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Geology of the Nicola Group between Merritt and Princeton

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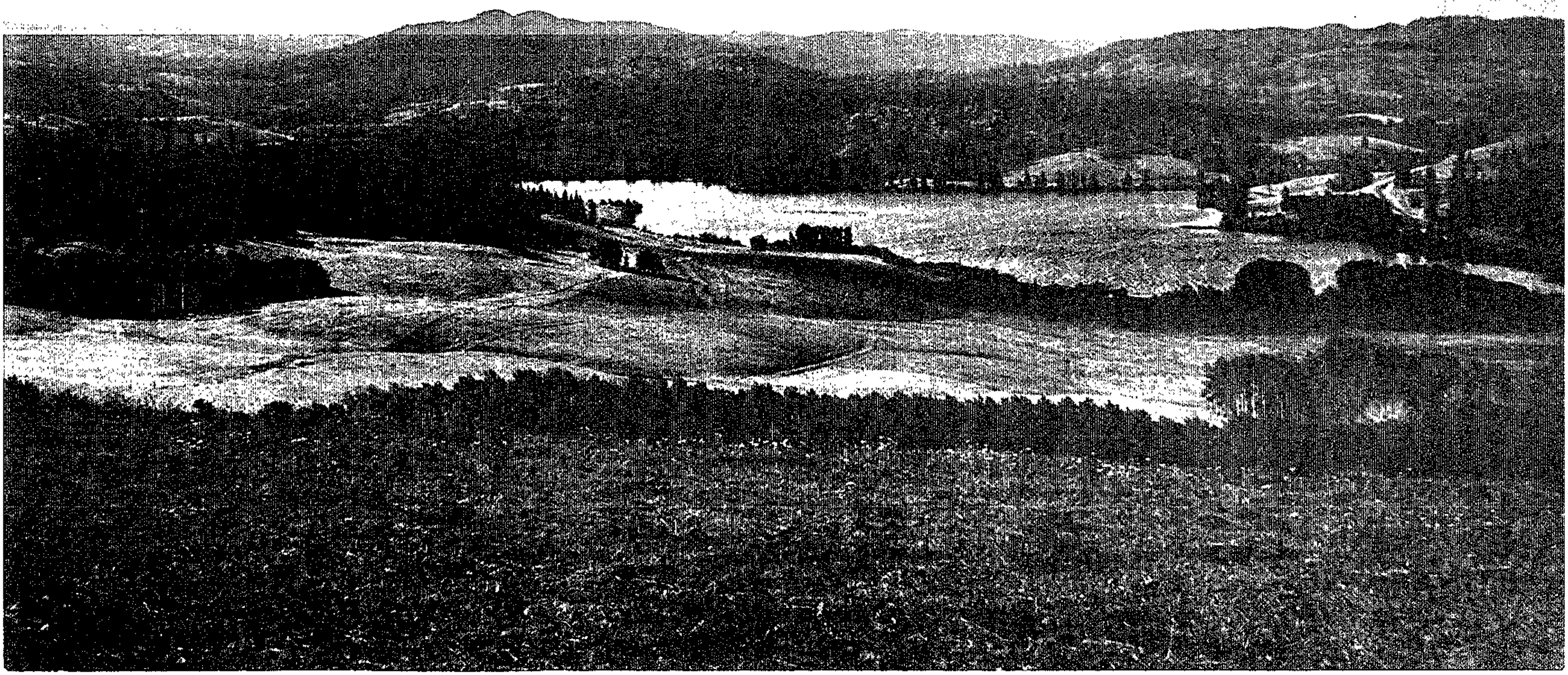

Frontispiece

View southward toward Fairweather Hills from north of Courtney Lake.

Geology of the Nicola Group between Merritt and Princeton

SUMMARY

This bulletin outlines the geology of the central part of the Upper Triassic Nicola Group between Nicola Lake and Princeton. The study area covers approximately 650 square kilometres and extends from latitude 49° 32′ 00″ north to 50° 07′ 30″ north and from longitude 120° 30′ 00″ west to 120° 41′ 00″ west.

Within this area the Nicola Group consists of three north-trending structural belts bounded by major faults and including rock units of varied lithology but similar composition and mode of origin.

The Central Belt, exemplified by subaerial and submarine assemblages in the Aspen Grove area, comprises extensive pyroxene and plagioclase-rich andesitic and basaltic flows, breccia, conglomerate, and lahar deposits. Comagmatic intrusive rocks are mostly diorite with subordinate syenite.

The Eastern Belt consists of submarine volcanic sedimentary rocks in the north but is dominated in the south by extensive lahar deposits, some basaltic flows, and high-level syenitic stocks.

The Western Belt consists of flow and pyroclastic rocks ranging in composition from andesite to rhyolite and interbedded with limestone, volcanic conglomerate, and sandstone which contain marine fossils of Lower and Middle Norian age.

Central and Eastern Belt rocks include both alkalic and calc-alkalic suites which were derived from comagmatic intrusions within these belts. Western Belt rocks, though mapped only in limited extent, appear to be distinctly calc-alkaline and derived from sources outside the study area.

Younger stratified rocks, ranging in age from Lower–Middle Jurassic to Recent, lie either in fault contact with Nicola strata or overlie them unconformably. The most conspicuous

of these later suites is a succession of Lower Cretaceous intermediate to acid continental *volcanic rocks with associated sedimentary and intrusive rocks which correlates with the* Kingsvale Group.

Most Nicola rocks are massive, non-foliated, and weakly metamorphosed. Metamorphic assemblages range from the quartz-prehnite subfacies of the prehnite-pumpellyite facies, locally transitional to greenschist facies, to rocks which are barely altered. Analcite phenocrysts are still preserved in some trachybasalt flows.

The structure of the study area is dominated by two major fault systems: the Alleyne–Summers Creek system to the east and the Allison system to the west. These faults are interpreted to represent an ancient, long-lived rift system which determined the extent and distribution of Nicola rocks and along which basins of continental volcanism and sedimentation formed in Early Tertiary time.

Copper mineralization is widespread in Nicola rocks and all deposits of economic importance are considered to be related to these strata in their origin. Within the study area, the Central Belt is the richest in mineral occurrences, though appreciable mineralization is also found in the southern part of the Eastern Belt. Eleven groups of mineral occurrences and deposits, separated on the basis of mineralogy, host rocks, and mode of occurrence, are outlined in this report.

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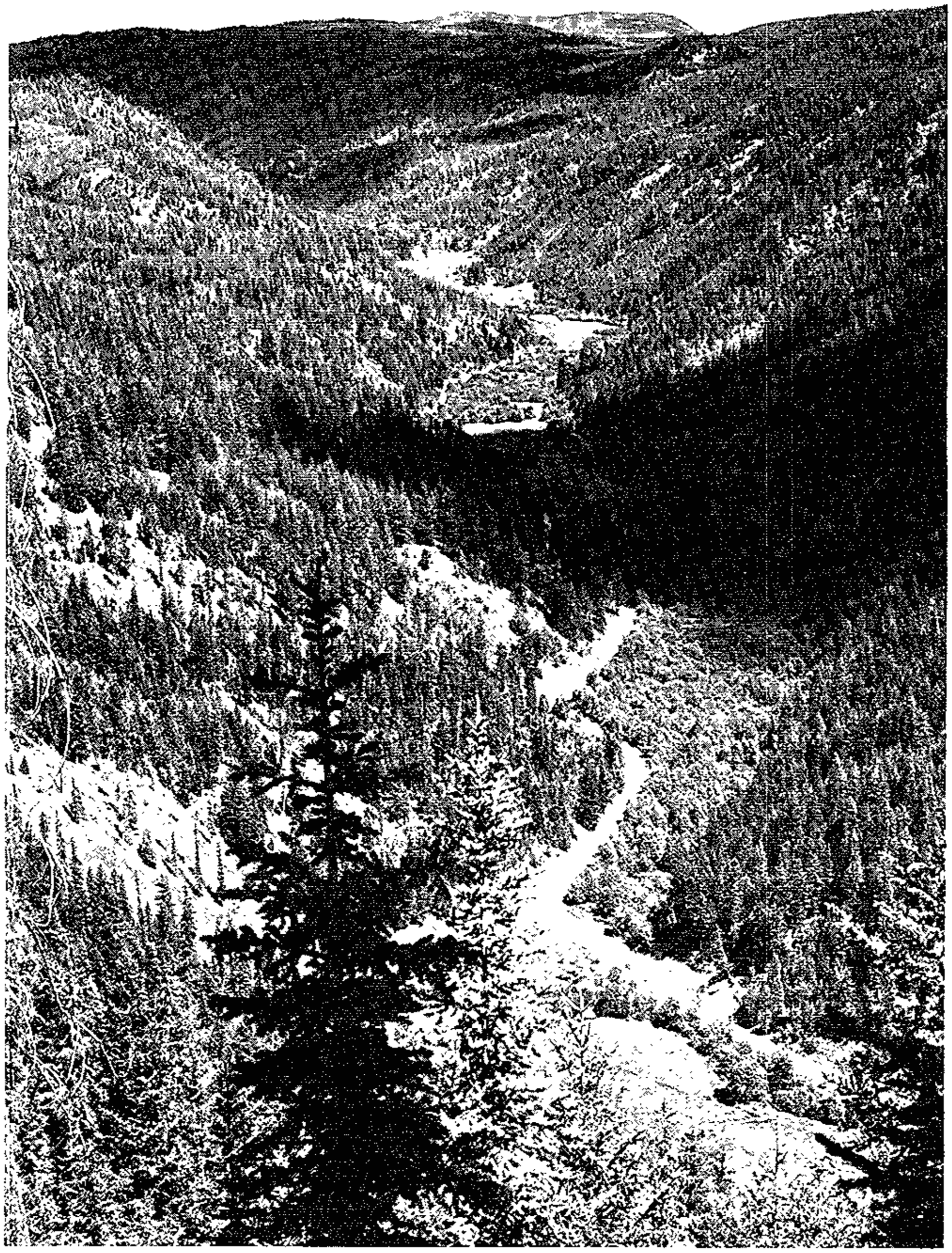

Plate I. Valley of Summers Creek south of Missezula Lake, looking north.

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INTRODUCTION

GENERAL STATEMENT

This bulletin is a summary progress report of work completed to date on the Nicola Project by the writer and by others under his supervision. Preliminary maps with marginal notes (Christopher, 1973; Preto, 1974, 1975, 1976) and a thesis (Lefebure, 1976) have been published separately, but all work is consolidated in this report.

Although the present mapping covers approximately 650 square kilometres of the Nicola Group, it represents only a small portion of a very complex and varied terrain that will undoubtedly continue to attract the interest of geologists for many years and stimulate discussion and controversy.

LOCATION, ACCESS, TOPOGRAPHY, AND DISTRIBUTION OF OUTCROP

The area mapped extends as a narrow strip from the hills immediately east of Merritt to the confluence of Summers and Allison Creeks, 8 kilometres north of Princeton (Fig. 2). It is bound by latitude 49° 32′ 00″ north and 50° 07′ 30″ north, and by longitude 120° 30′ 00″ west and 120° 41′ 00″ west. Highway 5 traverses the length of the map-area, and numerous secondary roads provide ready access to all other parts.

The topography is largely the result of the last period of glaciation and subsequent stream erosion. It is characterized by a relatively subdued and gentle upland deeply dissected by steep, northerly trending, V-shaped valleys.

The abundance and quality of rock exposures vary greatly over the area as roughly indicated on the geological map (Fig. 1, in pocket) but generally provide sufficient information for a reasonable understanding of the geology.

Plate II. View northward from the vicinity of Pothole Lake along the valley of Quilchena Creek; valley basalt of map unit 18 forms the flat bench in left foreground.

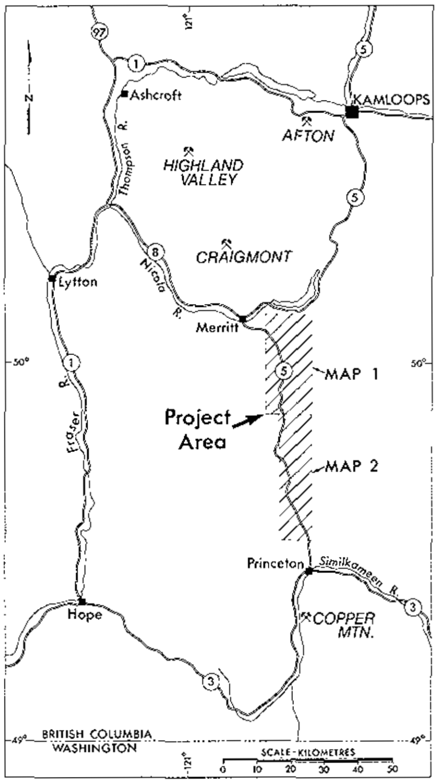


Figure 2. Location of project area.

PHYSIOGRAPHY

The map-area lies in the southern part of the Thompson Plateau (Holland, 1964), and is characterized by relatively gentle, heavily wooded upper slopes and deep, steep-sided, V-shaped north-south valleys. The drainage is dominated by north-trending streams: in the north by Quilchena Creek which drains into Nicola Lake, and in the south by Otter, Allison, and Summers Creeks, which all drain into the Similkameen River at Princeton, either directly or by way of the Tulameen River. The Summers Creek and Allison Creek valleys and, in part, the valleys of Otter and Quilchena Creeks, follow major faults. The

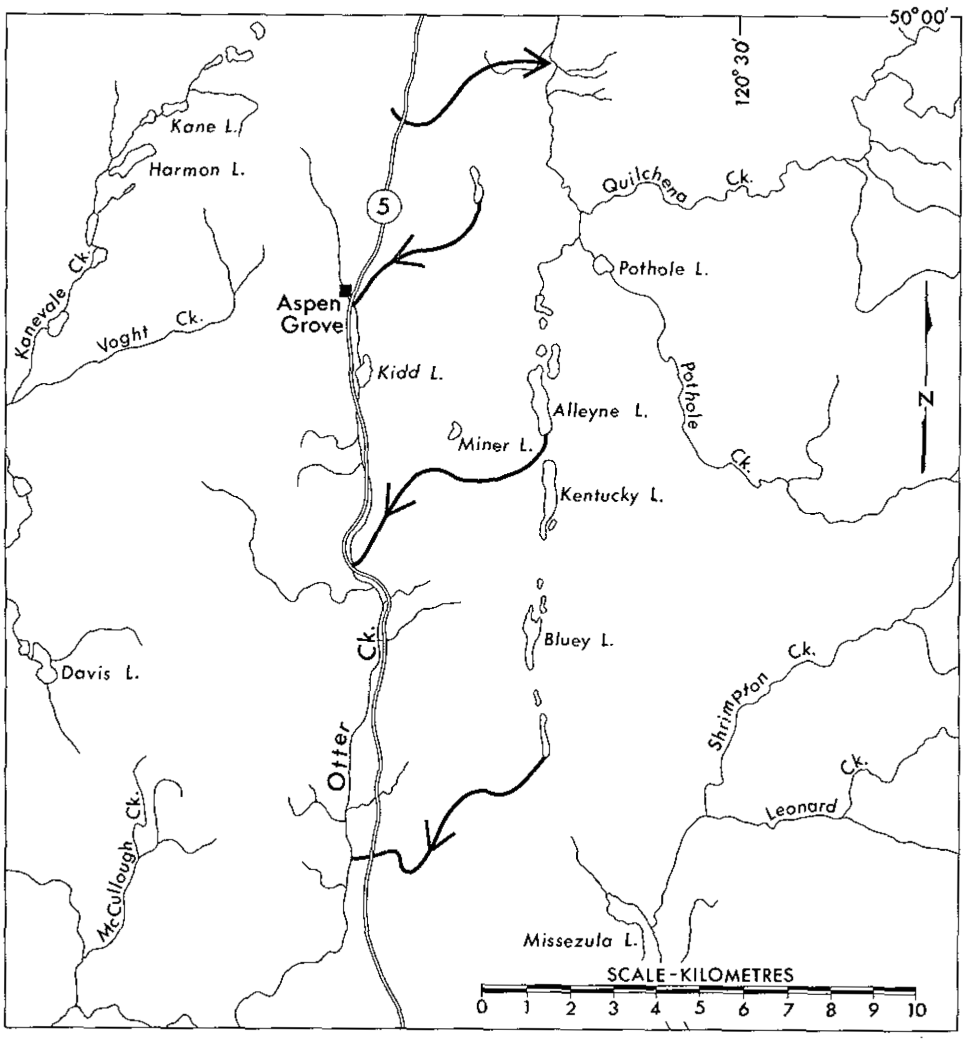


Figure 3. Pleistocene meltwater channels near Aspen Grove.

Plate III. Valleys connecting Kentucky Lake valley with Otter Creek valley mark the course of ancient westward-flowing meltwater channels.

former courses of at least three westward flowing streams, perhaps ancient meltwater rivers which flowed along the front of the northerly retreating Pleistocene ice sheet, are evident in the central part of the map-area (Fig. 3). The best preserved of these joins the valley of Otter Creek with that occupied by Alleyne and Kentucky Lakes 5 kilometres south of Aspen Grove. This valley still contains well-preserved outwash terraces but is no longer occupied by an active stream.

PREVIOUS WORK

The earliest geological work in the vicinity of Nicola Lake was done by G. M. Dawson in 1877 (1879). Later work in the region (R. A. Daly in 1901 to 1906, C. Camsell in 1906 to 1912, C. E. Cairnes between 1919 and 1923, H. S. Bostock from 1926 to 1930, and V. Dolmage in 1923) was mostly to the south along the International Boundary and in the vicinity of the Copper Mountain and Hedley mining camps.

The first comprehensive geological reports for the region are those of Rice (1947) and of Cockfield (1948) who respectively mapped the Princeton and Nicola map sheets between 1939 and 1944.

During 1960 and 1961 a consortium of Vancouver-based mining companies (Fahrni, 1962) initiated a study of Nicola rocks between Stump Lake and the International Boundary in an effort to subdivide the volcanic rocks and solve their structure. Work by the same interests continued in 1962 in a small area immediately north of the Princeton Tertiary Basin (Ball, 1963), and in 1963 in the Aspen Grove area (Hillhouse, 1964).

