseminations and veinlets of chalcopyrite (and rare bornite) along the foliation planes. However, chalcopyrite also occurs along fractures in both the fine-grained and coarse-grained syenites.

Quartz veins cut all units, and chalcopyrite was noted with quartz veining as well as with calcite-filled fractures in brecciated sections of core. This indicates two stages of mineralization, with the earlier foliated, disseminated type being the more predominant.

The mineralization here is identical to that on the original Tam showing, another smaller lens of the same foliated material. Also, these mineralized lenses are along the same general strike as those of the Lorraine deposit to the southeast, and the potential for further occurrences of this type within the Duckling Creek Syenite Complex is high.

COPPER/MOLYBDENUM IN GRANITES

Copper/molybdenum mineralization is spatially associated with the Unit 9 granitic rocks. Abundant pyrite, disseminated and in veinlets, is common in altered, fractured zones. Chalcopyrite and molybdenite are associated with quartz flooding of altered mafic-rich zones in hybrid, potash-feldspathized rocks near granite contacts. Molybdenite also occurs as disseminations and veinlets in and near aplitic and alaskitic dykes, and along fractures in fresh intrusive rocks adjacent to Unit 9 intrusions. (Secondary uranium minerals have been reported associated with minor molybdenite in pegmatitic granites north of Kwanika Creek.)

A detailed geological description of the Kwanika Creek area and the KWANIKA property, the most significant occurrence of this type, has been published previously (Garnett, 1972c), and is reproduced here with minor revision for detailed reference.

KWANIKA CREEK AREA

INTRODUCTION: The KWANIKA property is located in the centre of the Kwanika Mountains, part of the Swannell Ranges, a subdivision of the Omineca Mountains. Rocks of the Hogem batholith are exposed along the high ridges of these ranges at elevations between 6,000 and 6,200 feet. To the west, Kwanika Creek and Nation River flow southward into the Nation Lakes chain through a broad drift-covered valley which contains the trace of the Pinchi Fault Zone. Elevations at river level are approximately 3,000 to 3,200 feet. A good four-wheel-drive vehicle road traverses the northern portion of this area from east to west, running from Manson Creek, past Germansen Lake, to Takla Landing (see Fig. 20).

REGIONAL GEOLOGY: The major geologic features of this area include the various rock units of the Hogem batholith, which intrude Takla Group rocks; the Cache Creek Group metasedimentary strata to the west; and the Pinchi Fault Zone, a pronounced northwest-trending regional lineament that separates these major geologic units.

Diorite, monzodiorite, and monzonite units show gradational contacts. Leucocratic quartz monzonite clearly intrudes these more basic rocks. Aeromagnetic maps are useful in distinguishing certain phases; basic units show as distinct highs and quartz monzonite shows as a distinct low.

Along the western margin of the KWANIKA property, the intruded Takla Group rocks are mainly metasedimentary, and occur as wedges between the batholith margin and the Pinchi Fault Zone.

Interbanded, thinly bedded black argillite and brown siltstone cut by intrusive dykes crop out along Kwanika Creek and exhibit slaty cleavage parallel to the steeply dipping compositional layering. The Upper Triassic pelecypod *Halobia* has been identified in similar strata on Halobia Creek to the south (Armstrong, 1942, 1944).

The Pinchi Fault Zone is the main structural feature of this region, and separates Permian rocks (Cache Creek Group) on the southwest from Mesozoic rocks northeast of the fault. In this general area, the fault trace lies within a wide drift-covered valley, and outcrops close to the fault are rare. However, outcrops exposed along the banks of Kwanika Creek exhibit intense fracturing, brecciation, and numerous faults, indicating proximity to this major lineament. Investigation of these outcrops suggests that the Pinchi fault is in fact a zone of intense brecciation and faulting which could be up to 1,000 feet wide in this area. There is clearly more than one generation of fracturing present, demonstrating at least two periods of movement along this zone. The regional rock distribution indicates uplift of the southwest (Permian) block relative to the northeast (Mesozoic) block. However, numerous slickensides on the minor faults investigated along Kwanika Creek exhibit mainly shallow-plunging lineations.

A red, hematite-stained, polymict boulder conglomerate was observed at two localities on Kwanika Creek. Well-rounded pebbles and boulders of greenish altered intermediate intrusive rock predominate. Fragments of black argillite were also noted. The conglomerate appears to overlie the Lower Cretaceous granites in one exposed, faulted contact zone. An aligned oblate shape to the boulders defines a vertical, northerly striking foliation, suggesting that the conglomerate has been affected by late movements along the Pinchi fault immediately west of this area. This unit was mapped previously and was considered to be Cretaceous or younger in age (Armstrong, 1944, 1949).

BOOM, FRANKIE (KWANIKA) (MI 93N-73)

LOCATION:	Lat. 55° 28′-32.5′ Long. 125° 15′-19′ (93N/6W, 11W) OMINECA M.D. At approximately 3,100 feet elevation on Kwanika Creek, 4 to 8 miles north of its mouth at the east end of Tsayta Lake (Fig. 20).
CLAIMS:	BOOM, FRANKIE, T GEE, JAM, MG, HG, CHO, OVP, BH, CU, KS, BUD, TX, MAYA, POST, KQ, totalling 120.
ACCESS:	By road from Germansen Landing, 50 miles west.
OWNER:	BOW RIVER RESOURCES LTD., 333, 885 Dunsmuir Street, Vancouver.
METALS:	Copper, molybdenum.

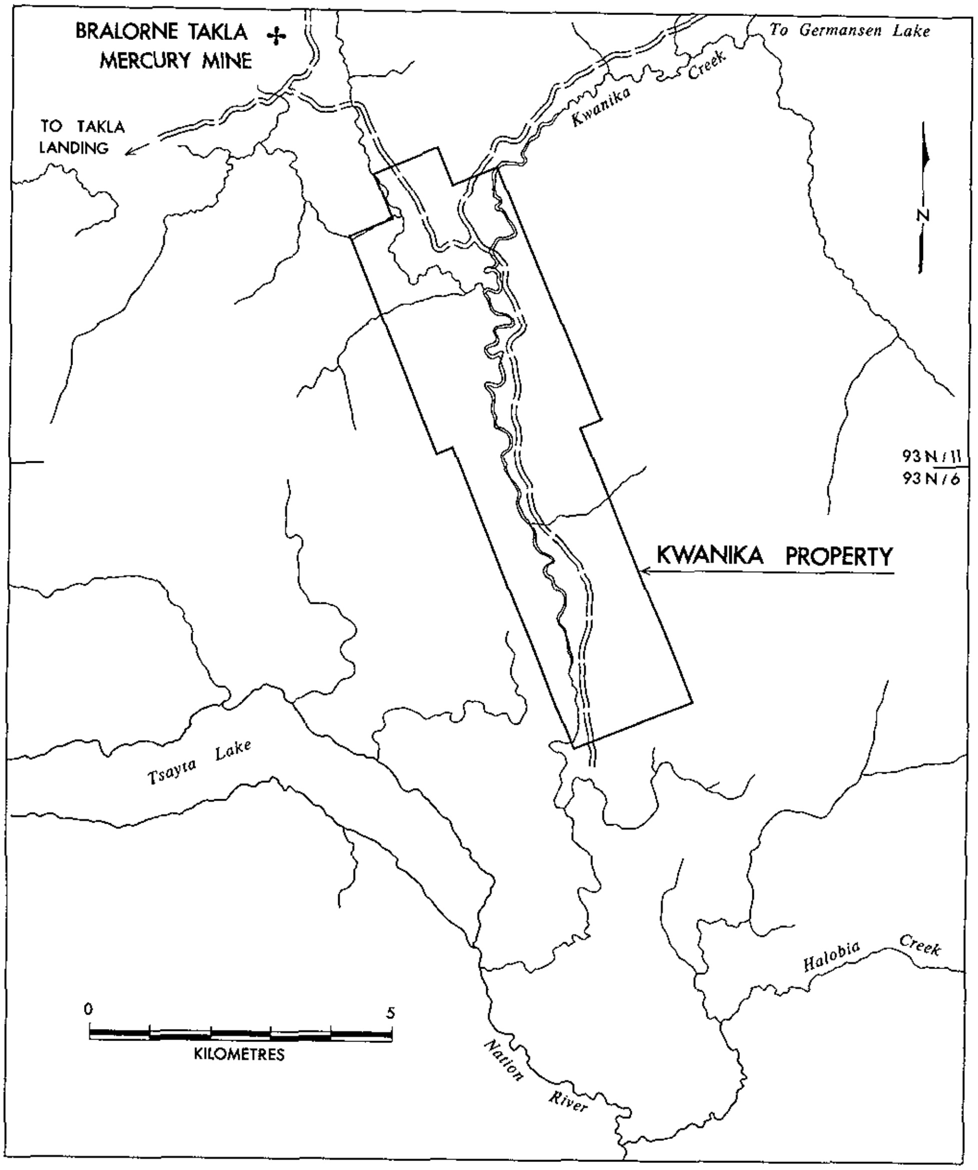


Figure 20. Kwanika property, general location.

DESCRIPTION:

HISTORY: Following the discovery of mercury at Pinchi Lake in 1937, exploration northwestward along the Pinchi Lake Mercury Belt was conducted by geologists of The Consolidated Mining and Smelting Company of Canada, Limited and others. The general Kwanika Creek area is part of this belt, and was first mapped by the Geological Survey of Canada in 1941 and 1943 in conjunction with this search for mercury (Armstrong, 1942, 1944). Occurrences of mercury within the boundaries of the present property were investigated at that time and the Bralorne-Takla mercury mine, which operated during

1943–44, is located 4 miles northwest of the property along the continuation of the Pinchi Fault Zone (Fig. 20). The Takla Silver property, first staked in the early 1940's, is located immediately west of Bralorne-Takla. Placer gold in Kwanika Creek was noted in the reports available from this period, but no mention was made of pyrite/chalcopyrite mineralization.

The rusty outcrops along Kwanika Creek were first recognized as having copper/molybdenum potential by A. Almond, G. Bleiler, and A. G. Hodgson and were staked in 1964. Hogan Mines Ltd. was incorporated in July 1965 and recommendations from consulting reports by A. F. Reeve and B. C. MacDonald were initiated. Bulldozer trenching, assaying, and X-ray drilling (two holes, 87 feet) were done on mineralized outcrops along Kwanika Creek in 1965.