In 1965, 1966, and 1967, M. P. Schau (1968, 1971) mapped in detail an area of some 1 200 square kilometres centred on the village of Quilchena and including Dawson's original type area of the Nicola Group. This work laid the foundation for detailed mapping of Nicola geology and represents the first determined effort at subdividing volcanic units, solving their structure, and understanding their environment of deposition.

PRESENT WORK

Although the writer had been engaged since 1967 in mapping of Nicola volcanic and associated intrusive rocks between Kamloops and Copper Mountain (Preto, 1972; *Minister of Energy, Mines & Pet. Res., B.C.,* Ann. Repts., 1967, 1968; *B.C. Ministry of Energy, Mines & Pet. Res.,* GEM, 1969), the Nicola Project as such did not commence until 1972 when P. A. Christopher mapped the area of Fairweather Hills, near Aspen Grove at a scale of 1:15 840 (Christopher, 1973). His mapping was expanded by the writer in 1973, 1974, and 1975 (Preto, 1974, 1975, 1976), and in addition, a more detailed study of the well-exposed volcanic rocks of Fairweather Hills was carried out by Lefebure in 1974 (Lefebure, 1976). In 1977, as part of the same project, McMillan

(1978) continued the mapping north to the south shore of Nicola Lake. This initial phase of the Nicola Project, together with recent mapping of the Princeton Tertiary Basin (McMechan, 1975) and the area near Copper Mountain (Preto, 1972) to the south, provides continuous detailed coverage of the geology of the central part of the Nicola Belt from Copper Mountain to the south shore of Nicola Lake.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the contributions of previous workers in the area, particularly M. P. Schau, from whose conclusions he has drawn freely. Discussions and field visits with fellow geologists of the Geological Survey of Canada and The British Columbia Ministry of Mines and Petroleum Resources were also helpful. Fossil identifications by H. Frebold, W. S. Hopkins, Jr., H. W. Tipper, and E. T. Tozer of the Geological Survey are gratefully acknowledged.

The co-operation of a number of mining companies engaged in mineral exploration in the area greatly facilitated the work.

In the field the writer was ably assisted in 1973 by T. E. Kalnins, J. Nebocat, and N. Thomsen; in 1974 by S. J. Atkinson, J. Nebocat, and L. K. Robertson; and in 1975 by D. C. Calder, M. Mann, and P. Tremblay-Clark.

The work of P. A. Christopher and D. V. Lefebure is an integral part of this report, and their contributions are acknowledged.

REFERENCES

Allen, D. G., Panteleyev, A., and Armstrong, A. T. (1976): Galore Creek, *CIM,* Special Vol. 15, Porphyry Deposits of the Canadian Cordillera, pp. 402-414.

Baker, P., *et al.,* (1964): The Volcanological Report of the Royal Society Expedition to Tristan da Cunha, 1962, Phil. Trans., *Royal Soc. London,* Series A, Vol. 56, pp. 439-578.

Ball, C. W. (1963): Aspen Joint Venture, Geological Report, Allison Project, Princeton, B.C., *Private Report.*

Barr, D. A., Fox, P. E., Northcote, K. E., and Preto, V. A. (1976): The Alkaline Suite Porphyry Deposits – A Summary, *CIM,* Special Vol. 15, Porphyry Deposits of the Canadian Cordillera, pp. 359-367.

B.C. Ministry of Energy, Mines & Pet. Res., GEM, 1969, pp. 283-287; 1972, pp. 209-220.

Campbell, C. J. (1966): The Method of Formation of Some Hollow Boulders near Merritt, B.C., Unpubl. B.Sc. Thesis, *U.B.C.,* 1966.

Campbell, R. B. (1966): Tectonics of the South Central Cordillera of British Columbia, *CIM,* Special Vol. 8, Tectonic History and Mineral Deposits of the Western Cordillera, pp. 61-72.

.... (1978): Personal Communication.

Carmichael, I.S.E., *et al.,* (1974): Igneous Petrology, *McGraw-Hill,* New York, 739 pp.

Carr, J. M. (1962): Geology of the Princeton, Merritt, Kamloops Area of Southern British Columbia, *Western Miner & Oil Review,* Vol. 35, pp. 46-49.

Christopher, P. A. (1973): Preliminary Geological Map of the Aspen Grove Area, British Columbia, *B.C. Ministry of Energy, Mines & Pet. Res.,* Preliminary Map No. 10.

Church, B. N. (1973): Geology of the White Lake Basin, *B.C. Ministry of Energy, Mines & Pet. Res.,* Bull. 61.

.... (1975): Quantitative Classification and Chemical Comparison of Common Volcanic Rocks, *Geol. Soc. Amer.,* Bull., Vol. 86, pp. 257-263.

Cockfield, W. E. (1948): Geology and Mineral Deposits of Nicola Map-Area, British Columbia, *Geol. Surv., Canada,* Mem. 249.

Dawson, G. M. (1879): Preliminary Report on the Physical and Geological Features of the Southern Portion of the Interior of British Columbia, 1877, *Geol. Surv., Canada,* Rept. of Progress, 1877-78.

Fahrni, K. C. (1962): Aspen Joint Venture, Study of Nicola Rocks, Princeton and Merritt Districts, British Columbia, *Private Report.*

Fulton, R. J. (1965): Field Notes for Day 12, Guidebook for Field Conference, Pacific Northwest, *Int. Ass. Quaternary Res.,* VII, Congress, 1965, pp. 86-92.

Hillhouse, D. N. (1964): The Geology of the Aspen Grove Area, Aspen Joint Venture, 1963, *Private Report.*

Hills, L. V. (1962): Glaciation, Stratigraphy, Structure and Micropaleobotany of the Princeton Coalfield, B.C., Unpubl. M.Sc. Thesis, *U.B.C.,* 1962.

Holland, Stuart S. (1964): Landforms of British Columbia, A Physiographic Outline, *B.C. Ministry of Energy, Mines & Pet. Res.,* Bull. 48.

Irvine, T. N. (1973): Bridget Cove Volcanics, Juneau Area, Alaska: Possible Parental Magma of Alaskan-type Ultramafic Complexes, *Ann. Rept. of the Director, Geophysical Laboratory,* 1972-73, pp. 478-491.

Irvine, T. N. and Baragar, W.R.A. (1971): A Guide to the Chemical Classification of Common Volcanic Rocks, *Can. Jour. Earth Sci.,* Vol. 8, pp. 523-548.

Kuno, H. (1960): High-Alumina Basalt, *Jour. of Petrology,* Vol. 1, pp. 121-145.

Lambert, M. B. (1963): The Valley Basalts in Quilchena Creek Area, British Columbia, Unpubl. B.Sc. Thesis, *U.B.C.,* 1963.

Le Maitre, R. W. (1962): Petrology of Volcanic Rocks, Gough Island, South Atlantic, *Geol. Soc. Amer.,* Bull., Vol. 73, pp. 1309-1340.

Lefebure, D. V. (1976): Geology of the Nicola Group in the Fairweather Hills, B.C., Unpubl. M.Sc. Thesis, *Queen's University.*

MacDonald, G. A. (1968): Composition and Origin of Hawaiian Lavas, *Geol. Soc. Amer.,* Mem. 116, pp. 477-522.

McMechan, R. A. (1975): Princeton Basin, *B.C. Ministry of Energy, Mines & Pet. Res.,* Internal Report.

McMillan, W. J. (1978): Preliminary Geological Map of the Guichon Creek Batholith, *B.C. Ministry of Energy, Mines & Pet. Res.,* Preliminary Map 30.

Mathews, W. H. and Rouse, G. E. (1963): Late Tertiary Volcanic Rocks and Plant Bearing Deposits in British Columbia, *Geol. Soc. Amer.,* Bull., Vol. 64, pp. 381-390.

Minister of Energy, Mines & Pet. Res., B.C., Ann. Repts., 1901, pp. 1177-1189; 1967, pp. 137-141; 1968, pp. 205-212.

Morton, R. L. (1976): Alkalic Volcanism and Copper Deposits of the Horsefly Area, Central British Columbia, Unpubl. Ph.D. Thesis, *Carleton University,* Ottawa, 196 pp.

Northcote, K. E. (1974): Geology of Northwest Half of Iron Mask Batholith, *B.C. Ministry of Energy, Mines & Pet. Res.,* Geological Fieldwork, 1974, pp. 22-26.

Olien, K. O. (1957): Geology and Mineral Deposits of the Aspen Grove Area, B.C., Unpubl. B.A.Sc. Thesis, *Unversity of Western Ontario,* 1957.

Parker, R. L. and Calkins, J. A. (1964): Geology of the Curlew Quadrangle, Ferry County, Washington, *U.S.G.S.,* Bull. 1169.

Parsons, W. H. (1969): Criteria for the Recognition of Volcanic Breccias: Review, *Geol. Soc. Amer.,* Igneous and Metamorphic Geology, Mem. 115, pp. 263-304.

Preto, V. A. (1972): Geology of Copper Mountain, *B.C. Ministry of Energy, Mines & Pet. Res.,* Bull. 59.

.... (1974): Geology of the Aspen Grove Area, B.C., *B.C. Ministry of Energy, Mines & Pet. Res.,* Preliminary Map No. 15.

.... (1975): Geology of the Allison Lake-Missezula Lake Area, *B.C. Ministry of Energy, Mines & Pet. Res.,* Preliminary Map No. 17.

.... (1976): Geology of the Nicola Group South of Allison Lake, British Columbia, *B.C. Ministry of Energy, Mines & Pet. Res.,* Preliminary Map No. 21.

Rice, H.M.A. (1947): Geology and Mineral Deposits of the Princeton Map-Area, British Columbia, *Geol. Surv., Canada,* Mem. 243.

Rouse, J. E. and Mathews, W. H. (1961): Radioactive Dating of Tertiary Plant-Bearing Deposits, *Science,* Vol. 133, No. 3458, pp. 1079, 1080.

Russell, L. S. (1935): A Middle Eocene Mammal from British Columbia, *Amer. Jour. Sci.,* Vol. 29, pp. 54, 55.

Schau, M. P. (1968): Geology of the Upper Triassic Nicola Group in South Central British Columbia, Unpubl. Ph.D. Thesis, *U.B.C.*

.... (1971): Stratigraphy and Structure of the Type Area of the Upper Triassic Nicola Group in South Central British Columbia, *in* Structure of the Southern Canadian Cordillera (J. O. Wheeler, ed.), *G.A.C.,* Special Paper No. 6, pp. 123-135.

Sutherland Brown, A. (1977): Morphology and Classification, *CIM,* Special Vol. 15, Porphyry Deposits of the Canadian Cordillera, pp. 44-51.

Sutherland Brown, A., Cathro, R. J., Panteleyev, A., and Ney, C. S. (1971): Metallogeny of the Canadian Cordillera, *CIM,* Trans., Vol. LXXIV, pp. 121-145.

Williams, H. (1933): Geology of Tahiti, Moorea, and Maiao, *Bernice P. Bishop Museum, Bull.,* Vol. 105, 89 pp.

2

GENERAL GEOLOGY

INTRODUCTION

The area described in this report covers the central part of the Nicola Belt of south-central British Columbia, a terrain approximately 40 kilometres wide that extends from near the International Boundary 180 kilometres northward to Kamloops Lake. This region is underlain mainly by Upper Triassic volcanic, sedimentary, and intrusive rocks of the Nicola Group which are noted for their copper deposits. Rocks of the Nicola assemblage continue northward beneath an extensive cover of Tertiary strata into the central part of the Quesnel Belt (formerly Quesnel Trough, R. B. Campbell, personal communication, 1978) and extend along the full length of the Intermontane Belt into northern British Columbia and Yukon where they are known as the Takla and Stuhini volcanic assemblages (Fig. 4).

Besides the Nicola rocks, which are the oldest in the map-area, rock units encountered during the course of mapping include intrusive, sedimentary, and volcanic rocks that range in age from Late Triassic to Pleistocene and Recent. Due mainly to their complex geology, little is known about the stratigraphy of Nicola rocks outside of those areas that have been mapped in detail, and only a few general statements can be made at this time about the geology of the Nicola Belt as a whole.

The dominating geologic elements in the map-area are two northerly trending, high-angle fault systems which divide the Nicola rocks into three subparallel belts (Fig. 1). The Western Belt consists mainly of an east-facing sequence of calc-alkaline flows which grade upward into pyroclastic rocks, epiclastic sediments, and abundant limestone. This succession is separated near Aspen Grove by the Allison fault, and in the northern part of the area by an unnamed fault, from the Central Belt assemblage which is dominated by alkaline and calc-alkaline volcanic and intrusive rocks and lesser associated sedimentary units. The Summers Creek – Alleyne fault system separates rocks of the Central Belt from those of the Eastern Belt. The latter assemblage consists of a westerly facing sequence of volcanic siltstone and sandstone, laharic deposits, conglomerate and tuff, and some distinctly alkaline flows which occur near small stocks of micromonzonite porphyry.

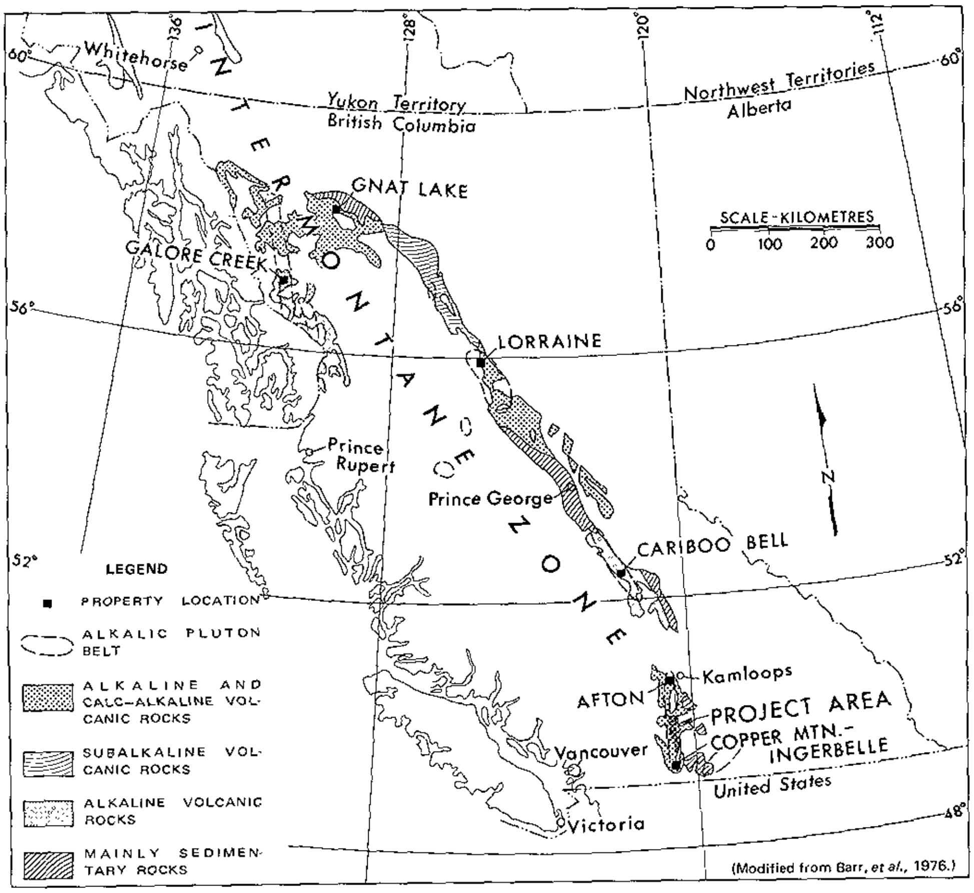


Figure 4. Upper Triassic and Lower Jurassic volcanic rocks, significant copper deposits, and associated alkalic plutons in the Intermontane Zone.

The separation of these sharply contrasting belts of Nicola rocks has undoubtedly been enhanced by late movements along the Summers Creek and Allison fault systems, but, as will be shown in this report, it is the belief of this writer that these large structures represent deep-seated crustal fractures which dominated the geology of the region in Late Triassic time and caused volcanic centres to be aligned in a northerly direction, thus producing a central zone of dominantly volcanic rocks, the Central Belt and part of the Eastern Belt, flanked to the east and west by basins of deposition. It is also believed that volcanic rocks of the Central and Eastern Belts originated from local eruptive centres, some of which can be identified with stocks of map unit 6 (Fig. 1). Conversely, rocks of the Western Belt have no obvious source within the area mapped. Their chemical and physical similarity with volcanic rocks to the north and west which occur around the periphery of the Guichon Creek batholith suggests that they probably originated from this large, calc-alkaline, Upper Triassic pluton.

The prominent northerly geological fabric of the map-area is also apparent in the distribution of mineral deposits. The Central Belt, being the richest in intrusive rocks and the most intensely faulted and fractured of the three, contains by far the largest number of prospects, particularly those of porphyry type which occur within subvolcanic intrusions and their associated extrusive rocks.

For these reasons the Nicola rocks in the map-area will be described as three separate assemblages, from the oldest, the Central Belt, to the youngest, the Western Belt.

STRATIFIED ROCKS

UPPER TRIASSIC

NICOLA GROUP: The Nicola Belt is overlain to the north by an extensive cover of Tertiary volcanic rocks, and is invaded to the south by Jurassic granitic rocks of the Similkameen batholith. To the west it is bounded by granitic rocks of the Lower Cretaceous Eagle Complex and by Jurassic and younger strata, and to the east is intruded by granitic rocks of the Jurassic Okanagan batholith and related plutons.

Earlier work (Campbell, 1966; Schau, 1968) has indicated that the Nicola Belt is characterized by a central zone of predominantly volcanic rocks flanked on the east and west by broader fringing zones rich in sedimentary rocks. This report describes the geology of that portion of the central volcanic zone between Merritt and the Princeton Tertiary basin and covers the southwestern portion of the region described by Schau (1968) as representing the remnants of a volcanic island archipelago consisting of some 7 500 metres of volcanic and related sedimentary rocks.

UNIT 1 – CENTRAL BELT: The Central Belt assemblage occurs along the full length of the map-area and is bound to the east by faults of the Summers Creek – Kentucky – Alleyne system and to the west by faults of the Allison system. This assemblage includes the oldest of the Nicola rocks within the map-area and is typified by an abundance of massive pyroxene and plagioclase-rich flows of andesitic and basaltic composition, coarse volcanic breccia, conglomerate, and lahar deposits and by lesser amounts of fine-grained pyroclastic and sedimentary rocks. Intrusive rocks mostly of gabbroic and dioritic composition, but including some syenite and monzonite, are abundant throughout the belt. The character and composition of these intrusions and lithologic changes in the surrounding extrusive rocks indicate that at least in some cases these stocks are the eroded remains of Upper Triassic volcanoes.

Both subaerial and submarine assemblages occur in the Central Belt (Fig. 5). In general, most of the red and purple flows and associated red laharic breccias, such as those found east and southeast of Aspen Grove, are considered to be of subaerial origin, whereas

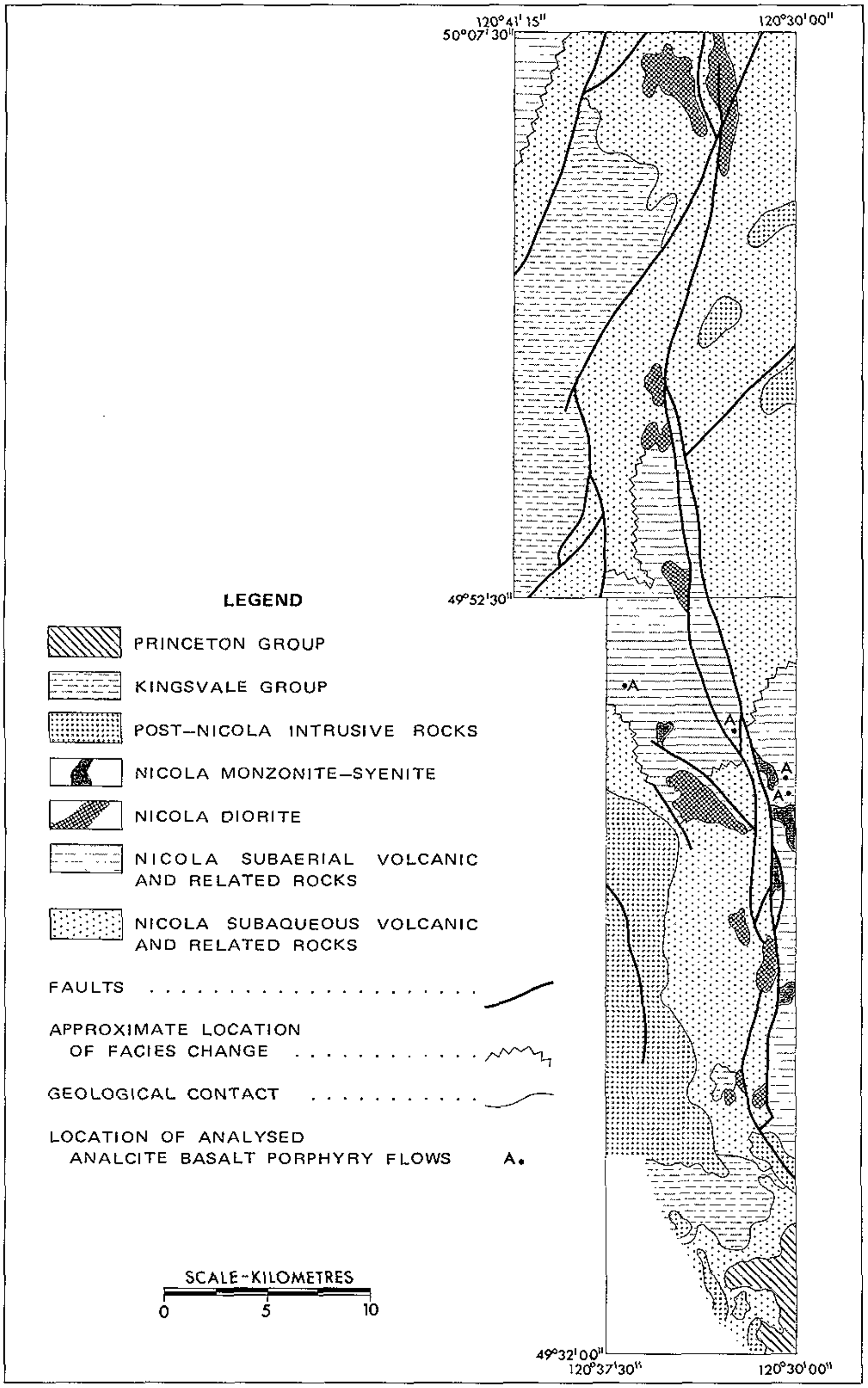


Figure 5. Generalized distribution of subaerial and subaqueous Nicola assemblages.

greenish flows and breccias, with associated small lenses of calcareous sandstone and impure limestone, such as those found in the vicinity of Missezula Mountain, are considered to be of submarine origin.

Most stocks in the Central Belt are elongated in a northerly direction and occur along northerly trending faults. It is apparent that areas of stronger volcanic activity, such as Fairweather Hills, contain more faults and more intrusive rocks than areas of less intense volcanism. Although many of these faults are subsidiary to and part of the major regional systems, they are intimately associated with and dependent on the more localized volcanic history of the Nicola rocks.

Units 1a and 1b: Flow rocks of the Central Belt range from basalt to rhyolite in composition. By far the greatest proportion of the flows are basalts, with andesite and more acid varieties comprising only an estimated 10 to 15 per cent. As will be discussed later, approximately two-thirds of the Central Belt lava flows are distinctly alkaline in composition, and roughly one-third is subalkaline. Most of the alkaline rocks are potassium-rich trachybasalts and alkali basalts though some are hawaiites of the soda-rich series. Subalkaline flows are characteristic of the calc-alkaline magma series and consist mainly of basalt and andesite with minor dacite and some rhyolite. In his report on the Fairweather Hills, Lefebure (1976, p. 29) estimated that 50 per cent of the basalts in his study area are trachybasalts. He also found these flows to range from 13 to 33 metres in thickness and to maintain a constant thickness for distances up to 1 kilometre.

Within the basic flows, phenocrysts of augite are by far the most common and widespread, amounting in some cases to nearly half of the total volume of a flow. Plagioclase, generally labradorite, is less common, and biotite and hornblende are rare and found only in the more felsic flows.

Massive green basaltic flows and their brecciated equivalents of mostly submarine provenance make up approximately 75 per cent of the Central Belt rocks south of Missezula Lake, and are especially prominent in the vicinity of Missezula Mountain. The breccias associated with these flows are mostly autoclastic flow and crumble breccias.

Between Missezula Lake and Bluey Lake, the flow rocks of the Central Belt are made up of green, massive augite basalt porphyry and maroon and reddish analcite-augite trachybasalt porphyry. A distinctive reddish grey hematitic trachybasalt, found mostly on the ridge southwest of Bluey Lake, is associated with a considerable amount of autobreccia and laharic breccia.

On Fairweather Hills west of Kentucky and Alleyne Lakes, basalt and trachybasalt flows are clearly less abundant than lahars. The best-developed flows, nearly all subaerial in origin, occur near and north of Miner Lake and comprise maroon, red, and green augite basalt and trachybasalt porphyry and autobreccia. Some thin, discontinuous rhyolite flows have been recognized by Lefebure (1976), but these only form a very minor proportion of the flows in this area.

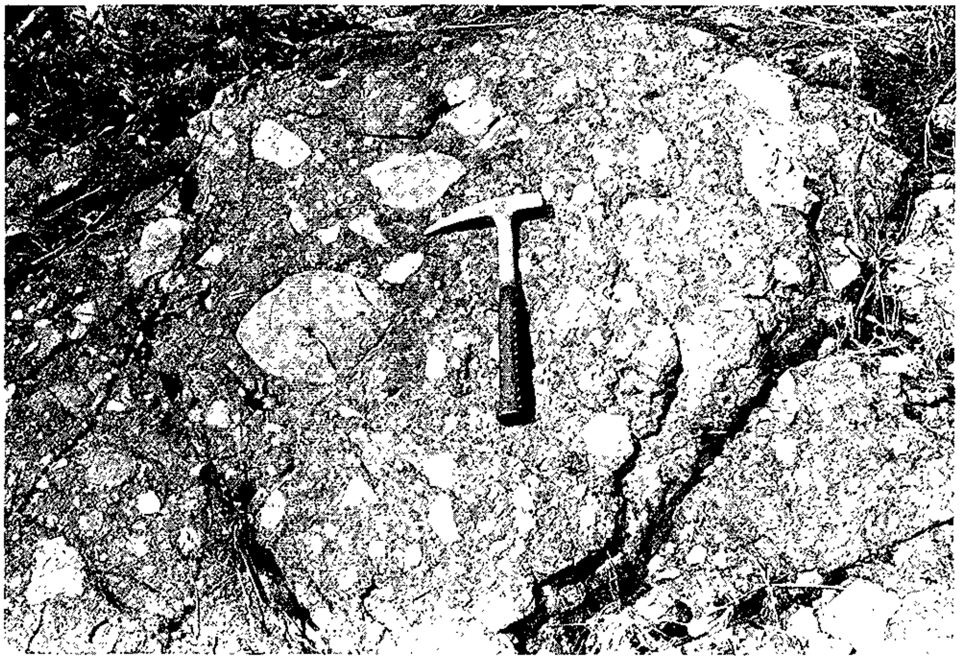


Plate IV. Red lahar of map unit 1c, Fairweather Hills.

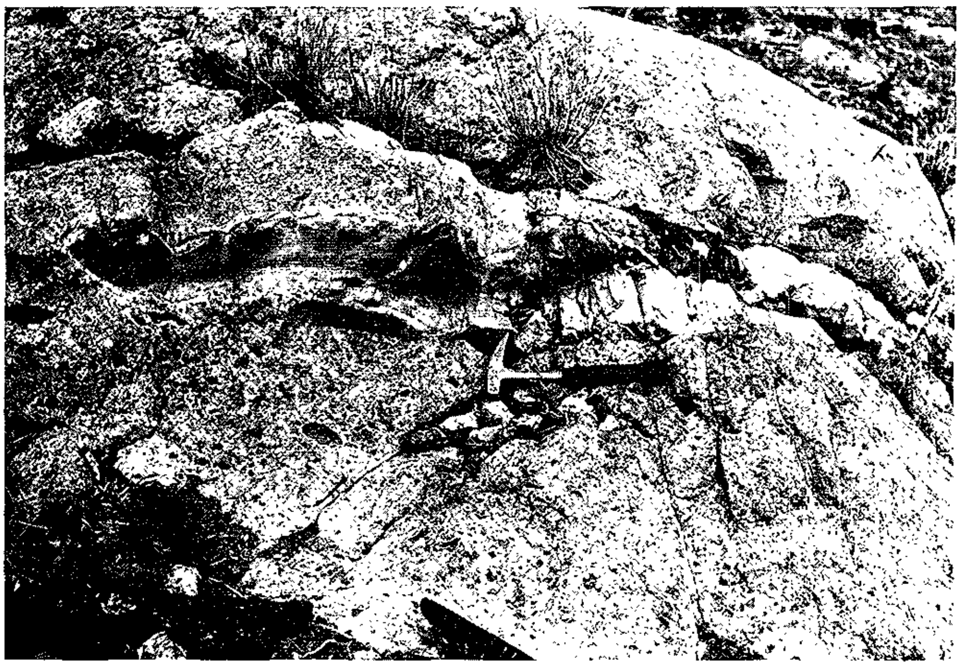


Plate V. Poorly bedded volcanic conglomerate with a large slab of volcanic siltstone, Fairweather Hills.

Between Courtney Lake and the northern boundary of the map-area the well-developed, largely subaerial succession of Fairweather Hills gives way again to a monotonous sequence of massive grey-green and dark green basaltic flows which appear to be mostly submarine in origin. In the extreme northeast corner of the map-area a prominent unit of massive and brecciated augite porphyry occurs as a wedge between two branches of the Quilchena Creek fault, and appears to continue for a considerable distance northward beyond the limit of present mapping.

Units 1c and 1d: Green and red volcanic breccias and laharic deposits are found only in the central part of the map-area, from Courtney Lake to the hills west of Missezula Lake. These breccias are best exposed on Fairweather Hills where they have been studied in detail by Lefebure (1976) who distinguished various types on the basis of colour, type of matrix, type of clasts, and degree of magnetism. Two main types, green and red, have been distinguished on the basis of colour, which almost invariably reflects the environment of deposition: subaerial for red and subaqueous for green.

Red lahars are associated with purple and maroon subaerial flows and are generally highly oxidized and nonmagnetic. Green lahars occur either as thick, monotonous sequences or intercalated with lenses of limestone and other water-lain sediments, and are moderately to strongly magnetic. All laharic breccias are massive to very crudely bedded, poorly sorted, and contain clasts, mostly of volcanic rocks, which may range to 5 metres in maximum dimension. The ratio of matrix to fragments is generally 1 to 1 or greater, and the clasts are commonly completely surrounded by the matrix material.

Though most of the rocks mapped as units 1c and 1d fit the above descriptions and can therefore correctly be called lahars, an appreciable proportion tends to contain less matrix, be more bedded and sorted, and have more rounded clasts. These rocks are best called volcanic conglomerates and are probably reworked laharic flows or their distal parts (Parsons, 1969). Other parts of units 1c and 1d are very similar to typical laharic breccias but are somewhat lacking in matrix, and should perhaps be called avalanche, slump, or talus breccias.

Unit 1e: Discontinuous, locally prominent sequences of generally well-layered crystal and lithic tuff are interlayered with flows and breccias along most of the Central Belt, except for the northernmost part. The widespread distribution of the tuffs clearly indicates that outpourings of ash and lapilli occurred throughout the volcanic history of the belt. Their general similarity in composition with the flows suggests that they were generated locally by the same sources as the lava flows. Their commonly well-bedded, locally graded nature also suggests that they were, at least in part, deposited in shallow basins either directly as air falls or as poorly reworked stream sediments.

Unit 1f: Small, generally discontinuous beds of reefoid limestone occur interbedded with volcanic and volcano-sedimentary rocks of the Central Belt at several localities, and occasionally provide useful fossils. A prominent, locally well-bedded limestone crops out on the western slopes of Oliphant Mountain approximately 2 kilometres north of the junction of Summers Creek and Allison Creek. Though Upper Triassic fossils have reportedly been collected at this locality (M. P. Schau, personal communication, August 1975), none were found during the course of the present work. Similarly, a prominent limestone 3 kilometres south-southeast of Kidd Lake did not yield any useful fossils, though considerable effort was spent in looking for both mega and micro-organisms. Other smaller limestones have yielded some fossils which, as listed in Table 1, indicate that rocks of the Central Belt are probably of Early Norian or possibly Late Carnian age.

TABLE 1. FOSSILS FROM UNIT 1f

FOSSILS	FOSSIL LOCALITIES			
	F1	F2	F3	F4
Spondylospira ? sp.			x	
Pecten (Variamussium) sp.			x	
Myophoria sp.			x	
Mysidioptera ? sp.			x	
Halobia sp.			x	x
Hexacorals indet.		x		
Trigoniid ? indet.		x		
Pectenid indet.		x		
Gastropods indet.		x		
Large megalodont bivalve ?	x			
Epigondolella abreptis Huckriede				x
Epigondolella primitia Mosher				x
Xaniognathus ? sp.				x

F1 From reefoid limestone 460 metres east of Kidd Lake. Field No. PC-72-21. Latitude 49 55'28" north, longitude 120 37'12" west. G.S.C. Report T2-3-1973-ETT, location 89563. AGE – probably Late Triassic.

F2 From reefoid limestone 1.6 kilometres south-southeast of Thule Lake. Field No. PC-72-282. Latitude 49 56'28" north, longitude 120 34'25" west. G.S.C. Report T2-3-1973-ETT, location 89562. AGE – probably Late Triassic.

F3 From a small lens of bioclastic limestone conglomerate 3.1 kilometres south 64 degrees east of centre of Kane Lake, elevation 1 270 metres. Field No. V-73-F-1. Latitude 49 58'04.5", longitude 120 38'55.8". G.S.C. Reports T2-6-1974-ETT and INSOL-3-1974-BEBC, locations 90786 and 86397. AGE – Late Triassic, but older than Late Norian.

F4 From reefoid limestone 2 700 metres south 33 degrees east of centre of Lundbom Lake, elevation 1 220 metres. Field No. N-73-F-3. Latitude 50 04'1.2" north, longitude 120 36'42.5" west. G.S.C. Reports T2-6-1974-ETT and INSOL-3-1974-BEBC, locations 90787 and 86390. AGE – Late Late Karnian to Early Norian, Early Norian most probable.

Unit 1g: Sedimentary rocks of this unit appear to be the oldest within the Central Belt. Dark green massive to graded-bedded siltstone, sandstone, and pebble conglomerate crop out along Allison Creek, and calcareous sandstone, gritstone, and pebble conglomerate is exposed along the west side of Summers Creek approximately 6 kilometres north of the confluence of these two streams. Siltstone, sandstone, and argillite occur east of Otter Creek for approximately 5 kilometres south of Kidd Lake.

Though these three occurrences of sedimentary rocks have been grouped together as a single map unit, it is not known whether they are of similar age, or merely that they lie at or near the base of the sequence of volcanic rocks that surrounds them.

UNIT 2 – EASTERN BELT: Rocks of the Eastern Belt crop out east of the Summers Creek – Alleyne fault in the central and southern part of the map-area. A short distance north of Alleyne Lake they are probably truncated by a northeast-trending fault, and are intruded by granitic rocks of the Jurassic Pennask Pluton. To the south they pinch out against the Summers Creek fault and are intruded by Upper Cretaceous granite and quartz monzonite of map unit 13.