The property was optioned by Canex Aerial Exploration Ltd. in 1966, and their investigation included access roads, linecutting, geological, geochemical, magnetometer, and induced polarization surveys, trenching, and 11 diamond-drill holes (2,807 feet) before dropping the option.

In 1969, Great Plains Development Company of Canada, Ltd. optioned the property and completed a magnetometer survey and seven diamond-drill holes (4,328 feet) before dropping the option in 1970.

The name Hogan Mines Ltd. was changed to Bow River Resources Ltd. in 1971. During 1972, following a report prepared by R. H. Seraphim, the company drilled six percussion holes (1,600 feet) in the area of the previous drilling.

The property was visited and briefly reported on by British Columbia Department of Mines and Petroleum Resources geologists A. Sutherland Brown in 1965 and N. C. Carter in 1970. During the field season of 1972, the writer, assisted by J. P. Franzen and D. V. Lefebure, spent 10 days mapping, investigating showings, and logging core on the property (Garnett, 1972c).

DESCRIPTION

Rock Types: Outcrops within the claim boundaries are scarce, occurring mainly along the banks of Kwanika Creek, where stream erosion has cut through a cover of fluvial/glacial overburden varying from 10 to 60 feet in thickness. Extrapolation was necessary in the production of Figure 21 (in pocket), but was kept within reasonable limits, and therefore large areas with overburden cover were left unclassified. Certain assumed boundaries were determined on the basis of a ground magnetometer survey made available to the writer by the company.

Basic to intermediate intrusive rocks of the Hogem basic suite, the major units of the Hogem batholith on the ridges rising to the east, are intruded by Phase III granitic rocks along the Kwanika Creek valley. Dykes and stringers of quartz/epidote/orthoclase pegmatite commonly cut the basic rocks on these west-facing slopes, and are considered to emanate from the granite body. Locally, subtle alignment of feldspars and mafic minerals defines a foliation along contact zones in these units. The granitic rocks extend north and south of the property, as a northward-pointing wedge-shaped body intruded between the more basic Hogem units and the Pinchi Fault Zone.

Two areas of hybrid rock have been mapped as representing an altered contact zone between the basic and granitic units. In detail, the hybrid rocks can be separated into quartz-rich, mafic-poor portions (quartz monzonite) and portions with significantly less quartz and some increase in mafic content (monzonite). This hybrid unit is therefore considered to be composed of light-coloured leucocratic quartz monzonite intruding and contaminating monzonites by silicification and hydrothermal alteration of feldspars and mafic minerals.

Investigation of drill core revealed numerous dark green-black aphanitic dykes cutting all other intrusive units. They are sometimes highly chloritized but unmineralized. Inclusions of similar appearance were noted in outcrops along Kwanika Creek.

The two areas of hybrid rock are separated partly by monzodiorite, but mainly by Takla Group banded argillite and minor greywacke. The argillites trend northwesterly, dip steeply, and exhibit slaty cleavage parallel to the thin interbands of black argillite and brown siltstone. Locally intense fracturing and minor concentric folds with highly fractured hinges are common. This unit is cut by fine-grained leucocratic dioritic dykes at some localities.

Near the south end of the claim block, outcrops of red boulder conglomerate occur in faulted contact with Phase III granites. Aligned oblate boulders define a vertical, northerly striking foliation, and may represent a mechanical rotation of rigid boulders within a passive matrix due to late movement along the adjacent Pinchi Fault Zone.

On the west side of the Pinchi fault trace, Cache Creek Group rocks are mainly massive limestone/dolomite. However, outcrops of gabbro and serpentinite were also mapped. A narrow vein of chromite occurs in the northern portion of the mapped area (Fig. 21) and magnesite was identified by X-ray diffraction as a constituent of the surrounding serpentinite. A blue mineral encrusted on fractures through the serpentinite was identified by X-ray as clino-chrysotile. Immediately north of this area, cinnabar occurs in tiny veinlets in a highly fractured, altered mariposite quartzite zone.

Faulting and Fracturing: Accurate location of the main lineament of the Pinchi Fault Zone was not possible due to extensive cover in this area. Eastward-facing scarps of Cache Creek limestone/dolomite occur both north and south of this claim block and are considered to define the major fault trace in those areas. The trace appearing on Figure 21 was determined partly by the eastern limit of Cache Creek limestone/dolomite outcrops and partly by aerial photo interpretation of subtle northwesterly trending topographic linears.

It is clear, however, that outcrops of both intrusive and metasedimentary strata adjacent to this trace exhibit intense fracturing, faulting, and brecciation on the outcrop scale, and obvious cataclastic textures on the microscopic scale. The majority of the minor (branch) faults trend north to northeast, with steep dips and shallowly plunging slickensides. Fracture patterns are locally consistent, but on a property scale, show random distribution. A north to northeast-trending set of fractures has been obscured by later fracturing and brecciation. Some fractures are coated with chlorite and hematite; others have been filled with quartz veinlets and pyrite (chalcopyrite) stringers. These fractures are cut by open fractures and others filled with calcite. Several generations of movement in this zone have been recorded, from pre to post-mineralization in age.

Alteration: On the slopes to the east of the grid area, the fresh monzonites locally contain black biotite clusters and orange-green bleached zones of K-feldspar/epidote alteration. In the Kwanika Creek valley, orange-coloured, leucocratic to holofelsic quartz monzonites exhibit moderate to intense pervasive sericitization and saussuritization of all feldspars. Within the hybrid zone, the previously mentioned alteration is accompanied by potash feldspathization of plagioclase grains and intergranular and veinlet quartz flooding. Fresh green-brown secondary biotite is a rare constituent in some hybrid rocks, but is abundant in one mineralized specimen taken from an outcrop on Kwanika Creek near line 50400. The most visible alteration products noted in the intensely pyritized and fractured trenches along Kwanika Creek were epidote/chlorite and K-feldspar.

As noted previously, calcite fracture filling appears to be the latest alteration event, cutting fractures filled with chlorite, quartz, and sulphides.

Mineralization: Pyrite is by far the most abundant sulphide, occurring as disseminations and fracture fillings in silicified and brecciated zones within Phase III granites and the hybrid zones. Rusty limonite cappings were noted in mineralized outcrops along Kwanika Creek in the southern hybrid zone. Native copper has been reported in rusty trenched areas in the north hybrid zone. Malachite-stained fractures are common.

Investigation of diamond-drill core revealed that increase in visible chalcopyrite occurs in mafic-rich zones within hybrid rocks which also show increased quartz flooding. Visible molybdenite was noted mainly as disseminations in quartz veins in these chloritic alteration zones. Disseminated chalcopyrite was noted in outcrops containing abundant secondary biotite on Kwanika Creek south of line 50400.

Bornite has been reported in diamond-drill holes C-1 and C-2 (*see* Table 3) and assays from original trenches reported trace gold and minor silver values (from trace to 0.86 ounce per ton).

TABLE 2. DRILLING INFORMATION

DRILL HOLE NO.	TYPE	APPROXIMATE LOCATION (Fig. 21)	BEARING/DIP (degrees)	CASING (feet)	DEPTH (feet)	AVERAGE ASSAY %Cu	%Mo	OPERATOR	DATE DRILLED
X-1	X-ray	59200N east bank – Kwanika Ck.	?	–	47	0.26	Tr.	Hogan Mines	1965
X-2	X-ray	59700N west bank – Kwanika Ck.	?	–	40	0.53	0.01	Hogan Mines	1965
A-1	AX	60820N south bank – Kwanika Ck.	–/90	15	464	0.04	–	Canex Aerial Exp.	Aug. 1966
A-2	AX	60020N east of Kwanika Ck.	–/90	49	201	0.12	–	Canex Aerial Exp.	Aug. 1966
A-3	AX	59200N east of Kwanika Ck.	–/90	34	200	0.19	–	Canex Aerial Exp.	Aug. 1966
A-4	AX	60820N east of Kwanika Ck.	–/90	106	325	not assayed		Canex Aerial Exp.	Aug. 1966
A-5	AX	60820N east of Kwanika Ck.	–/90	42	220	170′-220′ only 0.16	0.02	Canex Aerial Exp.	Sept. 1966
A-6	AX	62420N east of Kwanika Ck.	–/90	98	311	–	–	Canex Aerial Exp.	Sept. 1966
A-7	AX	63200N east of Kwanika Ck.	–/90	81	298	–	–	Canex Aerial Exp.	Sept. 1966
A-8	AX	58200N east of Kwanika Ck.	–/90	15	248	0.06	–	Canex Aerial Exp.	Sept. 1966
A-9	AX	58200N west of Kwanika Ck.	270/60	15	355	–	–	Canex Aerial Exp.	Sept. 1966
A-10	AX	58200N east of Kwanika Ck.	090/60	27	27	not assayed		Canex Aerial Exp.	Sept. 1966
A-11	AX	51200N east of Kwanika Ck.	–/90	20	128	not assayed		Canex Aerial Exp.	Sept. 1966

B-1	BQ	59200N west bank – Kwanika Ck.	090/75	7	392	0.26	Tr.	Great Plains Dev.	Apr. 1969
B-2	BQ	59700N west bank – Kwanika Ck.	090/75	10	381	0.25	Tr.	Great Plains Dev.	Apr. 1969
B-3	BQ	60020N west of Kwanika Ck.	090/65	84	402	Tr.	–	Great Plains Dev.	Apr. 1969
B-4	BQ	60200N west bank – Kwanika Ck.	105/75	22	432	0.17	0.01	Great Plains Dev.	Apr. 1969
B-5	BQ	58800N *east side* – Kwanika Ck.	290/75	12	359	not assayed		Great Plains Dev.	Apr. 1969
C-1	BQ	59700N *east side* – Kwanika Ck.	015/60	30	1,192	0'-610' 0.17 610'-1,192' 0.06	 – –	Great Plains Dev.	Aug. 1970
C-2	BQ	59700N east side – Kwanika Ck.	140/60	28	1,170	0'-620' 0.21 620'-1,170' 0.04	 0.008 0.005	Great Plains Dev.	Aug. 1970
P-1	percussion	63000N south bank – Kwanika Ck.	–/90	10	300	0.04	–	Bow River Res. *(Hogan Mines)*	Aug. 1972
P-2	percussion	62750N north of Kwanika Ck.	–/90	30	300	0.03	–	Bow River Res. (Hogan Mines)	Aug. 1972
P-3	percussion	63300N *north* of Kwanika Ck.	–/90	50	300	0.09	–	Bow River Res. (Hogan Mines)	Aug. 1972
P-4	percussion	58700N east of Kwanika Ck.	–/90	30	300	0.16	–	Bow River Res. (Hogan Mines)	Aug. 1972
P-5	percussion	58450N east of Kwanika Ck.	–/90	30	300	0.17	–	Bow River Res. (Hogan Mines)	Aug. 1972
P-6	percussion	59100N east of Kwanika Ck.	–/90	30	300	0.15	–	Bow River Res. (Hogan Mines)	Aug. 1972