The Eastern Belt can be described in terms of a northern and southern assemblage, separated by means of a facies change east of the northern end of Missezula Lake. The northern assemblage consists of a well-bedded, westerly dipping succession of volcaniclastic rocks that range from thinly layered volcanic siltstone and sandstone in the lower parts of the section to coarse volcanic conglomerates and massive green laharic breccia in the upper part. This part of the Eastern Belt is characterized by a lack of intrusive rocks and mineral showings. Northeast of the north end of Missezula Lake the sedimentary rocks quickly grade southward into a sequence of crystal and lapilli tuff, lahar deposits with clasts of syenite and monzonite, and some flows of analcite-augite trachybasalt and trachyandesite. These deposits occur within a radius of roughly 3 kilometres from a northerly elongated stock of micromonzonite porphyry and breccia that is believed to be a shallowly eroded volcanic centre. There is a similarity in composition between intrusive and extrusive rocks in this area and rock fragments in all the clastic units around this stock are clearly derived from it. South of Missezula Lake, most of the Eastern Belt consists of massive to crudely bedded, reddish to grey, lahar deposits that contain abundant clasts of pink and red microsyenite and micromonzonite porphyry and of purple trachyandesite. These continue almost to the southern terminus of Eastern Belt outcrop where a stratigraphically lower sequence of greywacke, thinly bedded tuffaceous siltstone and sandstone, and purplish green augite basalt porphyry and related breccia is exposed.

The various types of stratified rocks of the Eastern Belt are briefly described below, but not necessarily in stratigraphic order.

Unit 2a: Flows of greenish and greenish grey analcite-augite trachybasalt porphyry occur around the micromonzonite stock on the east shore of Missezula Lake and probably

Plate VI. Graded bedded volcanic siltstone and sandstone, Eastern Belt southeast of Pothole Lake.

Plate VII. Volcanic conglomerate, Eastern Belt southeast of Pothole Lake.

crudely outline the paleoslopes of an ancient volcano. Purplish and green augite porphyry flows and related breccia are found a short distance to the north on the west side of Shrimpton Creek. Similar massive flows and breccia are found northeast of Pothole Lake and at the southern terminus of Eastern Belt outcrop. These two latter occurrences of lava are stratigraphically in the lowest part of the Eastern Belt sequence exposed within the area mapped and may be correlative with one another.

Unit 2b: Reddish to greenish grey tuff unusually rich in feldspar crystals is found almost exclusively in the vicinity of the Missezula Lake stock. Because of its crystal and rock clast composition and of its distribution, it almost certainly originated from this small pluton. Two smaller occurrences of this unit are found on the hills east of Kentucky Lake. Rocks of unit 2b appear to have been produced by showers of crystals and *lapilli* which settled in basins of shallow water and were locally reworked by wave and current action.

Unit 2c: Thinly bedded, commonly graded and/or crossbedded, tuffaceous volcanic sandstone and siltstone are found at several localities but mainly in the northern and southern part of the belt. East of Kentucky Lake and south of Loon Lake, these finer grained sediments are interlayered with coarser grained deposits of unit 2d, but in the rest of the belt they tend to underlie the bulk of the lahar and volcanic conglomerate.

Rocks of unit 2c consist largely of reworked volcanic material and tend to be rich in tiny fragments of feldspar and pyroxene crystals. They are clearly epiclastic deposits of detritus from older volcanic units in the belt.

Unit 2d: Massive to crudely layered lahar deposits and lesser amounts of interbedded volcanic conglomerate and greywacke are by far the most abundant rock type in the Eastern Belt. East of Alleyne Lake this map unit consists mostly of coarsely sheeted deposits which, though poorly sorted and massive in detail, display a definite layering and even a crude sorting when viewed from a distance. In this area there is a complete gradation of varieties from clearly reworked and well-layered conglomerate to poorly layered distal lahar and massive lahar.

Approximately 3 kilometres north of the Missezula Lake stock, clasts of reddish syenite and monzonite porphyry become noticeable in the lahars and sharply increase in abundance southward to the point that the rock acquires a characteristic reddish colour that remains typical of this map unit in the rest of the belt. In this same area three other stocks of fine-grained syenite and monzonite cut rocks of unit 2d but none are surrounded by the assemblage of flows, tuffs, and volcaniclastic deposits that are found around the stock northeast of Missezula Lake. This means that if these stocks ever vented they did so at a higher level and their extrusive products were removed by erosion, but does not exclude the possibility that these same stocks could have, at some earlier time, generated the material which produced the laharic pile of unit 2d, which they later intruded in cannibalistic fashion.

UNIT 3 – WESTERN BELT: Rocks of the Western Belt are the youngest Nicola rocks within the map-area and differ sharply in composition from those of the Central and Eastern Belts. They form an easterly facing sequence that occurs only in the northwestern corner of the map-area and in a fault wedge south of Aspen Grove. In the north they are in fault contact to the east with rocks of the Central Belt and of map unit 11 which may be as young as Early Cretaceous, and are unconformably overlain by conglomerate of map unit 14 and younger units. East of Sugarloaf Mountain, flows of unit 3a are also in fault contact with Lower and Middle Jurassic strata of unit A. In the south they are separated by the Allison fault from rocks of the Central Belt and are in fault contact to the west with conglomerate of map unit 9.

Flow and pyroclastic units, in part subaerial, form the lower part of the sequence in the northwest corner of the map-area. These largely correspond to Schau's (1968) assemblage P1, and grade upward into interlayered fine-grained flows, pyroclastic rocks, epiclastic sediments, and prominent massive to well-bedded limestone which correspond to part of Schau's (1968) assemblage P2. Schau (1968, p. 62) brackets the age of his assemblage P2 between the Upper Carnian and Upper Norian. During the course of mapping, Lower and Middle Norian fossils have been obtained from the middle part of the Western Belt.

Unit 3a: Flow rocks of the Western Belt are characteristically richer in plagioclase than those of the other two belts and include a considerable amount of andesite, dacite, and some rhyolite, with subordinate basalt. Flow and pyroclastic units in the lower part of the section are greenish grey to maroon in colour, generally fine grained, and commonly show delicate flow laminations and welding. These are thought to be, in good part at least, subaerial in origin. Roughly midway in the sequence limestone lenses first appear intercalated with the volcanic rocks, and from this point upward in the section flow and breccia units tend to be more porphyritic in texture and greener in colour. Limestones and beds of epiclastic sediments become more common and prominent upward, indicating gradual submergence and transition from largely subaerial to submarine deposition. A repeated, almost rhythmic alternation of volcanic and sedimentary rocks is well displayed on the grass-covered hills 1 to 1.5 kilometres west of Marquart Lake by several interlayered limestone beds and fine-grained andesitic lava flows only a few metres thick.

Unit 3b: Extensive sequences of purple, mauve, and greenish grey volcanic breccia and lithic tuff are common in the Western Belt, especially in the upper part. This indicates a considerable amount of pyroclastic activity, as would be expected with volcanism of intermediate to acid character. The pyroclastic rocks are similar to the flows in composition, indicating a common source, and generally grade laterally either into flows or into finer grained tuffs. This is especially true of the coarse lapilli tuffs and breccias.

TABLE 2. FOSSILS FROM UNIT 3c

FOSSILS	FOSSIL LOCALITIES					
	F5	F6	F7	F8	F9	F10
Halobia sp.	x		x			x
Mysidioptera sp. (ribbed)		x				
Minetrigonia sp.		x			x	
Palaeocardita sp.			x			
Mojsisovicsites kerri (McLearn)				x		
Metabelemnites ? sp.					x	
Tibetitid ammonoid (probably a new genus)					x	
Bivalves indet.		x			x	
Trigoniid bivalve indet.					x	
Large smooth bivalves indet.					x	
Large smooth ammonoid indet.				x		
Pectenid bivalves indet.			x			
Spiriferid brachiopods indet.	x		x			
Fish teeth and bone			x			
Ammoniseus sp.			x			
Spines and pellets			x			
Conodont fragment indet.					x	
Bivalve fragment					x	
Ammonite fragments						x

F5 From a cherty limestone 15 to 23 metres thick, continuous for at least 460 metres and interbedded with plagioclase andesite, 2 100 metres north 40 degrees west of centre of Hamilton Lake, elevation 1 310 metres. Latitude 50 06'49.6" north, longitude 120 39'01.8" west. G.S.C. Report T2-6-1974-ETT, location 90797. AGE — Late Triassic.

F6 From a 3-metre lens of tuffaceous limestone interlayered with grey plagioclase andesite, 2 770 metres north 46.5 degrees west of centre of Hamilton Lake, elevation 1 255 metres. Latitude 50 06'56.6" north, longitude 120 39'33.9" west. G.S.C. Report T2-20-1974-ETT, location 91849. AGE — Late Triassic.

F7 From a clastic limestone within a sequence of fairly continuous interbedded massive limestone and andesite, 850 metres north 55 degrees west of centre of Marquart Lake, elevation 1 220 metres. Latitude 50 24'57.4" north, longitude 120 39'18" west. G.S.C. Report T2-20-1974-ETT, locations 91846 and 91847; INSOL-3-1974-BEBC, location 86396. AGE — Late Triassic.

F8 From a 9 to 15-metre bed of grey clastic limestone continuous over at least 460 metres and interbedded with plagioclase andesite, 2 160 metres north 44 degrees west of centre of Hamilton Lake, elevation 1 300 metres. Latitude 50 06'45.7" north, longitude 120 39'08" west. G.S.C. Report T2-20-1974-ETT, location 91845. AGE — Early Norian, Kerri zone.

F9 From a 3.7-metre lens of semi-massive limestone interbedded with plagioclase andesite, 1 750 metres north 49 degrees west of centre of Hamilton Lake, elevation 1 200 metres. Latitude 50 06'34" north, longitude 120 39'01" west. G.S.C. Report T2-6-1974-ETT, locations 90796 and 90808. AGE — probably Middle Norian.

F10 From a narrow lens of impure limestone and calcareous siltstone interbedded with plagioclase andesite, 2 000 metres north 05 degrees west of centre of Hamilton Lake, elevation 1 300 metres. Latitude 50 07'00" north, longitude 120 36'06" west. AGE — Middle to Early Norian (H. W. Tipper, written communication, May, 10, 1977).

Unit 3c: Grey beds and lenses of limestone are characteristic of the upper half of the Western Belt sequence. They are generally more prominent and more continuous laterally than the limestones of the Central Belt. Limestone beds near Sugarloaf Mountain and near Garcia Lake can be as much as 20 to 30 metres thick and can be traced laterally for distances of 1 to 2 kilometres.

Schau (1968) collected fossils in the vicinity of Sugarloaf Mountain which dated the rocks as younger than Late Carnian and older than Late Norian. Collections made during the present study west of Sugarloaf Mountain and west of Marquart Lake confirm Schau's (1968) dating as shown in Table 2.

Unit 3d: Buff and grey, commonly tuffaceous, calcareous granule and pebble conglomerate, sandstone, and siltstone, all composed of volcanic detritus, are common throughout the upper part of the Western Belt. Particularly good exposures of these generally friable and easily eroded sedimentary rocks are found south and east of Sugarloaf Mountain and near Garcia Lake. South of Sugarloaf Mountain buff and grey sandstone and grit contain numerous shell fragments and have reportedly yielded *Halobia* (M. P. Schau, personal communication, 1975).

LOWER TO MIDDLE JURASSIC

CORRELATION UNCERTAIN

UNIT A: Approximately 1.5 kilometres east of Sugarloaf Mountain, a poorly exposed unit of buff-weathering, grey, calcareous siltstone, sandstone, and grit with interlayered buff-weathering silty limestone is in fault contact with rocks of unit 3a. This contact may, in part, also be conformable. In turn, unit A is overlain unconformably by boulder conglomerate of unit 14.

Layered rocks of this unit appear to have the same northerly strike and easterly dips as rocks of unit 3 to the west, but, though similar in appearance to rocks of unit 3d, have yielded three collections of marine fossils of Early to Middle Jurassic age (Table 3). These strata are separated from rocks of unit 3 to the west by a gully, which probably follows a fault, and by a narrow septum of conglomerate of unit 14 from *Halobia*-bearing calcareous sediments interlayered with lavas of unit 3 to the north. It appears therefore that the strata of unit A form an allochtonous block which is in fault and/or unconformable contact with rocks of unit 3.

The unit cannot at this time be readily correlated with any known formation in the region — thus it is mapped separately.

TABLE 3. FOSSILS FROM UNIT A

FOSSILS	FOSSIL LOCALITIES		
	F11	F12	F13
Spiroceras orbignyi (Baugier et Sauce)		x	
Trigonia indet.		x	
Weyla acutiplicata (Hyatt)	x		
Weyla sp. indet. aff. ? *W. bodenbenderi* (Behrendsen)	x		x

F11 From a small lens of grey to buff fine-grained limestone 1.6 kilometres north of west end of Hamilton Lake, elevation 1 290 metres. Latitude 50 06'49.6" north, longitude 120 38'10.3" west. G.S.C. Report J-2-1975-HF, locations 90974 and 91856. AGE — Early Jurassic.

F12 From buff-weathering grey calcareous siltstone and silty limestone, 30 to 40 metres south of F11. G.S.C. Report J-2-1975-HF, locations 90975 and 91857. AGE — Late Bajocian.

F13 From a small lens of grey impure limestone 70 to 80 metres north of F11. AGE Sinemurian to Pleinsbachian, probably Early Pleinsbachian (H. W. Tipper, written communication, May 10, 1977).

UPPER JURASSIC TO LOWER CRETACEOUS

UNIT 9: Extensive exposures of ferruginous chert boulder and pebble conglomerate with interlayered grit and sandstone occur from a point 4.5 kilometres southwest of Aspen Grove to the northern boundary of the map-area. The best and most extensive exposures of the conglomerate are southwest of Aspen Grove and on the wooded hills southwest of Courtney Lake where a thickness of at least 460 metres is indicated. The conglomerate consists for the most part of well-rounded, smooth clasts of dark to light grey chert, and contains only a minor amount of pebbles and cobbles of volcanic, sedimentary, and granitic rocks, usually in an advanced state of decomposition. The high degree of sphericity and roundness of the chert clasts, compared with the more angular outlines of the softer and more friable sedimentary, volcanic, and granitic clasts, suggests that the conglomerate is a very mature, residual deposit which received debris intermittently over a long period of time.

From Courtney Lake south, exposures of the conglomerate are bound by branches of the Allison fault system. Southwest of Aspen Grove the conglomerate appears to have been thrust westward over rocks of map unit 11. This thrust may not be a structure of regional extent, but rather a local feature developed in response to movement along the Allison fault system. North of Courtney Lake, exposures of the conglomerate are found west of the Quilchena Creek fault system, and their distribution here suggests that the conglomerate unconformably overlies Nicola rocks but is in turn unconformably overlain by volcanic and sedimentary rocks of map unit 11.

The nearest suitable source for the chert clasts are the ribbon cherts of the Upper Paleozoic Chapperon Group some 45 kilometres to the northeast, or similar but somewhat less metamorphosed rocks of the Cache Creek Group more than 90 kilometres to the northwest.

Schau (1968) included exposures of this conglomerate north of Courtney Lake in his 'Clapperton Conglomerate' which he considered to be of Late Jurassic or Lower Cretaceous age, mostly because of the rock types making up the clasts. No more conclusive evidence on the age of this unit was found during present mapping. Similar conglomerates in the Intermontane Belt are generally considered to be of Late Jurassic to Early Cretaceous age (R. B. Campbell, H. W. Tipper, personal communication, 1975), which appears to be a reasonable estimate for this map unit.

Plate VIII. Flow-banded rhyolite of map unit 10b, east of Dry Lake.

LOWER CRETACEOUS

KINGSVALE GROUP

UNIT 10: A largely subaerial succession of flows, ash flows, tuff, and lahars unconformably overlies Nicola rocks and intrusive rocks of Allison Pluton south of Laird Lake. Rice (1947) mapped parts of this succession as Nicola rocks, and parts he correlated with the Lower Cretaceous Kingsvale Group.

Unit 10a: Coarse boulder conglomerate of unit 10a is exposed 1 kilometre southwest of Dry Lake, up slope from altered and mineralized granitic rocks of Allison Pluton. The conglomerate contains numerous rounded clasts of Nicola volcanic rocks and of granitic rocks identical to distinctive phases of the Allison Pluton. A large boulder of reddish granite identical to that of map unit 7a was removed from the conglomerate, and muscovite from it yielded a K/Ar age of 203±5 Ma. Conglomerate of unit 10a was found only at this locality, and in this setting appears to be basal to volcanic rocks of unit 10b.

Unit 10b: Grey and maroon, strongly flow-layered lavas and ash flows of rhyolitic and dacitic composition crop out along the northern periphery of map unit 10 and as smaller bodies in other parts of the succession. Very pronounced colour banding and flow layering, commonly warped or contorted into tight flow folds, is characteristic of these rocks and make them easily recognizable in the field. At some localities, parts of the flows contain numerous small cavities, lined with crystalline quartz, which are probably lithophysae. Small phenocrysts of quartz and sodic plagioclase strongly oriented in the plane of flow layering are common in these rocks. Because of the sparsity of mafic minerals, alteration is usually weak to moderate and consists mostly of sericite-carbonate-epidote with minor amounts of chlorite.

Layering in the lavas and ash flows dips gently to moderately in several directions. Some of these discordant attitudes are undoubtedly primary and some may have been caused by later folding or faulting. The distribution of the main body of unit 10b along the northern periphery of unit 10 suggests that it underlies the bulk of units 10c and 10d, and probably forms the foundation of the sequence. The setting of smaller bodies of rhyolitic lavas and ash flows elsewhere is not well understood, but these also appear to be at or near the bottom of the unit 10 sequence in discontinuous patches.