TABLE 3. GEOLOGICAL SUMMARY OF DRILL CORE

DRILL HOLE NO.	ROCK TYPES*	ALTERATION	FRACTURING	MINERALIZATION
X-1	?	?	?	pyrite, chalcopyrite, molybdenite
X-2	?	?	?	pyrite, chalcopyrite, molybdenite
A-1	UNIT 6/6A locally cut by andesite dykes	epidote-chlorite, sericitized feldspar, K-feldspathization, local silicification by veinlets, flooding	strong; filled with calcite, chlorite, hematite; local brecciation, gouge	pyrite; disseminated, in fractures; minor chalcopyrite
A-2	UNIT 9 interfingering with UNIT 6A	as above	intense; intersects large brecciated fault zone; fractures filled with hematite, calcite, chlorite, clay (?)	as above – increased values corresponds to increased altered mafic content and quartz veining, flooding
A-3	UNIT 9 interfingering with UNIT 6A	as above – increased silicification	strong; with local fault zones	as above – molybdenite noted in siliceous zones
A-4	UNIT 6 cut by numerous quartz-K-feldspar-epidote pegmatite dykes, veins (UNIT 9 ?)	epidote-chhorite, local K-feldspathization	moderate; locally strong	very rare pyrite
A-5	UNIT 9 cut by large andesite dyke	epidote-chlorite, sericitized feldspar	strong to intense with brecciated zones	pyrite; disseminated, in fractures; minor chalcopyrite, molybdenite in siliceous zones enveloping areas of increased mafic content
A-6	UNIT 9 cutting UNIT 6 (cut by grey feldspar porphyry dyke ?)	relatively fresh	strong to intense; with quartz, calcite veining, hematite staining	trace pyrite
A-7	UNIT 9	relatively fresh, epidote-chlorite, increase in biotite content near bottom	intense; central portion intersects highly brecciated zone	trace magnetite
A-8	UNIT 6/6A, interrfingers of UNIT 9	silicification dominant	intense; fractures healed by silicification; also chlorite, calcite fillings	pyrite; rare chalcopyrite

A-9	UNIT 6	*hornblende to chlorite, minor* K-feldspathization	locally intense; two minor fault zones intersected, hematite, chlorite, calcite fracture filling	erratic disseminated pyrite; rare chalcopyrite
A-10	abandoned in overburden at 27 feet			
A-11	UNIT 5	fresh, weak hornblende to chlorite	moderate; filled with quartz and younger calcite veinlets	nil
B-1	UNIT 6A *(altered granodiorite,* quartz diorite ?), cut by andesite dyke	epidote-chlorite, K-feldspathization, silicification, clay *minerals, sericitization*	intense; with numerous brecciated zones; slickensides; calcite, chlorite, hematite coatings	pyrite; disseminated, in fractures; quartz veins; minor chalcopyrite, best near siliceous flooding of zones of high altered mafic content
B-2	UNIT 6A, altered and cut by UNIT 9	epidote-chlorite-clay, *silicification,* K-feldspathization, sericitization	*intense*	as above
B-3	UNIT 6A ? cut by andesite dyke	epidote-chlorite	moderate; calcite, hematite, chlorite fillings	pyrite; disseminated, in fractures; rare *chalcopyrite*
B-4	*UNIT 6/6A ? cut by andesite dyke;* cut by grey feldspar porphyry dyke	epidote-chlorite, silicification, K-feldspathization, sericitization, clay *minerals*	intense; brecciated zones	pyrite; disseminated, in fractures; minor chalcopyrite, molybdenite, best near siliceous flooding of zones of high altered mafic content
B-5	UNIT 9 breccia	fault gouge, calcite, clay, chlorite	*brecciated fault zone ?*	pyrite, trace chalcopyrite, molybdenite
C-1	UNIT 6/6A to 610'; 610'-1142' – UNIT 9 cut by numerous andesite dykes	epidote-chlorite; K-feldspathized	*moderate*	pyrite, minor chalcopyrite, bornite, best values as in B-4
C-2	*UNIT 6/6A interfingered with* UNIT 9 to 620'; 620'-1170' – UNIT 9, occasional andeiste dykes	epidote-chlorite, silicification	moderate; occasional brecciated zones throughout	as above

*Units refer to original Figure 21 legend, not to the Hogem units defined in Table 1 of this bulletin.

Detailed information on diamond drilling done from 1965 to 1972 is contained in Tables 2 and 3, and average assays for copper (and molybdenum) across complete drill-hole depths are indicated in Table 2. Pechiney Development Limited optioned the property in 1973, and as a result of detailed geological and IP surveys conducted that year, initiated a follow-up percussion drilling program in July 1974. Previous drilling had concentrated on the north mineralized zone, but no drilling had been done on the less exposed south zone.

Thirty percussion holes were attempted during the 1974 season. Six failed to reach bedrock after encountering overburden cover in excess of 100 feet (30 metres). Seventeen holes were drilled in the south anomaly and 13 were drilled in the north anomaly, for a total of 9,820 feet (2 993 metres). Assaying of drill cuttings from the south zone reportedly produced discouraging results.

JEAN MARIE STOCK

Another significant copper/molybdenum prospect in the general area of the Hogem batholith is the JEAN property, which occurs along the margin of the Jean Marie stock, located approximately 6 kilometres south of Tchentlo Lake (Figs. 3 and 5). A brief geological description of this property, published previously (Garnett, 1974b), is reproduced here for reference.

JW, JEAN (MI 93N-79, 83)

LOCATION: Lat. 55° 06' Long. 124° 53' (93N/2W)
OMINECA M.D. Eight miles south of Tchentlo Lake, at the headwaters of Jean Marie Creek, at approximately 3,500 feet elevation.

CLAIMS: JEAN, JW, totalling 265.

OWNER: NBC Syndicate.

OPERATORS: COMINCO LTD., GRANBY MINING CORPORATION, DUVAL CORPORATION OF CANADA, STANDARD OIL COMPANY OF BRITISH COLUMBIA, c/o Cominco Ltd., 2200, 200 Granville Square, Vancouver.

METALS: Copper, molybdenum.

DESCRIPTION:

This large claim block is located within an intrusive outlier occurring south of Tchentlo Lake, about 6 kilometres due south of Mount Alexander. The area was staked in 1969 by NBC Syndicate. Geochemical and IP surveys and diamond drilling were performed on a central anomalous zone during 1970 and 1971. In 1973, Cominco Ltd., one of the original partners in the syndicate, returned to conduct geological and IP surveys on an anomalous area west of the initial drilling. During the 1974 field season, a 32-kilometre road was built from Chuchi Lake to this location, and 11,000 feet (3 350 metres) of percussion drilling was completed.

Reconnaissance traversing within the fresh intrusive rocks in the vicinity of the anomalous zones indicates that the rock type is mainly a grey, medium-grained granodiorite containing roughly 60 per cent plagioclase, 15 per cent orthoclase, 15 per cent quartz, and 10 per cent biotite and hornblende. Textures are mainly granitic with local porphyritic varieties exhibiting euhedral plagioclase. A sample of fresh granodiorite taken from outcrops northeast of the mineralized zone yielded K/Ar dates of 136±4 Ma (biotite) and 131±4 Ma (hornblende). Dating from the Hogem and Germansen batholiths had previously defined three separate intrusive events in this region, falling roughly within the following age brackets: 175 to 210 Ma, 160 to 180 Ma, and 105 to 125 Ma. The dates obtained from the Jean Marie stock suggest either a new intrusive period or an extension of the previously recognized Cretaceous event. In any case, the new dates indicate intrusive activity in this area similar in age to the Francois Lake intrusions of the Endako area.

The anomalous zones being investigated occur along the contact of this stock with dark grey aphanitic andesites and pyroxene porphyries of the Takla Group. This contact is pyritized and there is local garnet/epidote skarn development.

The main intrusive rocks within these zones are bleached granodiorites and quartz diorites cut by numerous dykes ranging in composition from plagioclase syenite porphyry through aplitic syenite to red granite.

Chalcopyrite, molybdenite, and hematite occur on orange-bleached (potash feldspathized) fractures in otherwise fresh granodiorites and quartz diorites. Chalcopyrite occurs as hornblende replacements in syenite dykes, and also occurs along with pyrite in quartz veins and fractures cutting both granodiorites and syenites. Malachite is common within fault zones along which granite and syenite dykes have cut the main intrusive and the adjacent volcanic rocks. The volcanic rocks exhibit blocky fracturing generally more pervasive than the fracture density of the crosscutting intrusive rocks, and chalcopyrite is locally significant along hairline fractures and smeared along small faults in the andesites.

SUMMARY

Tentative conclusions from a general review and tabulation of the major mineral occurrences in the southern Hogem batholith published previously (Garnett, 1974c) are summarized below.

(1) The major intrusive units of the Hogem batholith were emplaced as a differentiated mass approximately 190 Ma ago, and only minor chalcopyrite/magnetite mineralization has been documented locally in the basic rocks of this phase.

(2) A syenitic phase intruded the Hogem batholith approximately 175 Ma ago, with genetically related chalcopyrite/bornite/magnetite minerali-

zation occurring as disseminations in foliated syenite and in fractures in potash-feldspathized intrusive and volcanic units adjacent to syenite intrusions.

(3) A granitic phase intruded both these phases, approximately 120 Ma ago. Pyrite/chalcopyrite/molybdenite mineralization and hydrothermal alteration occur in fracture zones within and adjacent to this phase.

More detailed delineation of the boundaries of the younger phases should produce more specific exploration targets within the batholith. However, recent concentrated and sophisticated exploration programs by various companies have failed to develop an economic deposit within this intrusion to date. In comparison with other more productive batholiths to the south, it may be significant to mention that there appears to be almost no breccia development and little feldspar porphyry dyking within the southern Hogem batholith. [Note: One small possible breccia pipe was mapped, in association with felsite dykes, near Mount Nation. Rare malachite and chalcopyrite were observed at this locality (northwest of specimen 24, Fig. 5).]

METALLOGENIC CONSIDERATIONS

The Hogem batholith is a Mesozoic intrusion located within the island arc environment of the Quesnel Trough. Other intrusions within this space/time setting are hosts for major porphyry copper and copper/molybdenum deposits of the Canadian Cordillera. Two petrogenic suites are represented by these intrusions: the calc-alkaline suite, best illustrated by the Guichon batholith; and the alkaline suite, best illustrated by the Copper Mountain stock and the Iron Mask batholith (Sutherland Brown, *et al.,* 1971; Ney and Hollister, 1976).

The Hogem batholith has been documented as a composite intrusion, containing three, and probably four, partial plutons of varying chemical composition. The Phase I Hogem granodiorite and the Phase III granite are best categorized as calc-alkaline (subalkaline) intrusive rocks. The Phase II syenite is clearly alkaline and the Phase I Hogem basic suite is predominantly alkaline.

The co-existence of both petrogenic suites within the Hogem batholith represents a major difference from the other 'porphyry' associated intrusions. Also, the intrusive history of the Hogem spans a much larger time interval than the other single suite intrusions.

As previously described, there are no known ore deposits within the Hogem batholith, but the best known 'porphyry copper' mineralization is closely associated with Phase II alkali syenites.

Barr, *et al.*, (1976) state that the plutonic rocks of the Cordilleran alkaline porphyry suite range from syenogabbro to relatively rare alkali syenite. Most are small plugs and stocks intruding marine volcanic breccias of identical chemical composition and age. The copper deposits are localized in fault, fracture, or rift zones of brecciation.

The syenitic copper mineralization of the Hogem differs from this general environment in the following respects. The syenites mainly intrude other plutonic rocks and the mineral occurrences exhibit syngenetic characteristics and have none of the main alteration and structural features of the major Cordilleran porphyry deposits of the alkaline suite. Further, there are no known volcanic equivalents to the Phase II syenites in the general vicinity of the southern Hogem batholith.

The implication is that genetically related copper mineralization was associated with a younger syenite partial pluton intruding Phase I rocks of the Hogem batholith. Localized intrusions were probably related to alkaline volcanic centres. Subsequent erosion removed these local volcanic piles as well as the subvolcanic level of intrusive rock characterized by explosive brecciation, porphyry dyke swarms, and the typical high level alkaline porphyry copper deposits and their associated alteration halos. The existing syenitic copper occurrences of the southern Hogem batholith represent lower level, primary remnants of such deposits. A similar history can be attributed to the existing copper/molybdenum mineralization associated with Phase III granite intrusions within the Hogem batholith.

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APPENDIX I. RADIOMETRIC ANALYTICAL DATA, SOUTHERN HOGEM BATHOLITH

Sample No.	Field No.	Rock Unit	Rock Name	Apparent Age (Ma)	Material Analysed	%K	$\frac{Ar^{40} rad}{Total\ Ar^{40}}$	Ar^{40} rad	$\frac{Ar^{40} rad}{K^{40}}$	Remarks
1	G-73-25	2	mg. monzodiorite	188±5	biotite (60-80)	$\bar{x}$=7.12 ; σ±0.01 (3)	0.948	5.625	1.158×10^{-2}	
2	M-73-100	1	grey mg. pyx. diorite	184±6	hornblende (40-60)	$\bar{x}$=0.626; σ±0.004(3)	0.780	4.818×10^{-1}	1.129×10^{-2}	
				194±6	brown biotite (40-60)	$\bar{x}$=4.55 ; σ±0.02 (2)	0.884	3.718	1.198×10^{-2}	
				198±6	black biotite (20-40)	$\bar{x}$=4.58 ; σ±0.03 (3)	0.923	3.829	1.226×10^{-2}	
3	L-73-90	5	white mg. hb. monzodiorite	183±6	biotite (40-60)	$\bar{x}$=5.79 ; σ±0.04 (3)	0.937	4.440	1.124×10^{-2}	
4	G-72-36 (CHUCHI)	4	mg. plagio. syenite p'phy	181±5	biotite (40-80)	$\bar{x}$=7.46 ; σ±0.02 (5)	0.972	5.598	1.109×10^{-2}	partially reset by Unit 9 intrusion
5	FOX-13	4	mg. meso. monzonite	175±5	biotite (40-80)	$\bar{x}$=3.17 ; σ±0.03 (4)	0.931	2.308	1.076×10^{-2}	reset by Unit 6 intrusion
6	195-38 (CUESTA)	5	white mg. granodiorite	189±6	hornblende (40-80)	$\bar{x}$=0.497; σ±0.004(4)	0.872	3.920×10^{-1}	1.165×10^{-2}	
7	LORRAINE	6	K-feldspathized pyroxenite	175±5	biotite (40-80)	$\bar{x}$=5.65 ; σ±0.02 (4)	0.967	4.113	1.075×10^{-2}	Unit 1 pyroxenite enveloped within Unit 6
8	COL-12	7	mg. K-feldspath. monzonite	177±5	biotite (40-60)	$\bar{x}$=6.18 ; σ±0.03 (3)	0.967	4.532	1.083×10^{-2}	DDH core sample
9	KWANIKA	3	cg. hornblende diorite	121±4	phlogopite (40-80)	$\bar{x}$=6.31 ; σ±0.05 (6)	0.957	3.119	7.303×10^{-3}	reset by Unit 9 intrusion
10	G-73-87	9	K-spar granodiorite p'phy	112±4	biotite (40-60)	$\bar{x}$=6.05 ; σ±0.01 (2)	0.867	2.781	6.740×10^{-3}	
11	G-74-4	----	grey mg. granodiorite	131±4	hornblende (40-60)	$\bar{x}$=0.350; σ±0.002(3)	0.682	1.893×10^{-1}	7.932×10^{-3}	Jean Marie stock
				136±4	biotite (40-60)	$\bar{x}$=5.24 ; σ±0.00 (2)	0.950	2.951	8.259×10^{-3}	
12	G-74-1	----	grey cg. granodiorite	106±3	hornblende (40-60)	$\bar{x}$=1.14 ; σ±0.006(3)	0.915	4.979×10^{-1}	6.404×10^{-3}	Germansen batholith; biotite may be reset
				85.8±2.7	biotite (40-60)	$\bar{x}$=7.73 ; σ±0.03 (3)	0.893	2.706	5.132×10^{-3}	by adjacent aplitic dykes (Meade, 1975)
A		1?		203±9	hornblende					Mount Nation area (Stock, 1974)
B		5?		190±8	hornblende					Mount Nation area (Stock, 1974)
C		6		170±8	biotite					*Duckling Creek (Lorraine) area* (Koo, 1968)

Notes:

For accurate sample locations (1 to 11) *see* Figure 5 (in pocket).

All analyses listed were produced at the University of British Columbia geochronology laboratory.

Number in parentheses refers to number of K analyses; σ = standard deviation.

Constants used: $\lambda_e = 0.585 \times 10^{-10} yr^{-1}$; $\lambda_\beta = 4.72 \times 10^{-10} yr^{-1}$; $K^{40}/K = 1.181 \times 10^{-4}$ (samples 4 to 9); $K^{40}/K = 1.19 \times 10^{-4}$ (samples 1 to 3; 10 to 12).

APPENDIX II.