Unit 10c: Massive, grey to maroon, flows and autoclastic breccia of plagioclase-rich andesite and dacite make up the central part of map unit 10. These are best exposed on the cliffs west of Allison Creek between Laird Lake and McCaffrey Lake. In the field these rocks can be readily separated from the older, greenish, plagioclase-rich basalts of the Nicola Group by their lighter colour, greater abundance of plagioclase phenocrysts, and generally less altered condition. Even the more basic members of this unit, which, if

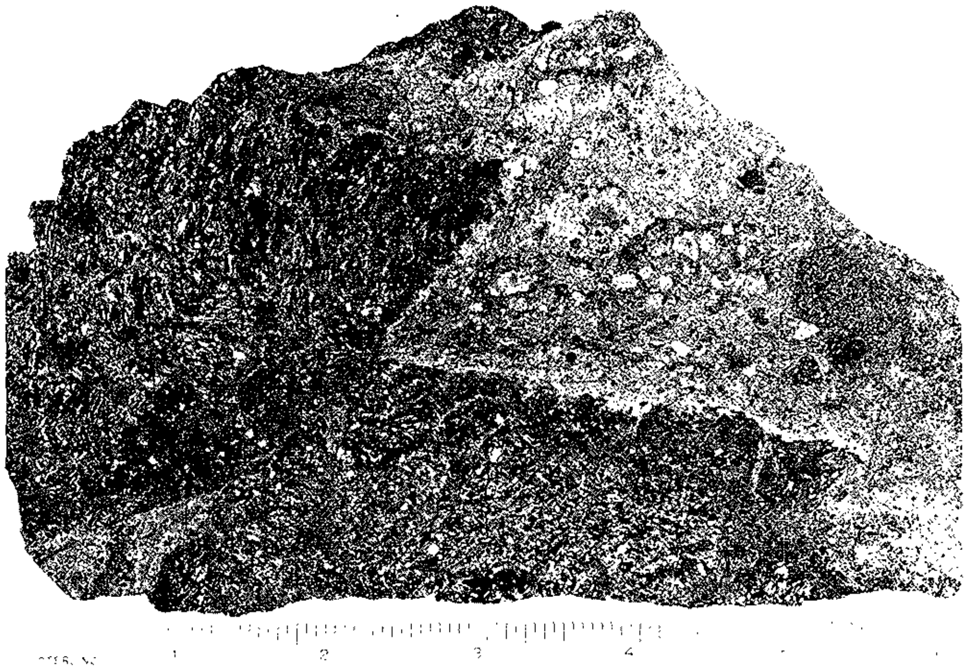


Plate IX. Green lahar of map unit 10d with a large clast of maroon ash flow, southeast of Dry Lake.

taken individually, could be difficult to distinguish from Nicola basalts, can be readily separated in the field by their association with more felsic flow-banded lavas of dacitic composition.

In thin section, the more basic lavas appear to be made up of well-rounded, rather fresh, plagioclase phenocrysts of andesine to low labradorite composition strongly oriented in a very fine-grained, nearly glassy matrix that is moderately to weakly altered to sericite, epidote, carbonate, and some chlorite.

Very crudely, the flows and breccias of this map unit seem to make up the middle part of the unit 10 subaerial succession, but between Allison and Summers Creeks they are interlayered, probably in their upper parts, with lahars and tuff of unit 10d.

Unit 10d: Thick piles of massive, grey to brown lahars, tuff, and breccia crop out mostly between Allison and Summers Creeks. The best exposures of these rocks are found east of Allison Creek between McCaffrey and Laird Lake, where they form bold cliffs.

The lahars are typically massive and have a greenish grey or grey matrix containing an unsorted variety of pebbles, cobbles, and large boulders derived from units 10b, 10c, and older rocks.

Tuff and breccia beds associated with the lahars are generally moderately sorted and bedded, thus providing information on the attitude of the massive lahars with which they are interbedded.

AGE OF UNIT 10: Map unit 10 unconformably overlies Nicola rocks and Allison pluton. This is indicated by the distribution of this subaerial succession in an east-west direction across the trend of Nicola rocks, by the lesser degree of alteration of even the more basic flows, and by the fact that boulder conglomerate of unit 10a, believed to be basal to the succession, contains numerous clasts of Nicola and Allison rocks. One of these boulders of distinctive Allison red granite was removed from the conglomerate and muscovite from it yielded a K/Ar age of 203±5 Ma.

Along Summers Creek, rocks of unit 10 are intruded by Cenomanian granite and quartz monzonite of map unit 13. Co-existing biotite and hornblende from this pluton have yielded K/Ar ages of 98.2±2.6 and 96.8±2.6 Ma respectively, and biotite from another sample has yielded an age of 96.7±2.1 Ma (Cenomanian). An Rb/Sr isochron from whole-rock samples of flows of unit 10 indicates an age of 112±10 Ma (Fig. 6 and Table 4). It appears therefore that this succession of subaerial, intermediate to acid flows, ash flows, tuffs, and lahars is Aptian to Albian in age and probably correlative with the Kingsvale Group.

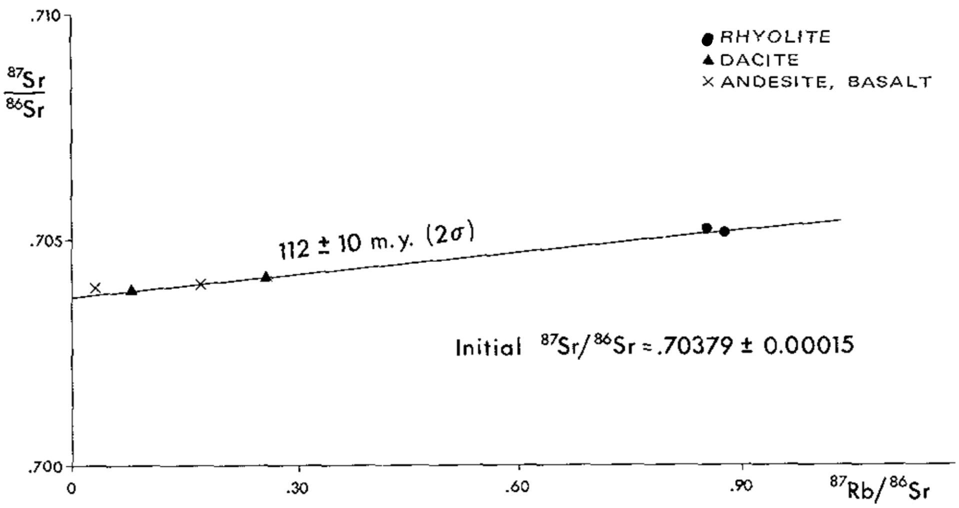


Figure 6. Whole-rock isochron for map unit 10.

TABLE 4. WHOLE–ROCK Rb/Sr ANALYTICAL DATA FOR UNIT 10

Field No.	Rock Type	Sr *ppm*	Rb *ppm*	Rb/Sr	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}
VP-75- 12	basaltic andesite	691	8	0.0115	0.033	0.7039
PT-75-285	dacite flow	795	22	0.027	0.078	0.7039
M-75- 83	grey andesite	587	34	0.058	0.168	0.7040
VP-75-117	dacite flow	496	44	0.088	0.255	0.7042
T- 11	rhyolite flow	227	66	0.290	0.839	0.7052*
M-75-189	rhyolite flow	202	60	0.298	0.862	0.7051*

*Confirmed by duplicate analysis.
Initial Sr^{87}/Sr^{86} = 0.70379 + 0.00015 $\sigma \approx 3\%$ or 0.00015
Age – 120±10 Ma (2σ)

UNIT 11: Intrusive, volcanic, and sedimentary rocks that are probably part of the Lower Cretaceous Kingsvale Group crop out on a 4.5-kilometre-wide belt that stretches southwesterly from Mount Nicola to beyond the western boundary of the map-area. The strata trend northeasterly, dip moderately to steeply to the southeast, and can roughly be divided into three facies: a lower volcanic facies of flows, breccias, and tuffs; a central sedimentary facies composed of coarse volcanic conglomerate, grit, sandstone, and shale which is interbedded with, and largely derived from, the underlying volcanic rocks; and an upper volcanic facies which includes thick accumulations of flows, breccias, and tuffs and interlayered silts and laccoliths of augite-plagioclase basalt porphyry which locally grade laterally into flows.

A small outlier of conglomerate with some interlayered impure limestone and calcareous grit unconformably overlies Nicola rocks a short distance north of the Axe prospect, and is correlated with the main body of map unit 11.

Unit 11a: The volcanic rocks of unit 11a range from andesite to basalt in composition and are commonly reddish, maroon, or brownish green in colour. North of Aspen Grove these are mostly flows, but to the south lavas are interlayered with a good deal of autoclastic breccia, pyroclastic breccia, and some tuff. Plagioclase phenocrysts are ubiquitous and abundant in these rocks, but augitic pyroxene is also common, though less abundant. Zeolites, mostly orange and reddish laumonite, are widespread and abundant as fracture and vesicle fillings in the flows and fragmental rocks.

Unit 11b: Several sills or laccoliths of augite-plagioclase porphyry of basaltic composition are interlayered with the extrusive rocks in the upper part of the succession southwest of Courtney Lake.

These intrusions typically contain large, tabular, well-twinned phenocrysts of labradorite/bytownite and a lesser amount of pyroxene. They are very similar in composition to the flows and in some instances have been observed to grade laterally into flows. This field relationship and the similarity in composition suggest that the intrusive rocks probably represent the feeders of the volcanic pile.

Unit 11c: The clastic sedimentary rocks are also reddish to brownish grey in colour and range from coarse boulder conglomerates and breccias to red shale. They are clearly an intraformational facies in the volcanic rocks and are largely composed of debris from the underlying volcanic rocks. The coarse conglomerate and breccia units also commonly contain granitic clasts probably derived from plutons such as the Guichon and Okanagan batholiths, and numerous clasts of delicately flow-banded rhyolitic lavas that very closely resemble those described by Rice as part of the Spences Bridge Group (1947, p. 24), or those of map unit 10b.

The sandstone beds in the sequence display a profusion of sedimentary features such as crossbedding, graded bedding, cut-and-fill structures, and sole markings which abundantly indicate that the section is right side up. The finer shale and silt beds commonly display mud cracks, occasional raindrop prints, and at one locality, some possible salt crystal casts. All indications are that these sediments, and the volcanic rocks were deposited in a subaerial environment or in very shallow water.

Unit 11d: A thin, discontinuous bed of grey impure limestone and calcareous grit is interbedded with a coarse conglomerate, similar to those of unit 11c, in an outlier which unconformably overlies Nicola rocks a short distance north of the Axe prospect. No fossils were found in the limestone, and the conglomerate above and below is very similar in all respects with conglomerates of unit 11c.

AGE OF UNIT 11: No definitive evidence is available as to the age of map unit 11. The sequence is bound by faults to the southeast and northwest, but the outcrop pattern and bedding attitudes on Mount Nicola suggest that there the assemblage probably unconformably overlies rocks of both unit 9 and the Nicola Group. Clasts of granitic rocks and acid lavas are common in the conglomerates of unit 11c, and appear to have been derived from Triassic/Jurassic plutons and from lavas of map unit 10 and/or the Spences Bridge Group.

A few fragments of pelecypods were found in a limestone boulder in brown volcanic conglomerate some 900 metres east of Menzies Lake (locality F14 on Fig. 1) and indicate a possible Early Jurassic age for the limestone (H. W. Tipper, written communication, August 9, 1973), thus setting a possible maximum age for the conglomerate. The tentative correlation of map unit 11 with the Kingsvale Group is made on the basis of lithology, degree and type of alteration of basic flows, types of clasts found in the conglomerate beds, and that, on the north slopes of Mount Nicola, the outcrop pattern of the unit suggests an unconformable relationship with rocks of unit 9 and the Nicola Group.

POST LOWER CRETACEOUS

UNIT 14: Several isolated exposures of a well-indurated boulder conglomerate with well-rounded clasts, a large part of which consists of granitic and of Nicola volcanic rocks, are found north and south of Lundbom Lake. At one locality east of Sugarloaf Mountain the conglomerate unconformably overlies fossiliferous Jurassic strata of unit A. No direct indication of the age of this conglomerate was found, but the abundance of granitic clasts in it would suggest that it was deposited at a time when the large Triassic and Jurassic plutons in the area were unroofed and were being actively worn down. The presence of a few Kingsvale-like clasts would also suggest a post Lower Cretaceous age.

UNIT 15: A few exposures of reddish weathering, hematitic boulder conglomerate composed almost entirely of debris from volcanic rocks of map unit 11 occur west of Allison fault, 4.5 kilometres south of Aspen Grove. The exposures are isolated and unfossiliferous. The age of this unit is uncertain but is probably post Lower Cretaceous.

PALEOCENE

COLDWATER BEDS – UNIT 16: Highly friable grit and conglomerate (map unit 16a) and sandstone, shale, and coal-bearing beds (map unit 16b) occur as isolated exposures in the northern part of the map-area. These are probably correlative with the Coldwater beds.

Vegetation remains collected 300 metres north of Lundbom Lake (locality F15) were examined by Dr. W. S. Hopkins, Jr., whose report is as follows:

Report: T-08 WSH 1974

Locality: Lat. 50° 05′ 29.8″ N; Long. 120° 37′ 18.9″ W
G.S.C. Locality 9247

Flora: Miscellaneous fungal spores
Lycopodium sp.
Miscellaneous bisaccate conifer pollen
Metasequoia sp.
Podocarpidites sp.

Alnus sp.
Paraalnipollenites sp.
cf. *Pterocarya* sp.
cf. *Carpinus* sp.
cf. *Betula* sp.
Tricolpites sp.
Triporopollenites sp.

Age: Paleogene, most probably Paleocene

MIDDLE EOCENE

PRINCETON GROUP – UNIT 17: Sedimentary rocks of Princeton Group crop out in the southern part of the map-area where they unconformably overlie older rocks. The unconformity with Nicola rocks is beautifully displayed in a cut where the Summers Creek road branches off Highway 5. Here, well-bedded grey sandstones, siltstones, an shales lap onto weathered, rusty, highly faulted, pyritic Nicola volcanic rocks. Numerous steep faults and fractures in the older rocks stop sharply at the unconformity. North of this locality, Princeton sedimentary rocks straddle the high ridge that separates Allison and Summers Creeks. This sharp east-west trend does not seem to be due to late east-west faulting, but rather to an old depression that was filled with Princeton sediments.

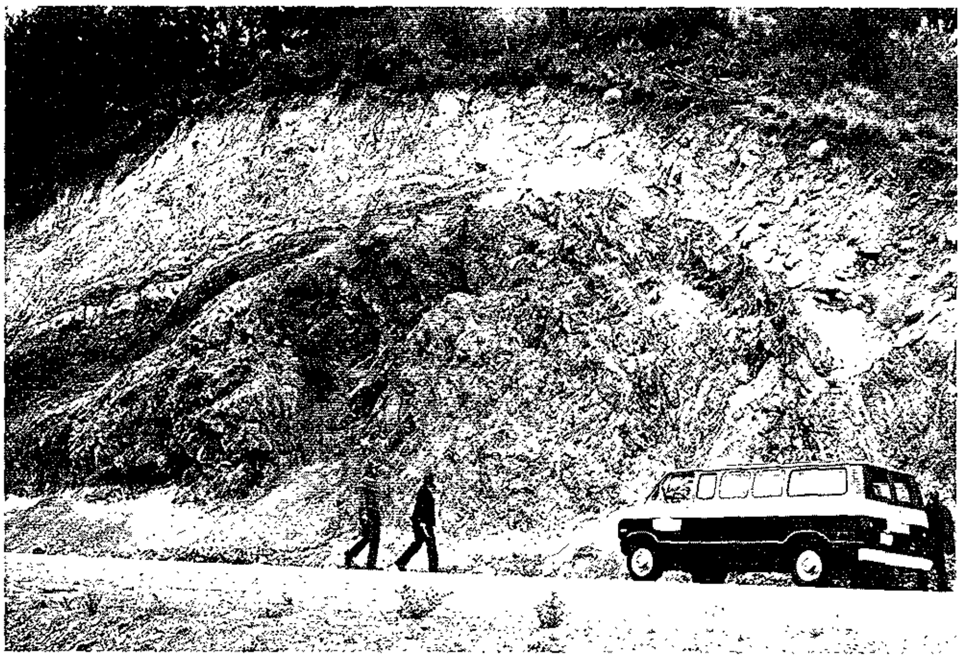


Plate X. Unconformity betwen Nicola volcanic rocks and sedimentary rocks of map unit 17 along Highway 5 at junction with the Summers Creek road.

Plate XI. Valley basalt of map unit 18 along Shrimpton Creek.

Plate XII. Hollow boulder of basalt of map unit 18 along Quilchena Creek, east of Courtney Lake.

Princeton sedimentary rocks (map unit 17a) are part of the Allenby Formation of Hills (1962) and include grit, sandstone, and siltstone, well displayed in cliffs along Summers Creek (Hills, 1962; McMechan, 1975) with minor coarse boulder conglomerate rich in clasts of feldspar porphyry similar to that of the Siwash Creek and Trout Creek bodies (Rice, 1974, p. 50). Volcanic rocks (map unit 17b) belong to the Lower Volcanic Formation of Hills (1962) and consist of reddish, probably subaerial, basaltic flows and breccia and some lahars.

The age of the Princeton volcanic and sedimentary rocks has been conclusively established as Middle Eocene by K/Ar dates (Mathews and Rouse, 1963; Rouse and Mathews, 1961), by macrofauna (Russel, 1935), and by microfauna (Hills, 1962).

PLEISTOCENE AND RECENT

VALLEY BASALT – UNIT 18: Flows of grey and reddish, vesicular olivine basalt (map unit 18a) occur in the northern part of the map-area, mainly in Shrimpton Creek valley, along the Missezula Lake – Kentucky Lake – Alleyne Lake valley and in Quilchena Creek valley. The basalt is usually 40 to 50 metres thick and consists of five or six flows (Lambert, 1963).

The flows characteristically form long, sinuous, flat-topped, vertical cliffs which follow the valley side and which can commonly be matched with similar exposures at the same elevation on the opposite side of the valley. These are clearly erosional remnants of lavas which once flooded the valley floor. The cliffs usually afford excellent exposures of flow contacts, columnar jointing, subvertical vesicle pipes and vesicle cylinders, and other features typical of basaltic pahoehoe flows. At one locality on the west side of Quilchena Creek, east of Courtney Lake, the basalt weathers into peculiar, hollow boulders, some large enough to comfortably house several persons in their cavity. This feature has been described and investigated by Campbell (1966) who attributes them to processes of differential weathering.

Approximately 2 kilometres south of Loon Lake an elongated plug of medium-grained gabbro (map unit 18b) cuts volcanic sediments of the Eastern Belt. This probably is an eroded volcanic neck from which the flows issued.