A. CHEMICAL ANALYSES OF HOGEM INTRUSIVE ROCKS AND TAKLA VOLCANIC ROCKS

Sample No.	Field No.	SiO_2	Al_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	FeO	Fe_2O_3	H_2O+	H_2O-	CO_2	P_2O_5	S	BaO	SrO	Total	Rock Unit	Remarks
1	L-73-9	48.77	15.28	8.25	9.50	2.78	1.02	0.93	0.28	7.33	2.89	0.68	0.98	0.06	0.46	0.02	0.04	0.04	99.31	B	
2	L-73-13	51.00	17.50	3.99	7.46	3.20	3.68	1.04	0.17	4.66	3.94	0.81	0.83	0.05	0.57	0.01	0.13	0.11	99.15	2	
3	L-73-65	63.89	17.88	2.16	5.27	5.89	0.50	0.06	0.09	1.50	1.22	0.47	0.69	0.21	0.32	0.01	0.02	0.09	100.27	5	
4	L-73-104	63.65	16.44	2.01	2.59	4.39	4.44	0.49	0.10	1.78	2.62	0.49	0.73	0.09	<0.18	0.03	0.08	0.05	100.16	5	
5	L-73-108	54.95	17.42	4.01	7.27	3.86	1.78	0.92	0.20	6.19	2.06	1.40	0.49	0.05	0.39	0.01	0.04	0.07	101.15	3	
6	L-73-129	72.64	14.79	0.70	1.58	3.99	3.98	0.21	0.07	0.78	1.08	0.07	0.56	0.12	<0.18	0.01	0.07	0.03	100.86	9	dyke
7	L-73-135	49.32	16.08	7.49	8.49	3.53	0.89	1.11	0.21	7.97	2.92	1.37	0.53	0.07	<0.18	0.02	0.03	0.05	100.26	B	
8	L-73-141	61.55	18.94	1.23	4.88	5.10	3.09	0.45	0.15	1.57	2.46	0.11	0.51	0.05	<0.18	0.01	0.12	0.05	100.45	5	
9	M-73-2	57.86	17.57	2.44	6.27	3.76	2.92	0.61	0.15	2.56	3.46	0.77	0.47	0.05	0.39	0.02	0.11	0.09	99.50	5	
10	M-73-23	54.24	18.33	2.54	3.72	3.80	6.14	0.74	0.17	3.70	2.94	1.10	0.58	0.03	0.60	0.01	0.09	0.06	98.79	2	
11	M-73-35	39.71	6.76	11.07	15.99	0.46	0.53	1.40	0.22	8.33	13.83	0.83	0.40	0.13	0.18	0.02	0.02	0.03	99.91	1	pyroxenite
12	M-73-53	51.83	17.86	3.33	6.92	4.06	2.98	0.85	0.24	4.38	4.29	0.93	0.49	0.18	0.39	0.04	0.09	0.06	98.92	2	
13	M-73-70	53.49	16.99	3.12	6.61	3.62	3.50	0.80	0.19	5.63	2.92	1.11	0.42	0.08	0.41	0.03	0.09	0.07	99.08	2	
14	M-73-82	63.14	15.67	1.93	4.71	3.74	3.69	0.52	0.11	2.17	2.73	0.24	0.67	0.06	0.14	0.02	0.08	0.06	99.68	5	
15	M-73-100	40.46	18.04	6.46	13.69	1.31	0.85	0.92	0.22	2.21	11.77	1.04	0.77	0.03	1.54	0.03	0.03	0.13	99.50	1	
16	M-73-133	54.72	18.24	2.25	6.12	4.58	3.16	0.66	0.16	2.32	4.35	0.39	0.93	0.88	0.24	0.01	0.08	0.10	99.19	3	
17	M-73-138	65.30	17.13	0.72	3.79	4.96	3.51	0.35	0.10	0.96	1.90	0.20	0.32	0.07	<0.18	0.02	0.07	0.08	99.66	5	
18	M-73-149	59.05	18.46	1.89	4.14	4.10	5.08	0.55	0.08	2.64	2.60	0.32	0.51	0.09	<0.18	0.02	0.09	0.07	100.38	4	
19	M-73-153	71.01	14.98	0.69	1.76	4.16	3.94	0.22	0.05	0.71	0.86	0.03	0.41	0.09	<0.18	0.04	0.06	0.04	99.23	9	
20	G-73-4	52.63	17.74	3.58	7.47	3.46	3.24	0.79	0.20	5.34	3.47	1.14	0.56	0.04	0.52	0.02	0.11	0.09	100.40	2	
21	G-73-38	53.85	17.40	2.71	6.61	3.45	3.88	0.83	0.19	5.87	1.97	0.93	0.56	0.06	0.62	0.03	0.10	0.09	99.15	2	
22	G-73-39	44.87	19.32	5.94	11.02	1.89	1.49	0.59	0.26	7.87	1.85	2.21	0.61	0.28	0.79	0.08	0.05	0.11	99.23	1	
23	G-73-58	64.66	16.35	1.56	4.64	3.74	3.63	0.54	0.10	1.82	2.20	0.10	0.47	0.04	0.18	0.02	0.11	0.06	100.00	5	
24	G-73-68	52.61	17.34	3.56	7.12	3.56	3.33	0.80	0.18	4.41	4.45	0.92	0.60	0.03	0.39	0.02	0.12	0.09	99.53	2	
25	G-73-73	52.80	14.93	5.06	8.02	2.77	4.47	0.63	0.16	4.48	4.30	0.78	0.41	0.05	0.28	0.01	0.14	0.10	99.39	4	
26	G-73-77	62.38	17.77	1.16	3.04	5.39	2.25	0.44	0.10	1.23	2.45	1.19	0.40	2.27	<0.18	0.05	0.11	0.05	100.28	5	
27	177-55	44.8	16.4	5.76	11.2	2.09	1.54	1.05	0.22	6.20	7.05	1.68	0.14	<0.07	1.4	0.05	0.11	0.10	99.8	1	
28	177-59	55.7	17.5	3.22	6.74	3.81	2.66	0.66	0.17	3.39	4.10	1.18	0.12	<0.07	1.03	<0.01	0.23	0.14	100.9	4	
29	177-94	53.4	18.3	2.51	9.14	3.78	2.33	0.64	0.21	6.03	1.01	1.66	0.20	-----	1.00	0.43	0.13	0.10	100.8	B	
30	177-153	51.9	19.2	2.78	8.92	4.74	1.52	0.47	0.19	3.51	4.81	1.51	0.14	0.07	1.00	0.04	0.09	0.16	101.1	3	
31	177-157	59.2	18.2	1.89	5.08	5.05	3.77	0.46	0.14	2.17	2.86	0.49	0.09	<0.07	0.69	0.03	0.31	0.11	100.6	4	
32	178-199	50.3	17.9	3.86	8.39	4.02	1.76	0.80	0.23	4.14	4.99	1.65	0.10	<0.07	<0.92	0.05	0.22	0.09	99.5	1	
33	178-200	55.3	16.0	1.10	2.31	2.49	9.34	0.54	0.20	3.35	7.82	0.66	0.13	<0.07	<0.2	0.03	0.23	0.12	99.9	6	hybrid

34	179-16	56.0	19.4	1.81	6.03	4.46	4.44	0.66	0.18	2.14	3.50	0.76	0.13	0.11	0.62	0.03	0.19	0.14	100.7	4	
35	179-35	45.5	7.58	11.8	13.2	1.11	3.84	1.17	0.25	5.63	7.71	1.34	0.12	0.11	1.44	0.01	0.25	0.10	101.2	1	pyroxenite
36	180-53	61.0	17.3	0.97	3.38	5.35	6.40	0.38	0.10	0.89	2.36	0.57	0.13	0.37	0.39	0.02	0.08	0.06	99.7	6	
37	180-77	64.9	18.4	0.06	0.47	3.64	10.9	0.07	0.03	0.08	0.88	0.28	0.09	0.07	<0.2	0.01	0.04	0.03	100.2	7	
38	181-112	72.2	15.0	0.29	0.90	6.32	3.83	0.13	0.03	0.13	0.83	0.28	0.12	0.26	<0.2	0.02	0.16	0.04	100.7	9	
39	195-38B	66.7	15.8	1.31	3.85	3.76	3.64	0.39	0.08	1.41	2.21	0.70	0.32	<0.07	0.41	<0.01	0.22	0.04	101.0	5	
40	195-41	73.8	14.4	0.25	1.68	3.82	4.02	0.18	0.05	0.23	0.93	0.32	0.25	<0.07	0.34	0.03	0.12	0.03	100.4	9	dyke
41	197-103	60.8	18.4	0.83	3.40	5.52	5.57	0.39	0.12	1.25	2.23	0.45	0.17	<0.07	0.39	0.02	0.16	0.15	99.9	6	hybrid
42	197-122C	54.5	16.7	2.56	6.20	5.10	3.37	0.75	0.23	3.08	4.95	0.72	0.19	<0.07	0.48	<0.01	0.03	0.13	101.5	3	
43	DOT-123	58.0	17.4	2.59	6.87	3.89	2.23	0.66	0.15	3.07	3.26	0.61	0.20	0.07	0.69	<0.01	0.17	0.09	100.0	4	in NTS 94C
44	KIP-206	58.1	18.2	2.42	5.90	3.97	2.65	0.67	0.13	2.79	3.27	0.88	0.21	<0.07	0.64	0.03	0.27	0.08	100.2	3	
45	LOR-180C	74.0	13.9	0.03	0.41	4.62	5.25	0.08	0.01	0.00	0.68	0.15	0.11	0.37	<0.2	<0.01	0.08	0.03	99.9	9	dyke
46	F-72-5	58.4	17.2	1.85	3.18	4.13	7.41	0.96	0.10	3.65	1.52	0.86	0.12	0.04	0.60	<0.01	0.031	0.036	100.0	8	
47	F-72-17	57.3	17.4	1.65	3.38	3.30	8.19	0.66	0.09	3.00	2.51	0.15	0.10	0.03	0.75	<0.01	0.084	0.076	98.7	8	
48	F-72-34	59.2	17.4	1.61	2.86	4.12	7.78	0.89	0.09	3.57	1.16	1.56	0.07	0.04	0.63	<0.01	0.022	0.033	101.0	8	
49	F-72-42	53.3	15.9	6.32	10.72	3.91	0.27	0.86	0.16	5.93	0.76	1.24	0.17	0.07	0.37	<0.01	0.006	0.089	100.1	B	
50	F-72-60	69.5	15.8	0.10	0.55	5.29	5.76	0.14	0.01	1.00	0.89	0.32	0.13	0.03	0.12	<0.01	0.006	0.003	99.7	9	
51	F-72-64	63.4	18.0	0.33	1.52	5.59	6.32	0.31	0.08	2.57	0.72	0.21	0.22	0.02	0.12	0.01	0.005	0.009	99.4	8	
52	F-72-66	72.1	14.7	0.04	0.17	4.42	5.64	0.08	0.03	0.43	1.23	0.35	0.10	0.03	0.10	<0.01	0.006	0.002	99.5	9	
53	F-72-70	60.1	17.9	0.87	9.33	4.33	0.62	0.61	0.15	2.86	0.73	1.20	0.13	0.02	0.20	0.01	0.017	0.077	99.0	B	
54	F-72-93	45.5	13.7	9.29	11.69	1.26	1.71	1.02	0.21	8.86	4.35	1.13	0.14	0.02	0.08	0.02	0.025	0.055	99.1	1	
55	F-72-98	52.9	16.4	3.93	6.88	3.86	3.21	1.03	0.17	5.50	2.50	1.06	0.19	0.02	0.66	0.01	0.031	0.023	98.3	2	
56	F-72-101	58.0	17.2	2.20	5.73	3.83	3.71	0.79	0.14	2.93	3.54	0.24	0.13	0.06	0.45	<0.01	0.063	0.062	99.1	B	
57	F-72-108	48.6	16.9	5.30	10.38	3.17	1.70	0.78	0.20	4.50	5.02	1.62	0.26	0.03	0.48	0.10	0.031	0.125	99.3	B	
58	F-72-151	68.7	16.8	0.70	4.72	5.08	0.54	0.31	0.08	0.57	0.62	0.01	0.17	0.21	0.17	<0.01	0.014	0.095	98.8	5	
59	F-72-159	64.6	16.4	1.20	3.68	4.24	3.57	0.42	0.07	1.36	1.87	0.01	0.14	0.10	0.23	<0.01	0.063	0.064	98.0	5	
60	F-72-186	64.0	17.2	1.14	3.75	4.64	3.60	0.42	0.09	1.22	2.09	0.11	0.10	0.03	0.23	<0.01	0.078	0.078	98.7	5	
61	F-72-194	66.3	17.4	0.99	3.29	4.04	3.52	0.37	0.10	1.36	1.79	0.01	0.10	0.02	0.24	<0.01	0.070	0.073	99.7	5	
62	F-72-215	51.6	14.3	4.91	8.31	2.19	5.48	0.73	0.27	4.29	5.93	0.62	0.16	0.08	0.50	0.02	0.053	0.114	99.6	B	
63	F-72-219	58.9	17.4	2.19	3.54	5.94	2.44	0.58	0.12	1.50	4.81	0.46	0.22	0.33	0.42	<0.01	0.051	0.099	98.9	B	
64	F-72-240	52.6	17.9	4.17	7.72	3.17	2.53	1.06	0.19	5.22	3.83	0.69	0.11	0.06	0.39	0.03	0.057	0.066	99.8	3	
65	F-72-257	44.5	18.7	4.46	14.32	2.31	0.77	0.61	0.13	4.29	7.37	0.05	0.06	0.07	0.76	0.02	0.014	0.195	98.7	1	
66	F-72-271	53.7	17.3	3.69	7.24	3.74	3.25	0.85	0.17	4.29	3.45	0.49	0.09	0.03	0.48	<0.01	0.050	0.118	99.0	3	
67	F-72-278	57.0	18.5	2.03	5.89	4.48	3.56	0.73	0.12	2.72	3.41	1.09	0.19	0.02	0.36	0.02	0.060	0.106	100.3	3	
68	F-72-285	62.1	17.9	1.48	4.92	4.79	2.79	0.54	0.13	2.14	1.97	0.69	0.14	0.01	0.27	<0.01	0.063	0.079	99.9	4	
69	F-72-296	62.2	14.9	1.42	3.42	3.86	4.49	0.43	0.11	1.50	2.06	1.12	0.14	0.04	0.21	0.02	0.051	0.028	96.0	9	hybrid
70	F-72-299	55.0	18.1	3.31	6.92	4.31	2.32	0.67	0.14	4.14	2.99	0.54	0.28	0.19	0.39	0.01	0.056	0.086	99.4	4	
71	F-72-300	76.6	12.7	0.17	0.66	3.90	4.42	0.15	0.03	0.29	0.45	0.21	0.12	0.24	0.11	<0.01	0.005	0.006	100.1	9	
72	F-72-322	54.7	18.1	2.70	6.41	4.33	3.59	0.80	0.17	3.50	3.72	0.89	0.12	0.04	0.44	0.02	0.054	0.109	99.6	4	
73	F-72-330	75.3	13.0	0.06	0.30	4.04	4.40	0.03	0.01	0.14	0.30	0.32	0.07	0.03	0.12	0.02	0.013	0.006	98.2	9	

A. CHEMICAL ANALYSES OF HOGEM INTRUSIVE ROCKS AND TAKLA VOLCANIC ROCKS *(CONTINUED)*

Sample No.	Field No.	SiO_2	Al_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	FeO	Fe_2O_3	H_2O+	H_2O-	CO_2	P_2O_5	S	BaO	SrO	Total	Rock Unit	Remarks
74	F-72-337	59.9	15.3	2.98	4.87	2.90	3.12	0.86	0.16	3.93	3.80	1.40	0.26	0.03	0.35	0.01	0.075	0.069	100.1	4	
75	F-72-341	57.2	18.4	2.02	5.89	4.50	3.57	0.68	0.11	2.64	3.51	0.87	0.21	0.04	0.38	<0.01	0.060	0.109	100.2	4	
76	F-72-348	49.9	16.1	5.10	9.06	2.80	3.25	0.83	0.20	4.79	4.94	1.70	0.07	0.03	0.48	0.01	0.038	0.099	99.4	1	
77	F-72-362	61.8	15.9	3.38	4.28	3.91	2.71	0.42	0.11	2.36	2.35	1.08	0.14	0.05	0.29	0.02	0.048	0.118	98.9	B	
78	F-72-369	61.8	16.8	1.98	3.87	3.53	4.12	0.54	0.12	2.43	2.83	1.35	0.24	0.03	0.31	0.02	0.054	0.076	100.1	4	
79	F-72-372	51.7	14.6	5.72	8.83	2.87	3.42	0.79	0.17	5.43	3.70	1.40	0.13	0.03	0.49	0.02	0.041	0.102	99.4	3	
80	F-72-393	56.3	17.5	2.32	5.79	3.83	4.11	0.65	0.14	3.07	3.71	1.09	0.19	0.09	0.43	0.02	0.059	0.116	99.5	4	
81	G-72-5	51.2	15.1	4.86	8.12	2.56	4.47	0.85	0.18	4.93	3.61	2.03	0.30	0.05	0.54	0.01	0.053	0.109	98.9	B	
82	G-72-7	60.6	14.6	2.47	6.64	4.31	3.06	0.61	0.09	4.08	0.63	1.31	0.20	0.04	0.49	<0.01	0.053	0.090	99.3	B	
83	G-72-11	46.2	14.6	7.60	12.60	1.69	1.23	1.06	0.22	8.30	3.93	1.41	0.19	0.37	0.46	0.04	0.028	0.079	100.0	1	
84	G-72-20	50.0	19.0	4.33	8.21	4.05	1.57	0.88	0.13	6.07	1.42	2.36	0.14	0.03	0.40	0.67	0.032	0.106	99.3	B	
85	G-72-25	43.0	12.2	9.45	13.99	0.75	1.43	0.82	0.29	7.94	5.67	2.08	0.18	0.05	0.67	0.04	0.022	0.073	98.7	1	
86	G-72-26	67.2	16.0	0.19	0.79	5.09	5.64	0.11	0.08	1.43	1.41	0.46	0.22	0.21	0.13	<0.01	0.004	0.005	99.0	9	
87	G-72-39	58.9	18.1	1.59	2.97	4.41	6.80	0.59	0.07	3.00	1.57	0.74	0.08	0.03	0.46	0.01	0.036	0.053	99.4	8	
88	G-72-46	46.6	14.4	7.44	12.65	1.66	1.23	0.99	0.21	8.22	3.92	1.55	0.15	0.03	0.46	<0.01	0.026	0.073	99.6	B	
89	G-72-52	54.4	15.4	5.05	6.28	3.13	5.19	0.63	0.14	4.86	2.45	0.85	0.18	0.05	0.61	0.01	0.057	0.053	99.3	2	
90	G-72-55	72.8	15.0	0.05	0.75	4.80	5.12	0.06	0.02	0.72	0.59	0.40	0.15	0.03	0.10	<0.01	0.018	0.010	100.6	9	
91	G-72-61	54.3	15.9	4.22	7.57	3.22	3.60	0.77	0.16	6.07	2.03	1.41	0.14	0.01	0.49	<0.01	0.044	0.066	100.0	2	
92	G-72-66	58.3	18.2	1.98	4.01	3.94	6.65	0.46	0.07	2.21	2.20	0.64	0.11	0.02	0.67	0.02	0.112	0.111	99.6	8	
93	G-72-72	54.7	15.5	4.77	7.00	3.47	4.40	0.79	0.16	6.36	1.15	0.98	0.09	0.04	0.48	<0.01	0.049	0.073	100.0	2	
94	G-72-76	70.1	15.7	0.34	0.40	4.22	5.79	0.08	0.02	0.78	1.00	1.25	0.25	0.35	0.13	<0.01	0.013	0.008	100.4	9	
95	G-72-88	54.5	16.7	3.52	6.85	3.29	3.80	0.93	0.19	6.57	1.15	1.80	0.20	0.04	0.44	0.02	0.061	0.066	100.1	2	
96	G-72-115	63.3	16.9	1.18	3.33	4.33	3.89	0.39	0.09	1.29	2.22	1.19	1.50	0.16	0.22	<0.01	0.090	0.069	100.2	5	
97	G-72-116	56.6	14.6	3.02	4.20	3.36	2.42	0.70	0.09	5.54	1.36	3.34	1.75	1.49	0.38	0.61	0.077	0.069	99.5	B	
98	G-72-133	53.5	17.6	2.93	7.35	3.90	3.78	0.90	0.16	4.08	4.00	1.54	0.18	0.06	0.49	<0.01	0.077	0.114	100.6	3	
99	G-72-143	50.4	16.1	4.70	9.48	3.17	2.02	0.91	0.19	4.88	4.74	1.68	0.14	0.16	0.56	<0.01	0.049	0.146	99.3	1	
100	G-72-153	65.6	15.7	1.35	2.70	3.56	4.25	0.51	0.04	1.79	2.11	1.16	0.36	0.09	0.10	<0.01	0.054	0.059	99.4	9	hybrid
101	G-72-157	75.6	11.5	0.48	1.46	3.67	4.15	0.06	0.02	0.29	0.37	0.27	0.10	0.78	0.55	0.05	0.034	0.006	99.4	9	
102	G-72-172	53.9	16.4	3.91	6.82	3.77	3.98	0.88	0.16	4.75	3.26	0.72	0.12	0.04	0.22	<0.01	0.054	0.085	99.1	3	
103	G-72-188	57.9	18.7	1.47	4.49	3.99	5.74	0.59	0.11	2.07	2.82	1.64	0.20	0.31	0.31	<0.01	0.087	0.099	100.2	4	
104	G-72-191	53.7	16.2	3.91	6.83	3.83	3.97	0.87	0.16	4.93	3.04	0.66	0.20	0.05	0.53	0.01	0.054	0.083	99.1	3	
105	G-72-196	76.5	13.2	0.05	0.38	3.59	4.94	0.08	0.01	0.21	0.12	0.27	0.13	0.04	0.10	0.04	0.003	0.0025	99.7	9	
106	G-72-203	62.9	18.1	0.91	4.48	5.07	3.10	0.39	0.10	1.36	1.85	0.33	0.22	0.05	0.20	0.01	0.068	0.106	99.2	5	
107	G-72-212	61.4	14.7	2.73	6.97	2.94	0.29	0.71	0.12	4.65	1.74	1.66	0.13	0.04	0.24	0.47	0.011	0.026	98.8	B	
108	CHUCHI	55.6	17.3	3.06	5.37	3.90	5.61	0.81	0.12	4.29	1.99	0.63	0.15	0.05	0.58	0.01	0.066	0.069	99.6	2	