The valley basalts of Quilchena Creek have been described by Lambert (1963, pp. 15, 16) who indicates that along Quilchena Creek the flows overlie unconsolidated sand and gravel and are overlain by glacial drift and glacio-fluvial deposits. Fulton (1965) also states that south of Merritt, along the Coldwater River, valley basalts rest upon interglacial sediments. It would therefore appear that the flows are of Pleistocene age.

INTRUSIVE ROCKS

Intrusive rocks in the map-area range in age from Upper Triassic to Upper Cretaceous. The oldest plutons are compositionally and genetically related to Nicola rocks and some probably represent the roots of Nicola volcanoes.

The Allison Pluton, though only slightly younger, clearly cuts Nicola rocks and bears no obvious genetic relation to them. Younger plutons include parts of the Jurassic Pennask batholith and Cretaceous intrusions along Allison and Summers Creeks.

UPPER TRIASSIC TO LOWER JURASSIC

UNIT 4: Leucocratic, pyritic, sheared quartz porphyry occurs along a northerly trending shear zone west of Summers Creek and 2 to 5 kilometres north of the Axe prospect. Though fine grained and highly sheared, the porphyry appears to be intrusive into flow rocks of unit 1a. It clearly predates the shear zone which seems to be truncated to the north by a body of diorite of unit 5. Since the diorite is considered to be only slightly younger than the volcanic rocks it intrudes, the porphyry of unit 4 is also assumed to be roughly of the same age as the Nicola rocks.

UNIT 5: Generally elongated, structurally controlled stocks and irregular bodies of fine and medium-grained diorite, syenodiorite, quartz diorite, monzonite, and diorite breccia occur almost exclusively in the Central Belt from the Axe prospect to the northern boundary of the map-area. The largest of these forms two nearly coalescing masses northeast of Lundbom Lake and was termed South Nicola stock by Schau (1968). The most common rock type in the stocks is a medium-grained equigranular to weakly porphyritic pyroxene diorite that is generally strongly saussuritized and locally flooded by potash feldspar. This rock type is most common in the smaller stocks. Larger plutons tend to be of coarser grain and commonly contain quartz-bearing phases.

Contact relationships between these intrusive rocks and the volcanic rocks vary. In most cases they are either a fault or sharply intrusive, but in others, and especially, the larger bodies in the northern part of the map-area, they are highly irregular and gradational and the volcanic rocks around the pluton are highly altered and recrystallized.

All stocks, large or small, are similar in composition to the surrounding volcanic rocks and are strongly oriented parallel to the main trends of bedding and faulting in the volcanic rocks. Lithologically most of the plutons are very similar to dioritic intrusive rocks at Copper Mountain (Preto, 1972) and near Kamloops (Northcote, 1974) which, though intrusive into the surrounding volcanic rocks, are coeval and comagmatic with them. Similarly, though no K/Ar data is available, it is suggested that the stocks of map unit 5 are magmatically related to the Nicola volcanic rocks and are of much the same age.

UNIT 6: Stocks of pink and grey, medium-grained porphyritic pyroxene monzonite and syenite and small pipes of monzonite and syenite breccia occur in the Central Belt from near Courtney Lake to the north end of Missezula Lake and in the Eastern Belt from Missezula Lake south. Two stocks of somewhat similar but much finer grained rock occur in the Western Belt.

Typically, rocks of unit 6 are grey-green to salmon pink in colour and are essentially composed of zoned intermediate plagioclase, augitic pyroxene, and varying amounts of potash feldspar. Sericitization of the plagioclase and variable alteration of the pyroxene to chlorite, epidote, and actinolite are ubiquitous. Extensive flooding of potash feldspar outward from fractures and veinlets is common, especially in zones of brecciation. Breccia pipes, such as the Big Kid breccia northwest of Alleyne Lake, are one variety of this unit and contain abundant fragments of porphyry as well as of country rocks in a strongly propylitized and variably mineralized matrix. The similarity is striking between the Big Kid pipe and similar breccia bodies associated with the Lost Horse intrusions of Copper Mountain (Preto, 1972).

Wherever these stocks are surrounded by Nicola fragmental volcanic rocks, a remarkable number of clasts of the intrusive are found in the nearby volcanic rocks thus indicating a close overlap of ages between intrusive and extrusive or volcaniclastic rocks. The intrusive is younger than part of the volcanic succession, which it cuts, and older than part of it, to which it supplied clasts. These relationships suggest that most of these small stocks are the high level, intrusive part of volcanic centres which periodically extruded the surrounding volcanic rocks but which were soon after denuded and eroded to supply debris for slightly younger parts of the succession.

A remarkably clear display of these relationships is provided by the sinuous and northerly elongated stock of syenomonzonite and breccia and its surrounding volcanic rocks immediately east of Missezula Lake. This pluton not only supplied abundant debris to the nearby conglomerates and lahars but also forms the core of a small dome and is surrounded by discontinuous flows of analcite trachybasalt and small lenses of reefoid limestone and calcarenite which probably once formed a fringing reef around the volcano. Clearly this is the volcanic centre from which issued the nearby basalt flows.

Though no radiometric data is available on the absolute age of these plutons, they, like their well-dated counterparts at Copper Mountain and near Kamloops, are considered to be essentially coeval with the surrounding Nicola rocks and genetically related to them.

ALLISON LAKE PLUTON – UNIT 7: Granitic rocks of Allison Lake pluton crop out on both sides of Highway 5 from Laird Lake northward for 12 kilometres. This pluton has been previously described by Rice (1947, p. 39) as consisting of red granodiorite. The portion that was surveyed during mapping was found to consist mostly of reddish and grey, locally miarolitic, biotite-hornblende granite and quartz monzonite with some muscovite granite (map unit 7a). Grey hornblende granodiorite (map unit 7b) and grey to dark grey, locally migmatitic, hornblende diorite and quartz diorite (map unit 7c) are lesser constituents. Large inclusions or roof pendants of strongly altered, locally migmatized Nicola rocks (map unit 7d) occur at several places within the pluton and as a long, narrow, strongly silicified zone outside the pluton southeast of Stringer Lake, suggesting that the present level of erosion is close to the former roof of the intrusion.

The Allison pluton clearly intrudes Nicola rocks which are intensely sheared, silicified, and pyritized along its contact. Rice (1947, p. 39) indicates that southwest of Allison Lake the pluton is unconformably overlain by Lower Cretaceous Kingsvale rocks.

Radiometric age dating of biotite and muscovite from quartz monzonite and granite yielded ages of 200±5 Ma and 203±5 Ma, respectively.

Thus the pluton is roughly coeval with the surrounding Nicola rocks but is not obviously genetically related to them.

LOWER JURASSIC OR LATER

PENNASK BATHOLITH – UNIT 8: Granitic rocks of the Pennask batholith crop out along the eastern edge of the map-area north and northeast of Pothole Lake and southeast of Loon Lake. The rock is biotite-hornblende granodiorite occasionally cut by felsic dykes which also cut the country rocks near the batholithic contact. The area of extensive overburden east and west of Quilchena Creek in the northeast corner of the map-area is probably shallowly underlain by Pennask rocks because the Nicola rocks that are sparsely exposed here are extensively altered to epidote-garnet skarns.

Rice (1947) assigned a 'Jurassic or later' age to the Pennask batholith, and Schau (1968) concluded that the intrusion is probably Early Jurassic image. The batholith is clearly younger than Nicola rocks, but it must have been unroofed and actively eroded by the time the conglomerate of map unit 14 was deposited. An Early Jurassic or later age for this intrusion therefore seems likely.

POST LOWER CRETACEOUS

ALLISON CREEK STOCKS – UNIT 12: Several small stocks and numerous northerly trending dykes occur along Allison Creek south of Laird Lake. These range from pink leucogranite to mafic microdiorite, but mostly are of the less mafic varieties. The stocks cut volcanic rocks of unit 10 and older Nicola rocks, and are cut by and altered along faults which parallel Allison Creek and are part of the Allison fault system. A good deal of silicification occurs in the stocks and nearby country rocks, and some copper mineralization has been observed in a few places.

The general scarcity of suitable minerals and the ubiquitous alteration have frustrated efforts to select samples for radiometric dating and the stocks can only be considered to be post Early Cretaceous in age since they cut rocks of unit 10.

UPPER CRETACEOUS (CENOMANIAN)

SUMMERS CREEK STOCKS – UNIT 13: Granitic rocks of map unit 13 crop out along Summers Creek south of the Axe prospect and as a separate stock 1.2 kilometres north of the Axe Adit zone. Unit 13a consists of grey biotite-hornblende granodiorite, biotite quartz monzonite, and minor pink granite. It forms a northwest-trending lobe which protrudes from the main batholithic mass of Jurassic Okanagan intrusions to the east, and is traversed longitudinally by a branch of the Summers Creek fault. Co-existing biotite and hornblende from grey granodiorite 1.6 kilometres south of the Axe south zone yielded the following K/Ar ages for the unit: biotite, 98.2±2.6 Ma; hornblende, 96.8±2.6 Ma. Similarly, biotite from quartz monzonite 2.4 kilometres farther to the southeast along Summers Creek yielded a K/Ar date of 96.7±2.1 Ma. This unit cuts Nicola rocks and volcanic rocks of unit 10.

Unit 13b forms a small, northerly elongated stock of diorite, quartz diorite, and granodiorite on the west slope of Summers Creek, north of the Axe prospect. No information is available on the age of this pluton other than it cuts Nicola rocks, but it is considered to be part of unit 13 on the basis of its lithology.

Northeast-trending quartz feldspar porphyry dykes, numerous quartz veins, some silicification, and minor molybdenum mineralization in the volcanic rocks at the Adit zone are probably related to these Cenomanian intrusions.

3

METAMORPHISM AND CHEMISTRY

INTRODUCTION

The metamorphism and chemistry of the Nicola rocks have been previously studied and described by Schau (1968) and Lefebure (1976). The former report includes the northern part of the Central and Western Belts, whereas the latter documents an area of excellent exposures entirely within the Central Belt.

Nicola rocks are by far the most abundant in the map-area, and are the main object of this study. A brief section at the end of the chapter is dedicated to rocks of unit 10.

NICOLA ROCKS

METAMORPHISM: In general, over the whole map-area, Nicola rocks are characterized by a highly variable, low-grade state of alteration that is indicative of a low pressure metamorphic environment. Metamorphic variations may be encountered locally near intrusions or along major faults and shear zones where minerals indicative of higher metamorphic grades and strong secondary fabrics may have developed. Most Nicola rocks within the map-area, however, are massive and non-schistose, and are weakly altered. The fresher basaltic rocks tend to be subaerial, and commonly have only slightly altered, well-zoned augite and calcic plagioclase phenocrysts. The green basaltic andesites and basalts of submarine sequences are generally more altered and contain a good deal of epidote, actinolite, chlorite, albitized plagioclase, and calcite. Apart from these minerals, which are very widespread and locally abundant in the basaltic rocks, other common secondary minerals include prehnite, pumpellyite, potassium feldspar, hematite, some quartz, sphene, and, locally, garnet. Many of the basaltic flows, and especially those rich in clinopyroxene, contain patches and subhedral masses of hematite and antigorite which are probably pseudomorphous after olivine. Olivine itself, however, was not identified.

METASOMATISM: Schau (1968) reported that the Nicola rocks in his map-area have undergone extensive metasomatism as indicated by textural, mineralogical, and chemical evidence. Metasomatic changes involving redistribution of major elements, and especially alkalis, are described by him as having affected his whole map-area and, accordingly, he classified his rocks as belonging to the calc-alkaline series on the basis of textures, relict minerals, and inferred original chemistry (1968, p. 111).

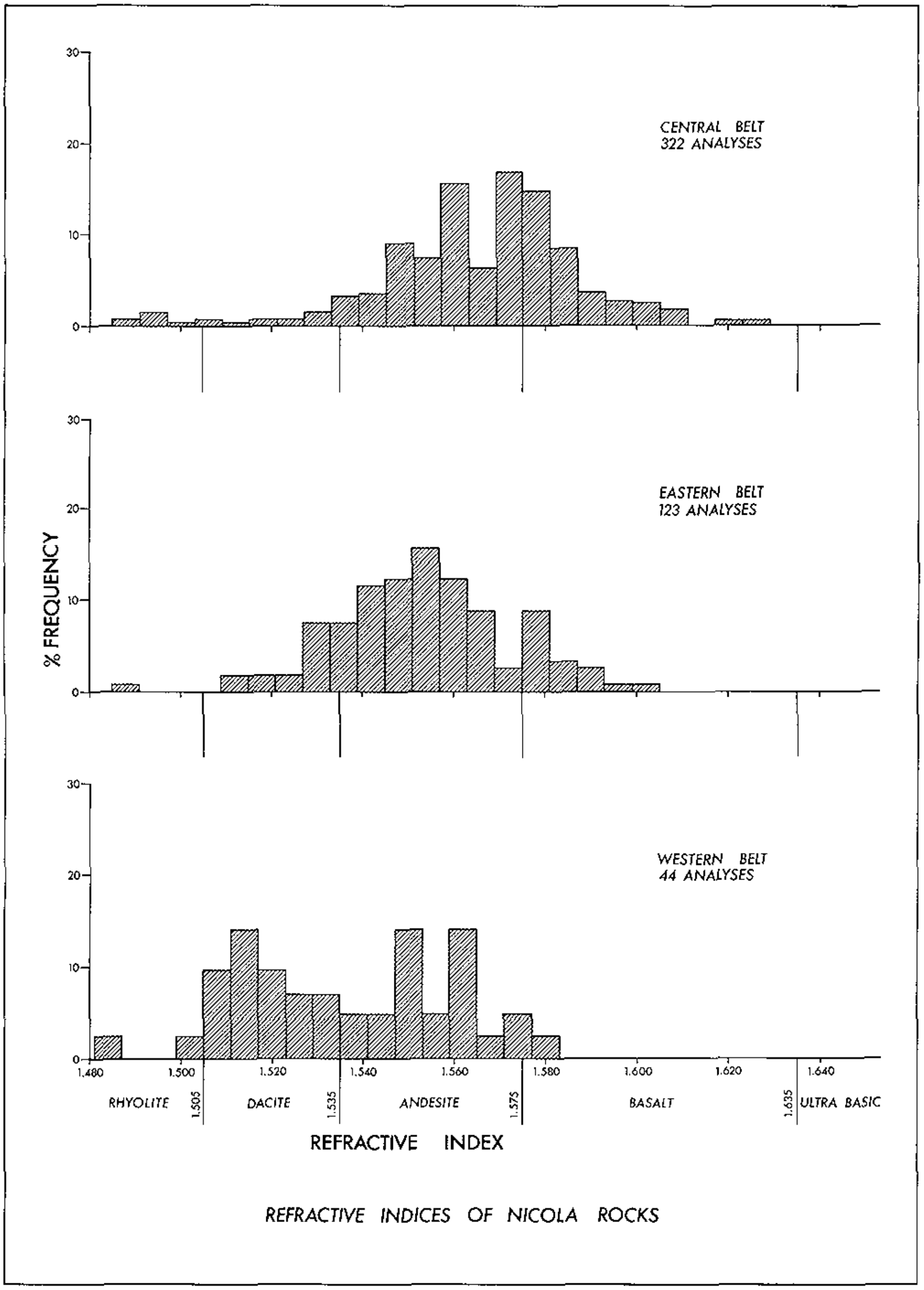
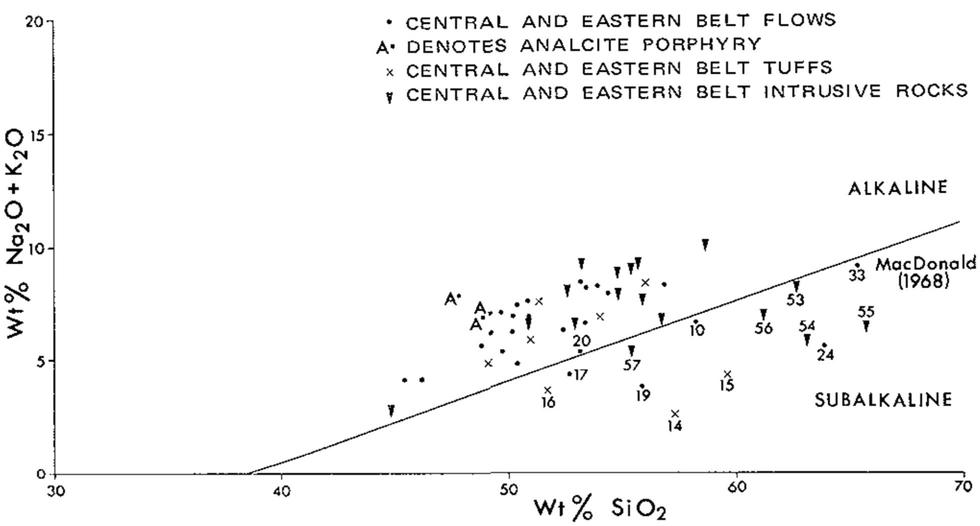


Figure 7. Refractive indices for Nicola rocks.

To the south in Fairweather Hills, Lefebure (1976) studied in considerable detail a well-exposed succession of mostly basaltic flows and lahars which have undergone variable degrees of alteration. Following an exhaustive chemical study as well as electron microprobe studies of many of the constituent minerals, especially pyroxene, Lefebure (1976, pp. 121-126) concluded that metasomatism in the basaltic igneous rocks occurred over distances of millimetres and occasionally centimetres but that domains the size of a hand specimen or larger remained unaffected. The evidence produced by Lefebure to support these statements is impressive, and his conclusions contrast sharply with those of Schau (1968). Though no such study was undertaken for the rest of the map-area by this writer, Lefebure's findings may well be applied to most of the area of this report. In short, Nicola rocks are variably but generally weakly metamorphosed and do not appear to have been extensively metasomatized. As will be shown in the next section, their major element chemistry supports these conclusions and clearly indicates that a large part of the volcanic rocks belong to an alkalic clan.



SUBALKALINE:

33 SA-74-152 IS FLOW EAST OF MISSEZULA LAKE
14,15,16 VP-74-106, 145, 154 ARE TUFFS NEAR MISSEZULA MOUNTAIN
17,19,20,24 LK-74-47; SA-74-229, 263; JN-74-110 ARE FLOWS NEAR MISSEZULA MOUNTAIN
10 VP-73-164 IS FLOW (?) ALONG OTTER CREEK
57 SA-74-111 IS INTRUSIVE AT SOUTH END OF MISSEZULA LAKE
54,55,56 VP-74-17, 18, 105 ARE INTRUSIVES SOUTHWEST OF MISSEZULA LAKE
53 SA-74-210 IS INTRUSIVE EAST OF SUMMERS CREEK

Figure 8. Total alkali-silica plot for volcanic and intrusive rocks of the Central and Eastern Belts.

PETROCHEMISTRY: Chemical analyses of Nicola volcanic or intrusive rocks, their normative compositions, and a brief petrographic outline are given in Appendices 1 to 5.

Fig. 9a

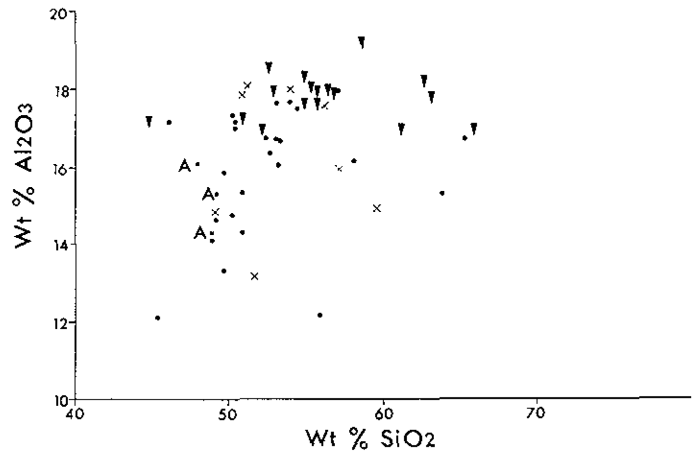


Fig. 9b

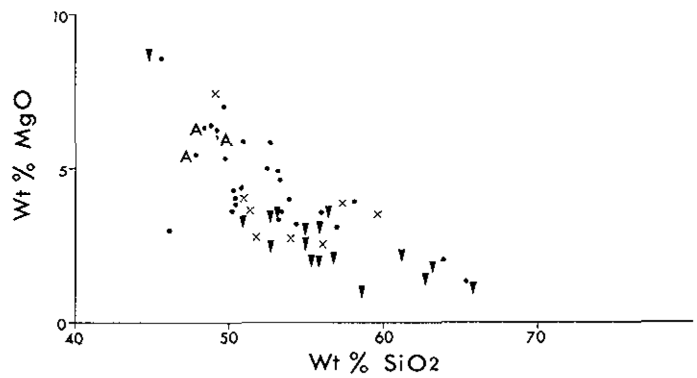
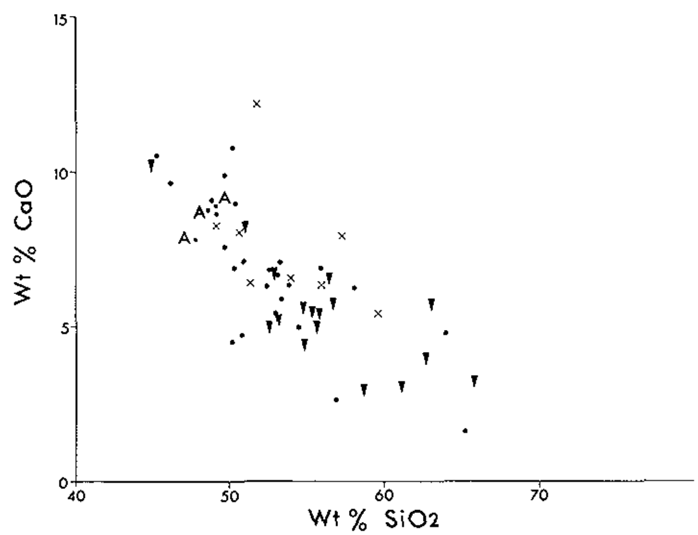


Fig. 9c



• CENTRAL AND EASTERN BELT FLOWS
A• DENOTES ANALCITE PORPHYRY
× CENTRAL AND EASTERN BELT TUFFS
▼ CENTRAL AND EASTERN BELT INTRUSIVE ROCKS

Figure 9. Harker variation diagrams for volcanic and intrusive rocks of the Central and Eastern Belts.

The location of the analysed rocks is given on Figure 1.

Refractive index plots (Fig. 7) indicate a predominance of andesitic and basaltic rocks in the Central Belt and to a lesser extent in the Eastern Belt. In contrast, dacite and andesite predominate in the Western Belt.

Figure 8 is a total alkalis versus silica plot for volcanic and intrusive Nicola rocks and clearly indicates that the bulk of the rocks analysed fall in the alkaline field. Those volcanic rocks which fall in the subalkaline field, below the dividing line of MacDonald (1968), are all from the submarine succession in the vicinity of Missezula Mountain in the south-central part of the map-area or from the Western Belt. Similarly, three of the five subalkaline analyses of intrusive rocks are from one fault-bound body southwest of Missezula Lake.

Harker variation diagrams are given on Figure 9 and show that intrusive and extrusive rocks plot together and thus are probably comagmatic. The CaO and MgO variation diagrams also show that the Nicola rocks plot between the typical calc-alkaline trend, and the trend of Tahiti alkaline rocks (Williams, 1933). The Al_2O_3 variation diagram shows a greater scatter of points with a weak elongation parallel to but not corresponding with that of the alkaline Tahitian lavas.

All of the subalkaline rocks are strongly quartz normative whereas those which plot in the alkali field have very little or no quartz in their norms. Some of these, and especially those which have identifiable analcite phenocrysts, are distinctly nepheline normative.

Figure 10 shows that most of the alkalic rocks that were analysed belong to a potassic series somewhat similar to that of alkali basalts from Gough Islands (Le Maitre, 1962) and Tristan da Cunha (Baker *et al.,* 1964), two alkalic volcanic islands associated with the mid-Atlantic rift.

Figure 11 is a comparative plot of average values of rock suites and shows that the averages of Central and Eastern Belt volcanic and intrusive rocks, of Lefebure's (1976) Fairweather Hills volcanics, and of Schau's (1968) A1 assemblage plot close to the averages of other Upper Triassic suites in the Quesnel Trough and also close to the averages of several alkaline suites from other parts of the world.

If the analyses from Fairweather Hills of Lefebure (1976) and those of assemblage A1 of Schau (1968) were added to the diagrams of Figures 8, 9, and 10 they would produce very similar plots. Lefebure's rocks (1976, p. 88) all cluster in the alkali field, and Schau's analyses also fall largely in this field. One possibility for these high $Na_2O + K_2O/SiO_2$ ratios is that, as suggested by Schau (1968), the whole map-area has suffered metasomatic introduction of alkalis. Lefebure's (1976) work, however, indicates that this is not the case. Moreover, three of the rocks analysed by this writer are augite basalt porphyry flows crowded with clearly recognizable tiny phenocrysts of analcite. As shown on Figure 1, these samples come from widely separated localities. The identity of analcite has been determined by X-ray powder diffraction (Table 5) and by standard optical techniques, including the determination of the refractive index of powdered mineral. There is no question as to the identity of this mineral, and its mode of occurrence, exclusively as euhedral crystals, strongly suggests that it is of primary origin. The analyses of three representative samples of the analcite basalts plot clearly in the alkali field close to one another and to most of the other analyses. The above strongly suggests to this writer that the analyses of these three samples and, by association, those of most of the others, fairly reflect the original composition of the rocks and indicate that no appreciable alkali metasomatism has taken place.

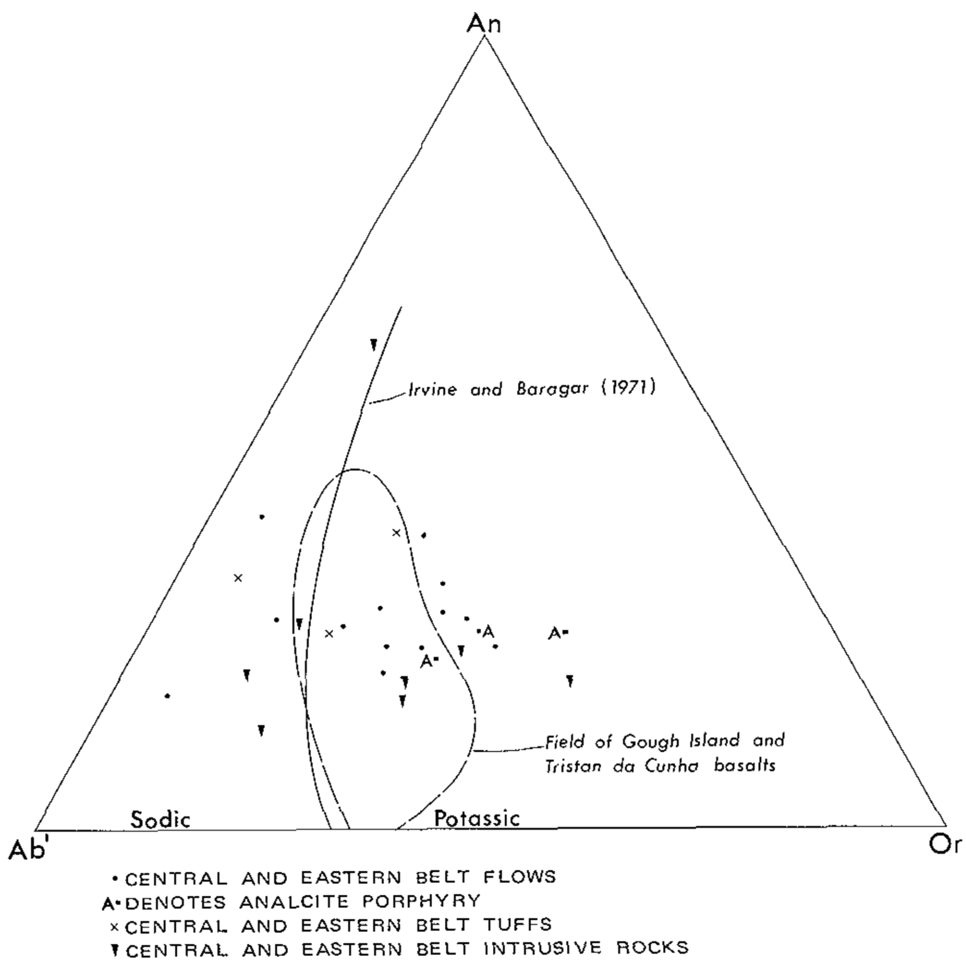


Figure 10. Plot of normative An, Or, and Ab' for the Central and Eastern Belt volcanic and intrusive rocks which have norm Q = O (Ab' = Ab + $\frac{5}{3}$ Ne).

TABLE 5. X–RAY POWDER DIFFRACTION DATA FOR ANALCITE

Laven Analcite Standard No. 7-363		Nova Scotia Analcite Standard No. 19-1180		Aspen Grove Analcite N-73-252		Aspen Grove Analcite SA-74-114		Aspen Grove Analcite SA-74-154	
dA	I	dA	I	dA	I	dA	I	dA	I
-----	---	-----	---	-----	---	9.61	1	-----	---
-----	---	9.14	2	-----	---	-----	---	9.02	1
-----	---	7.93	2	-----	---	-----	---	-----	---
6.88	20	6.88	2	-----	---	6.92	1	6.92	1
-----	---	6.20	2	-----	---	-----	---	-----	---
5.61	80	5.60	60	5.87	2	5.61	10	5.61	5
-----	---	-----	---	5.43	7	-----	---	-----	---
4.85	40	4.85	20	4.875	2	4.85	6	4.85	4
-----	---	4.15	2	-----	---	-----	---	-----	---
-----	---	3.80	2	-----	---	3.83	5	-----	---
-----	---	-----	---	-----	---	-----	---	3.75	4
-----	---	3.67	8	-----	---	-----	---	-----	---
3.428	100	3.43	100	3.52	spot	3.43	10	3.43	10
-----	---	-----	---	3.36	10	-----	---	-----	---
3.24	5	3.24	2	3.20	spot	-----	---	-----	---
3.08	20	-----	---	3.07	spot	-----	---	3.10	5
3.06	5	-----	---	-----	---	-----	---	-----	---
-----	---	2.979	2	-----	---	-----	---	2.98	2
2.929	70	2.927	50	2.93	7	2.92	10	2.92	6
2.896	30	-----	---	-----	---	-----	---	-----	---
-----	---	-----	---	-----	---	-----	---	2.848	6
2.804	20	2.803	8	-----	---	2.805	4	-----	---
2.779	10	-----	---	2.763	5	-----	---	-----	---
2.696	40	2.693	16	-----	---	2.69	6	2.682	3
2.673	20	-----	---	-----	---	-----	---	-----	---
2.506	50	2.506	14	-----	---	2.508	5	2.521	6
2.434	20	2.427	8	-----	---	2.43	3	-----	---
2.412	20	-----	---	-----	---	-----	---	2.417	1
2.36	5	-----	---	-----	---	-----	---	-----	---
2.290	10	-----	---	-----	---	-----	---	-----	---
-----	---	-----	---	-----	---	-----	---	2.242	5
2.229-2.217	30	2.226	40	-----	---	2.226	4	-----	---
2.170	10	2.169	2	2.201	1	-----	---	2.181	4
2.125	10	2.118	8	-----	---	-----	---	-----	---
2.10	5	-----	---	-----	---	-----	---	-----	---
2.015	20	2.024	2	-----	---	-----	---	1.997	4
1.94	5	1.9418	2	1.937	2	-----	---	-----	---
1.906	30	1.9041	14	-----	---	1.903	6	-----	---
1.892	30	-----	---	1.892	8	-----	---	1.899	2
1.869	40	1.8681	8	-----	---	1.87	5	1.87	4
-----	---	1.8353	2	-----	---	-----	---	-----	---
1.744-1.734	50	1.7430	20	1.731	5	1.743	7	1.765	1
-----	---	1.7166	6	-----	---	-----	---	1.728	1

NOTE: Standard patterns taken from 'Selected Powder Diffraction Data for Minerals,' Publication DBM-1-23 by Joint Committee on Powder Diffraction Standards, First Edition.

Rocks of the Western Belt, though not as comprehensively analysed, are largely subalkalic and belong to a calc-alkalic series (Fig. 8). Acid types such as rhyolite and dacite are commonly identified in the field, and form an appreciable part of the refractive index plot of Figure 7. Only four analyses from this belt are available (Appendix 1). These are all considerably siliceous, strongly quartz normative, and contain very small amounts of K_2O.

PETROCHEMISTRY OF MAP UNITS 10 AND 11: Rocks of map unit 10 form a well-differentiated suite that ranges from basaltic andesite to rhyolite in composition. This variation can readily be observed in the field and is supported by the chemical data. Appendix 6 lists eight chemical analyses from unit 10 and three from unit 11. Figure 12 shows that virtually all the analysed samples are subalkaline, and Figure 13 clearly indicates that these closely follow a calc-alkaline trend which in this plot is clearly discernible from an alkaline trend (Church, 1975).

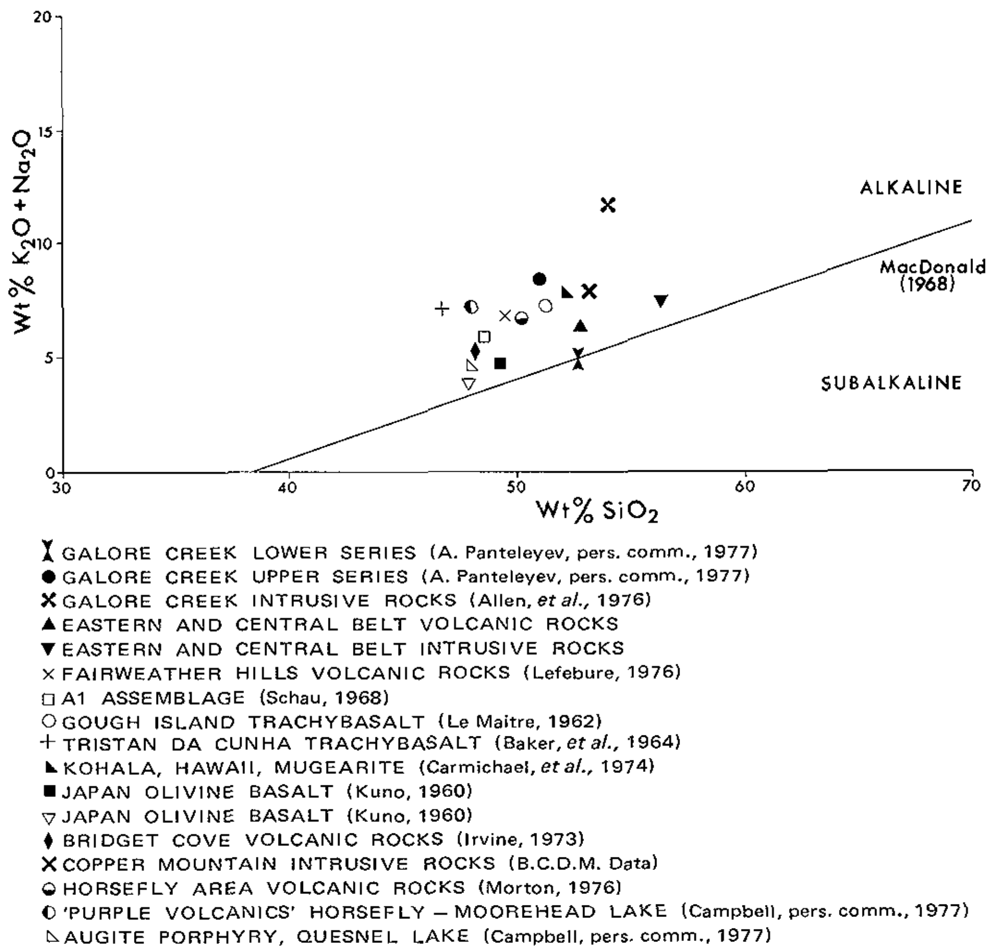


Figure 11. Comparative total alkali-silica plot of average values for various rock suites.