109	CUESTA	65.3	16.6	1.20	3.90	4.11	3.12	0.42	0.09	1.43	1.81	0.53	0.14	0.06	0.20	0.02	0.060	0.083	99.1	5	
110	FOX-13	54.1	17.9	2.70	6.19	4.27	3.66	0.78	0.19	3.43	3.69	0.91	0.10	0.04	0.55	<0.01	0.074	0.106	98.7	4	hybrid
111	L-72-7	73.6	14.2	0.03	0.41	4.91	4.75	0.08	0.01	0.43	0.76	0.28	0.06	0.03	0.11	<0.01	0.007	0.003	99.7	9	
112	L-72-26	55.7	16.2	3.20	5.47	3.99	5.35	0.83	0.16	5.29	2.08	0.59	0.09	0.02	0.49	0.01	0.036	0.046	99.5	8	
113	L-72-32	59.5	18.3	1.52	3.12	4.53	5.82	0.70	0.08	2.93	1.77	0.75	0.18	0.03	0.34	<0.01	0.050	0.052	99.7	8	
114	L-72-69	59.3	18.2	2.13	4.67	3.74	3.30	0.60	0.13	2.59	3.33	0.44	0.17	0.12	0.35	0.01	0.070	0.092	99.3	3	
115	L-72-80	56.6	17.8	2.56	4.54	4.40	3.53	0.65	0.15	3.50	2.71	1.12	0.08	0.40	0.38	0.03	0.069	0.072	98.6	3	
116	L-72-83	56.5	18.1	1.87	5.62	5.24	3.99	0.65	0.11	2.86	2.22	1.01	0.13	0.22	0.41	0.08	0.073	0.088	99.3	B	
117	L-72-94	69.5	15.6	0.90	1.60	4.85	3.44	0.28	0.03	1.21	0.76	0.87	0.13	0.22	0.18	<0.01	0.098	0.053	99.7	5	
118	L-72-98	56.7	17.7	2.58	4.56	4.40	3.56	0.61	0.15	3.50	2.78	1.15	0.16	0.39	0.37	0.03	0.060	0.072	98.8	B	
119	L-72-100	50.2	17.6	4.08	5.33	3.85	3.62	0.80	0.16	3.98	4.46	2.54	0.12	0.97	0.36	<0.01	0.059	0.053	98.2	B	
120	L-72-101	58.0	18.4	1.77	3.72	4.68	4.72	0.58	0.12	2.59	2.59	0.85	0.09	0.15	0.39	<0.01	0.050	0.083	98.8	4	
121	L-72-102	49.5	12.4	5.74	7.65	2.60	4.27	1.28	0.31	6.97	6.78	1.55	0.13	0.06	1.06	0.01	0.026	0.043	100.4	1	
122	L-72-107	57.2	16.2	2.79	5.14	3.68	4.51	0.79	0.17	4.88	2.51	1.17	0.09	0.45	0.49	<0.01	0.059	0.056	100.2	4	
123	L-72-122	54.2	16.1	4.01	7.64	5.10	1.13	0.81	0.17	4.75	2.28	2.10	0.42	0.32	0.24	0.08	0.029	0.069	99.5	B	
124	L-72-129	58.3	17.3	2.56	4.91	4.02	3.68	0.70	0.13	3.41	2.91	1.38	0.16	0.04	0.39	<0.01	0.063	0.069	100.0	4	
125	L-72-137	64.8	15.7	1.35	2.92	4.19	4.12	0.46	0.07	1.53	2.01	1.19	0.14	0.05	0.22	<0.01	0.074	0.043	99.0	5	
126	L-72-141	67.1	16.1	1.06	3.23	3.87	3.76	0.36	0.06	1.33	1.54	1.24	0.21	0.18	0.20	0.01	0.056	0.050	100.3	5	
127	L-72-143	49.6	17.8	3.95	7.28	4.14	1.21	0.96	0.21	2.29	7.19	2.72	0.35	0.49	0.41	0.03	0.031	0.073	98.8	B	
128	L-72-153	52.1	15.4	4.09	7.44	3.26	3.38	0.98	0.19	4.80	4.56	1.43	0.13	0.04	0.45	0.01	0.073	0.085	98.4	4	
129	G-73-25	51.1	17.2	3.63	8.00	3.25	3.22	0.92	0.21	5.80	4.62	0.65	0.25	0.21	0.69	<0.01	0.18	0.11	100.1	2	

APPENDIX II.

B. METHODS OF ANALYSIS

SILICATE ANALYSIS (MINISTRY OF MINES AND PETROLEUM RESOURCES)

1. For SiO_2, Al_2O_3, TiO_2, total Fe, MnO, MgO, CaO, Na_2O, K_2O, BaO, and SrO:

   (1) 0.2 gm of sample is fused in 1 gm of $LiBO_2$ for 20 minutes at 1050° C to 1100° C.

   (2) The fused mixture is extracted c 4% HNO_3 for 1 hour, then 5 ml of 60% HF and 20 ml of 50 gm/l boric acid solution and 10 ml of 20 000 ppm CsCl.

   (3) The sample is bulked to 200 ml c 4% HNO_3 and immediately put into plastic bottles.

   (4) Multi-element standards (12) are made up to give a range of matrices covering those usually found in the samples submitted.

   (5) The batches are 36 samples consisting of 3 blanks and 3 C.G.S. standards and 30 unknowns (including duplicates) in each set.

   (6) Each element is measured on the A.A. 3 or 4 times and the standards are measured 5 or 7 times.

   (7) Na and K are analysed using an air-acetylene flame and all the rest are run using a N_2O-acetylene flame. Instrumental parameters are adjusted individually for each element to minimize interferences and maximize precision.

   (8) The data are processed in the government computer and statistical information on analytical precision, variance, and related details is computed and sent to the geologist with his results. The analytical precision is calculated on the basis of the replicated results of all of the standards and the samples. The program works on the basis of drift-corrected data with the variance due to flame noise and changes being the major factor to be corrected for.

   The average performance experiences is $<$1% relative standard deviation using this technique.

2. Ferrous iron is determined by boiling in H_2SO_4 and HF and titrating with $KMnO_4$. Ferric iron is determined by difference between this ferrous iron result and the total iron result obtained by the above A.A. method. The average performance is ±0.1% (1.2% ± 0.1% for example).

3. CO_2 and SO_2 are determined by volumetric and titration methods respectively using a Leco induction furnace with standard automatic Leco carbon analyser and sulphur analyser attachments. The CO_2 and SO_2 detection limits are 0.01% and relative standard deviation over 2 or 3 times the detection limit are about 5%.

4. P_2O_5 is done quantitatively on an A.R.L. 3-metre grating emission spectrograph. Detection limits are 0.1% and the relative standard deviation is about 10% at 2 or 3 times the detection limit.

5. Total H_2O is run by fusing 1 gm of sample with 2.5 gm of Li_2CO_3 in a pyrex test tube over a bunsen flame. The water released is captured in a tared $MgCLO_4$ U-trap and the water is determined by re-weighing. The detection limit is about 0.1% and the precision is ±0.2% absolute (for example, 3.5% ± 0.2%).

   The H_2O figure is obtained by weighing a sample before and after drying at 105° C with a detection limit of 0.02% and the precision is ±0.05 (for example, 0.5% ± 0.05%). The difference between this figure and the total water is the H_2O+ value and the uncertainties of both go into this figure.

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GEOLOGY OF THE SOUTHERN HOGEM BATHOLITH
Geology by
J.A. GARNETT, 1971-1973
FIGURE 3
KILOMETRES 0 1 2 3 4 5 6 KILOMETRES
1:125000
LEGEND
RECENT
E GLACIAL OVERBURDEN
LOWER CRETACEOUS
USLIKA FORMATION
D SANDSTONE, CONGLOMERATE
HOGEM BATHOLITH
9 LEUCOCRATIC GRANITE, QUARTZ SYENITE, ALASKITE
PHASE III
LOWER/MIDDLE JURASSIC
CHUCHI SYENITE:
8 LEUCOCRATIC SYENITE, QUARTZ SYENITE
PHASE II
DUCKLING CREEK SYENITE COMPLEX:
7 MAINLY LEUCOCRATIC SYENITE
6 MAINLY FOLIATED, MIGMATITIC SYENITE
UPPER TRIASSIC/LOWER JURASSIC
HOGEM GRANODIORITE:
5 GRANODIORITE, QUARTZ MONZODIORITE; minor tonalite, quartz diorite, quartz monzonite, granite
HOGEM BASIC SUITE:
PHASE I
4 MONZONITE, QUARTZ MONZONITE
3 MONZODIORITE, QUARTZ MONZODIORITE
NATION LAKES PLAGIOCLASE PORPHYRY:
2a (a) MONZONITE
2b (b) MONZODIORITE
1 DIORITE; minor gabbro, pyroxenite, hornblendite
TAKLA GROUP
C MAINLY INTERBANDED BLACK ARGILLITE, BROWN SILTSTONE AND SHALE; minor limestone
B MAINLY DARK GREEN ANDESITIC AND BASALTIC VOLCANIC ROCKS, TUFFS, AND BRECCIAS, INTERBEDDED WITH FLOW ROCKS AND COMMONLY CUT BY PYROXENE AND FELDSPAR PORPHYRY DYKES
PERMIAN
CACHE CREEK GROUP
A MASSIVE LIMESTONE, DOLOMITE; minor gabbro, serpentinite, quartzite
SYMBOLS
SPECIMEN COLLECTION SITE
CHEMICAL ANALYSIS
RADIOMETRIC SAMPLE SITE
PINCHI FAULT ZONE, APPROXIMATE TRACE
FRACTURE TRACE LINEAR, INFERRED
GEOLOGICAL CONTACTS, APPROXIMATE
INTRUSIVE BOUNDARIES, MAINLY GRADATIONAL
BRITISH
MAP AREA
ALBERTA
COLUMBIA
U. S. A.
LOCATION MAP
125° 30'
125° 00'
55° 45'
55° 30'
55° 15'
OMINECA RIVER
OLD HOGEM
MOUNT NATION
CHUCHI MOUNTAIN
TCHENTLO LAKE
CHUCHI LAKE
MT. ALEXANDER
JEAN MARIE STOCK
Tsayta Lake
Indata Lake
Albert Lake
Takatoot Lake
Klawli Lake
Airline Lake
Kloch Lake
Silver Lake
Byrnes Lake
Duckling Creek
Kwanika Creek
Haholin Creek
Ahdatay Lake
TO ACCOMPANY BULLETIN 70

Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

FIGURE 5

MINERAL OCCURRENCES AND SAMPLE LOCATIONS, SOUTHERN HOGEM BATHOLITH

Kilometres 0 1 2 3 4 5 6 Kilometres
1:125 000

SIGNIFICANT MINERAL OCCURRENCES ASSOCIATED WITH THE SOUTHERN HOGEM BATHOLITH

PROPERTY NAME	COMMODITY	MINERAL INVENTORY NUMBER – 93N
TAM, HAM, REM	Cu	93, 180
LORRAINE	Cu	2
MISTY	Cu	1
RONDAH	Cu, Mo	5
DUCKLING	Cu	89
TWIN	Cu	82
BURN	Mo, Cu	107
KWANIKA	Cu, Mo	73, 110
BAL	Cu, Mo	68, 69
HEATH	Cu	71, 72
COL	Cu	101
JEAN	Cu, Mo	79, 83
SOONER	Mo, Cu	169
VECTOR	Cu, Mo	91, 92

● LOCATIONS WHERE CATALOGUED SAMPLES WERE TAKEN.
★ 1–11 – SAMPLE SITES OF K/Ar DATES, *SEE* APPENDIX I.
◉ 1–129 – SAMPLE SITES OF CHEMICAL ANALYSES, *SEE* APPENDIX II.

NOTE: FAULT AND GEOLOGIC CONTACTS ARE REPRODUCED FROM FIGURE 3, DETAILED GEOLOGY.

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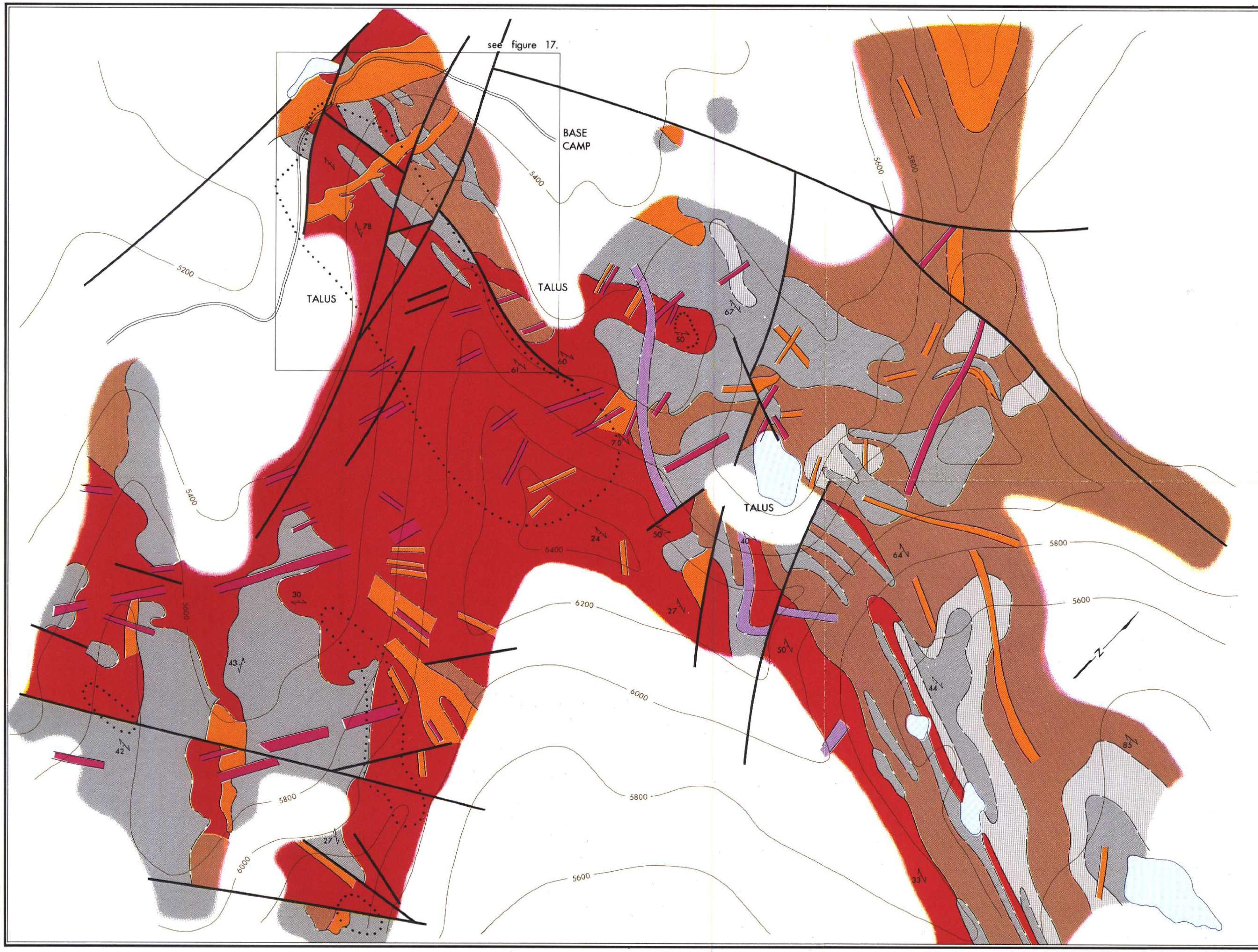
FIGURE 15

GEOLOGY OF THE LORRAINE COPPER DEPOSITS AND VICINITY – DUCKLING CREEK AREA



LEGEND

- LIGHT GREY FELDSPAR PORPHYRY DYKES
- PINK HOLOFELSIC GRANITE DYKES
- PINK HOLOFELSIC SYENITE DYKES, SILLS
- PINK TO GREY SYENITE MIGMATITE
- PINK AND BLACK FELDSPAR PYROXENITE PORPHYRY
- GREY–BLACK MONZONITE, DIORITE
- BLACK BIOTITE PYROXENITE

SYMBOLS

FOLIATION ....

FAULTS ....

CONTOURS (in feet) ....

GEOLOGICAL CONTACTS (approximate) ....

MINERALIZED ZONES ....

0 100 200 300 400
SCALE-METRES

TO ACCOMPANY BULLETIN 70

FIGURE 21

GEOLOGY OF THE KWANIKA PROPERTY

LEGEND

UPPER CRETACEOUS (?)

10 — **POLYMICT BOULDER CONGLOMERATE:** RED (HEMATITE) MATRIX; BOULDERS MAINLY GREEN-ALTERED, MEDIUM-GRAINED INTRUSIVE ROCK; MINOR BLACK ARGILLITE BOULDERS; BOULDERS APPEAR STEEPLY ORIENTED ALONG PINCHI FAULT TRACE

HOGEM BATHOLITH

LOWER CRETACEOUS

9 — **QUARTZ MONZONITE; GRANITE:** ORANGE, MEDIUM GRAINED LEUCOCRATIC TO HOLOFELSIC; LOCALLY PORPHYRITIC; HIGHLY FRACTURED AND FAULTED; RUSTY (PYRITE, LIMONITE); PERVASIVE SERICITIC ALTERATION OF FELDSPARS COMMON; CUT BY DARK GREEN-BLACK APHANITIC DYKES

LOWER JURASSIC

6a — **HYBRID QUARTZ-BEARING MONZONITE:** PINK-GREEN MOTTLED, LEUCOCRATIC, HIGHLY ALTERED (EPIDOTE, CHLORITE, SERICITE, POTASH FELDSPAR, BIOTITE); LOCALLY HIGHLY SILICIFIED AND PYRITIZED; MODERATE TO INTENSE FRACTURING ALONG COMPLEX CONTACTS WITH INTERFINGERING UNIT 9

6 — **MONZONITE; QUARTZ-BEARING MONZONITE:** GREY, ORANGE, BLACK MOTTLED, MEDIUM GRAINED, MAINLY LEUCOCRATIC; LOCALLY UP TO 40 PER CENT MAFIC MINERALS WITH MODERATE CHLORITE-EPIDOTE ALTERATION

5 — **MONZODIORITE; DIORITE:** GREY-BLACK, MEDIUM GRAINED, MAINLY MESOCRATIC (BIOTITE-HORNBLENDE); HAS QUARTZ-BEARING VARIETIES, LOCALLY FOLIATED; POTASH FELDSPATHIZED, SECONDARY BIOTITE ALTERATION; CUT BY PEGMATITIC EPIDOTE-QUARTZ-FELDSPAR DYKES, QUARTZ DIORITE DYKES

UPPER TRIASSIC

TAKLA GROUP

2 — **BANDED ARGILLITE:** BROWN-BLACK, LOCALLY CONTORTED, CUT BY FELSIC DYKES; MINOR GREYWACKE, LIMESTONE

PERMIAN

CACHE CREEK GROUP

1a;1b — **LIMESTONE:** GREY, MASSIVE; MINOR GABBRO, SERPENTINITE

SYMBOLS

GEOLOGICAL CONTACTS: APPROXIMATE, ASSUMED . . . .

JOINTS . . . .

FOLIATIONS . . . .

BEDDING . . . .

MINOR FAULTS . . . .

PINCHI FAULT ZONE: APPROXIMATE TRACE . . . .

OUTCROP AREAS INVESTIGATED . . . .

MAPPABLE RUBBLE AREA . . . .

AREAS OF GEOLOGICAL INTERPOLATION . . . . COLOURED AREA

AREAS OF OVERBURDEN COVER . . . . NO COLOUR

DIAMOND-DRILL HOLE LOCATION: VERTICAL, INCLINED . . . .

PERCUSSION-DRILL HOLE . . . .

PYRITE, CHALCOPYRITE, MOLYBDENITE, CINNABAR, CHROMITE . . . . py, cp, mo, Hg, Cr