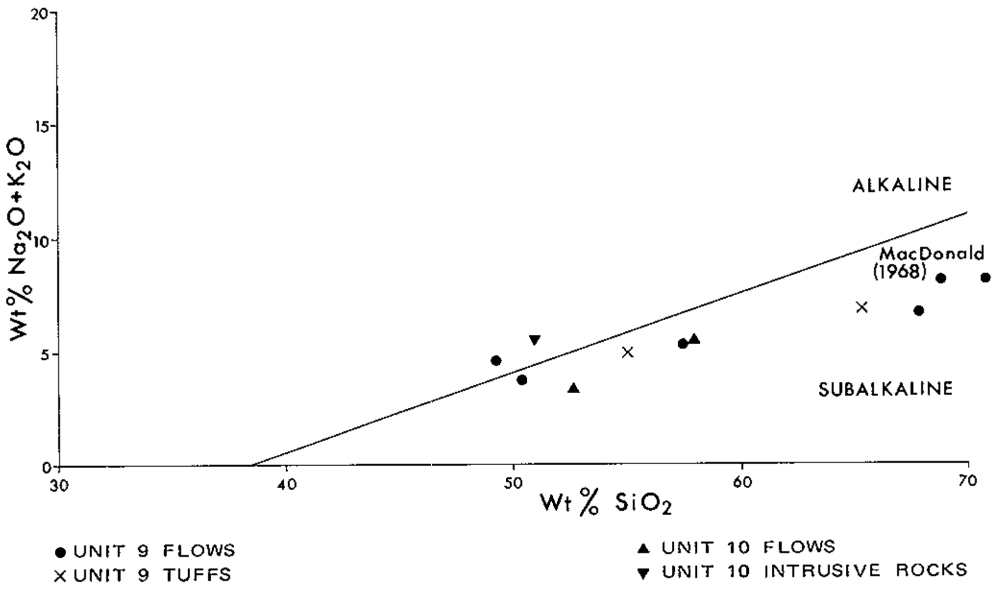


Figure 12. Total alkali-silica plot for analysed rocks of map units 10 and 11.

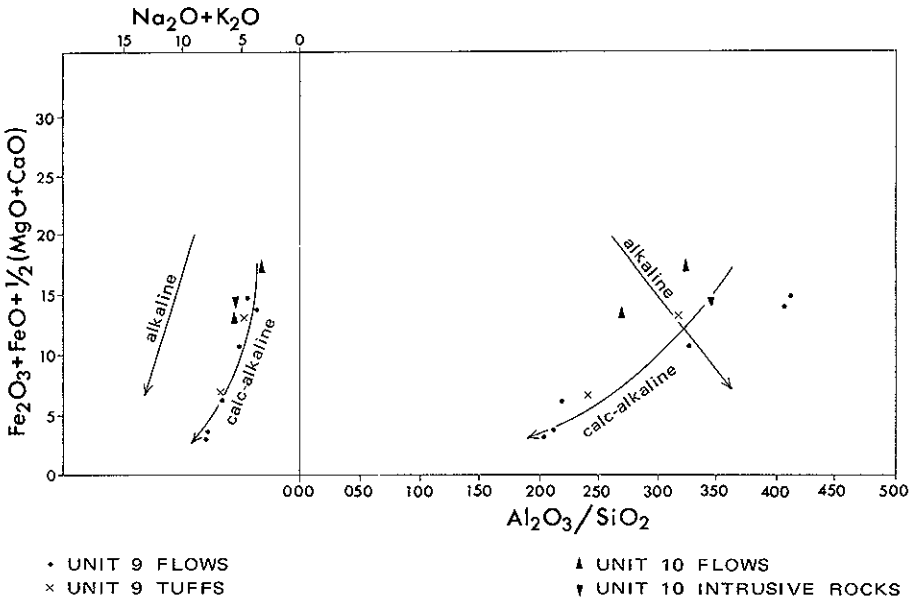


Figure 13. Triaxial plot for analysed rocks of map units 10 and 11.

4

STRUCTURE AND STRATIGRAPHY

INTRODUCTION

The structure of the map-area is typically one of brittle deformation characterized by large northerly trending high-angle fault systems which divide the Nicola rocks into three subparallel belts. These faults were intermittently active for a long period of time and controlled the distribution of Nicola volcanic and intrusive rocks and Early Tertiary volcanic/sedimentary basins. Thus, in a broad sense, these faults define a rift system which originated in or before Early Triassic time and was intermittently active at least until the Middle Eocene and possibly later.

FOLDS

Immediately north of the map-area, Nicola rocks are reported to be locally strongly schistose and to have been thrown into a series of upright and overturned folds (Schau, 1968). These structures do not extend south into the map-area. They are probably related to emplacement of the Nicola batholith and are confined to its southern terminus.

A large, northerly trending, synclinal structure, the Meander Hills syncline, has been described by Rice (1947) and by Schau (1968) to extend from the Meander Hills east of Nicola Lake to a point just west of Princeton. The trace of this fold, as shown on Rice's (1947) map, lies within the map-area in the region east and northeast of Alleyne Lake and between the south end of Missezula Lake and Dry Lake. Nowhere in this area is the existence of the Meander Hills syncline substantiated by the present mapping. In fact, all bedding plane attitudes taken indicate that the Nicola rocks are arranged in a series of roughly monoclinal panels separated by faults, and are not folded.

The possibility of a local, broad, northerly trending synclinal warp truncated by branches of the Summers Creek fault system is suggested by bedding plane attitudes on the ridge 3.2 kilometres north of Missezula Lake. Immediately east of Missezula Lake, flow and volcaniclastic rocks of unit 2 are arranged in a northerly elongated domal structure around a small stock of unit 6. It is believed that this structure is of volcanic, not tectonic, origin. The stock is the core of an ancient volcano and the volcanic rocks were built up around it.

FAULTS

SHEAR ZONES: A prominent shear zone marks the western boundary of the Summers Creek fault system from the Axe prospect northward for at least 12 kilometres. The zone ranges in width from a few metres to more than 300 metres. Over most of its length rocks within this zone are deformed to highly fissile green schist or sericite schist with a strong west-dipping foliation. To the north the shear zone is lost in an area of no exposure southwest of Missezula Lake, and to the south it narrows abruptly and appears to merge into a fault north of the Axe Adit zone. A number of copper occurrences exist along or near this shear zone northwest of Missezula Mountain, both in flow rocks of unit 1a and in diorite of unit 5.

The age of shearing is not well known but it appears to be older than a large diorite body (map unit 5) which was intruded west of Summers Creek, roughly midway along the shear zone. The diorite cuts strongly schistose volcanic rocks but is itself not significantly sheared. No absolute age is available for this intrusive body, but on the basis of its lithology and distribution, it is considered to be part of map unit 5 and to correlate with Central Belt intrusive rocks that are probably Late Triassic to Early Jurassic in age.

Another northerly trending shear zone has been identified along the boundary of the map-area, approximately 5 kilometres northeast of Lundbom Lake, where lavas and tuffaceous rocks of unit 1 are strongly sheared and foliated across a width of 200 metres. The foliation in this zone trends northerly and dips steeply east. The shear zone appears to be the southern terminus of a wide zone of foliated rocks mapped by Schau (1968, pp. 118, 122) which extends northwesterly past the west end of Nicola Lake and along the western border of the Nicola batholith. Schau (1968, p. 124) reports that foliation in this zone 'is older than local overturned folds at Nicola Lake and is cut by late hydrothermal veins associated with the Central Nicola batholith. The foliation is probably lower Jurassic in age.'

MAIN FAULTS: Regional, north to north-northeasterly trending faults define the structural fabric of the map-area and apparently control the distribution of volcanic and intrusive rocks. The Summers Creek – Quilchena Creek fault system (*see* Fig. 14) is the largest of these and is part of a structure that has been traced for more than 160 kilometres from south of Copper Mountain at least as far as Kamloops. The Allison Creek fault roughly follows Highway 5 north of Allison Lake, crosses into the valley of Otter Creek, and joins with the Summers Creek fault system north of Courtney Lake. Another fault crosses the northwest corner of the map-area between Hamilton Lake and Garcia Lake and continues southwestward and northeastward.

These three main breaks divide the Nicola rocks within the map-area into three belts. Rocks of the Central and Eastern Belts, as shown in the preceding chapter, are chemically

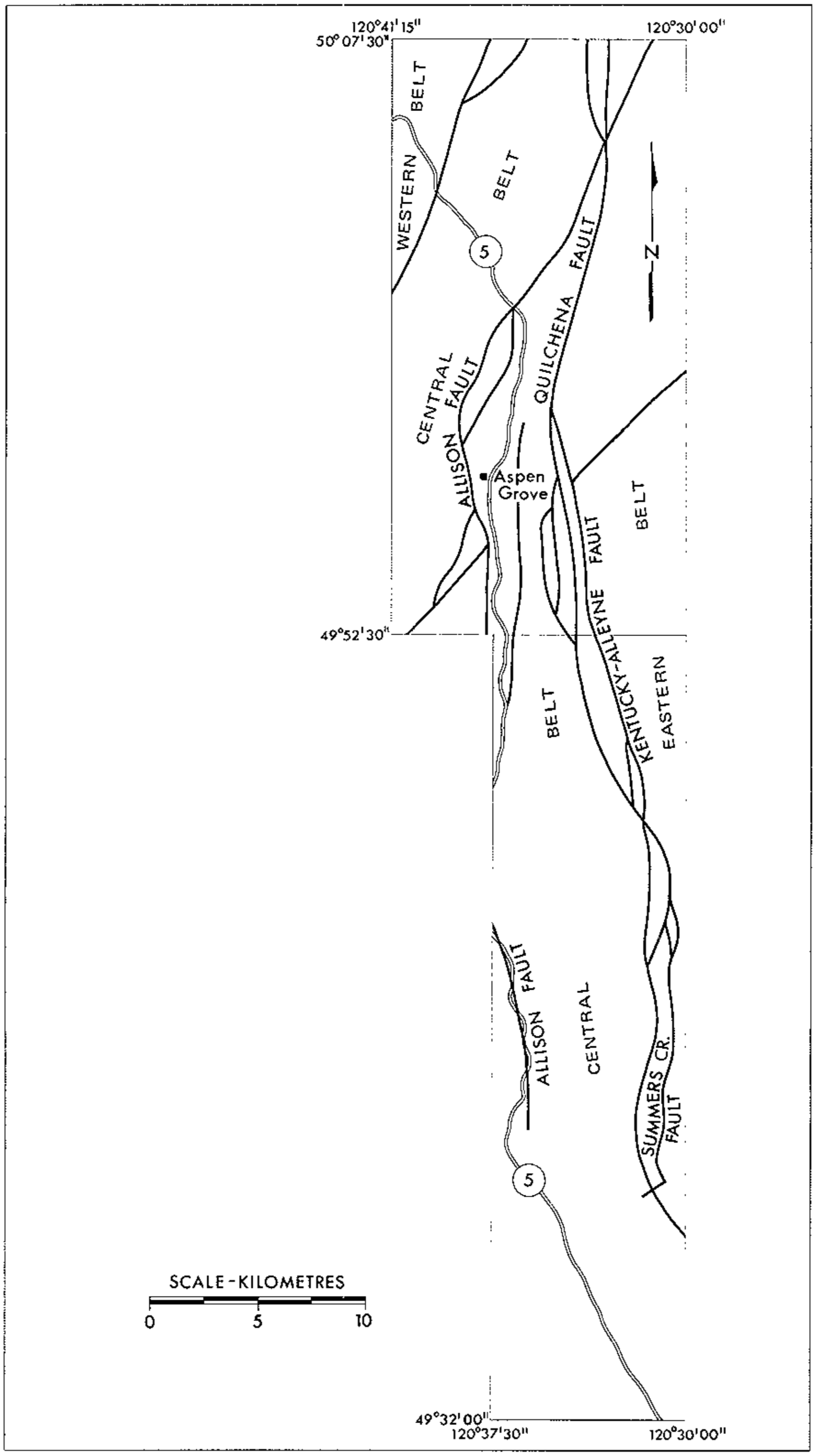


Figure 14. Distribution of main faults.

similar and are in large part alkalic. Those of the Western Belt are calc-alkalic and, for the most part, younger than those of the other two belts.

The Summers Creek fault is sharply defined from near Alleyne Lake to the vicinity of the Axe prospect, and marks the boundary between the Central and Eastern Belts. South of Missezula Lake the fault juxtaposes mainly submarine basaltic flows and breccias and associated dioritic stocks of the Central Belt against mainly subaerial lahars, with lesser sandstone and siltstone, and associated monzonitic and syenitic stocks of the Eastern Belt. The attitude of layered rocks and elongation of intrusive bodies of both assemblages parallel the northerly trend of the main fault system. North of Missezula Lake, well-layered, submarine volcaniclastic strata of the Eastern Belt with no associated intrusive rocks, are separated by the Summers Creek fault from predominantly subaerial flows, breccias, and lahar deposits of the Central Belt which are cut by numerous intrusions. South of Aspen Grove, volcanic and sedimentary rocks of the Western Belt are separated by the Allison fault from volcanic rocks of the Central Belt. Branches of the same fault system also bring slices of Late Jurassic or Early Cretaceous conglomerate of map unit 9 in contact with Western Belt rocks and with Cretaceous rocks of map unit 11. North of Aspen Grove the Western Belt assemblage is missing, and Central Belt rocks are in direct contact with rocks of units 9 and 11. The unnamed fault between Garcia and Hamilton Lakes brings Western Belt rocks in contact with rocks of both the Central Belt and map unit 11. This fault continues to the northeast and southwest beyond the boundaries of the map-area. To the northeast it may join with Schau's (1968) Nestor Creek fault, and to the southwest with his Howarth Creek fault.

Field relationships and chemical data suggest that volcanic rocks of the Central and Eastern Belts were derived locally from several stocks of diorite, micromonzonite, and syenite (map units 5 and 6), the distribution and elongation of which is strongly controlled by the northerly trending minor faults. In contrast, the Western Belt assemblage correlates more readily with rocks found to the west and northwest which flank, and were probably derived from, the Upper Triassic Guichon Creek batholith.

Separations of these sharply contrasting belts of Nicola rocks have undoubtedly been enhanced by late movements along these major fault systems, but are also considered to be too systematic and complete to be entirely due to late fault displacements unrelated in origin to Nicola volcanism. All structures in the volcanic and intrusive rocks are dominated by the same northerly trend as the major faults. Such structural conformity is probably the result of an old system of major, deep-seated crustal fractures which dominated the structural framework of this region in Upper Triassic time and caused Nicola volcanic centres to be distributed in northerly trending belts flanked by basins. These basins were probably not very deep at any one time, as evidence of deep water volcanism and sedimentation is not common in this part of the Nicola Group. Accumulation of a considerable thickness of strata was possible locally, probably because of renewed movement along the master faults and resulting downdropping of the basin floors as volcanism and sedimentation continued.

The influence of large-scale faults on sedimentation and volcanism is also evident in the distribution of the Middle Eocene Princeton and Quilchena basins and in other Tertiary basins throughout southern British Columbia and northern Washington. Excellent accounts of the influence of graben tectonics on the distribution of volcanism and sedimentation in two Early Tertiary basins have been provided by Parker and Calkins (1964) and Church (1973). These same studies have also shown that the basins are characterized by thick shallow water and subaerial deposits rather than deep water sedimentary and volcanic successions.

In summary, the present mapping has shown that large, northerly trending faults divide Nicola rocks in three distinct belts. The Central Belt contains the greater proportion of high energy, proximal extrusive rocks, such as flows, coarse breccias and lahars, and many coeval intrusions, several of which apparently mark eruptive centres. The main fault systems were established early in the geologic history of the region, provided conduits for volcanism and the structural framework which restricted the distribution of sedimentary basins. Similar systems of large, high angle, northerly trending faults occupy many major valleys in southern British Columbia and define a series of rift valleys or grabens which fan out from the Columbia basalt plateau south of the International Boundary (Carr, 1962, pp. 48, 49). Some of these grabens have been known for some time to be filled with Middle Jurassic to Early Tertiary sedimentary and volcanic rocks (Carr, 1962, p. 48). In the area of this report the main faults appear to have been formed at least as early as Upper Triassic time.

STRATIGRAPHIC CONSIDERATIONS

Details of the stratigraphy and thickness of the Nicola Group remain tentative mostly because of the very limited amount of research that has been done and the complexity of the geology, especially in its volcanogenic portion. Rice (1947) described in some detail the sedimentary rocks in the vicinity of Hedley as forming a succession some 2 000 metres thick which he considered to be the basal part of the Nicola Group. Fragmentary information indicates that similar rocks may occur in the north on Trepanege Plateau. Recently (A. V. Okulitch, personal communication, 1976), microfossils from sedimentary rocks overlying the Salmon River unconformity northeast of Salmon Lake have shown that these strata, which had been considered to be Upper Paleozoic, are in fact Upper Triassic. This finding raises the possibility that a large part or all of the presumably Upper Paleozoic rocks of the Douglas Plateau may be part of the Nicola Group. Tuffaceous sandstone and argillaceous sedimentary rocks trending north of the Thompson River for several kilometres east of Kamloops have recently been discovered to be of Late Triassic age and in fault contact with Pennsylvanian and Permian strata to the east (R. Smith, work in progress; P. B. Read, personal communication, 1976). These recent discoveries, though from widely separated localities, strongly suggest that the eastern portion of the Nicola Group, from Hedley to Kamloops, consists of a sedimentary pile that includes extensive tuffaceous sandstone and argillite, some prominent limestone units, and lesser quartzite. Little evidence has been found to support Rice's (1947) suggestion that the sedimentary rocks at Hedley form the base of the Nicola Group and underlie the volcanic rocks that dominate the central part of the group. In fact, preliminary petrographic studies of the Hedley sediments (R. H. Wallis, personal communication, April 1977) indicate that these strata consist of fine debris from the volcanic rocks to the west of which they are probably distal equivalents. In similar fashion, the western part of the Nicola Belt from the west end of Kamloops Lake to the Tulameen area is known to contain abundant sedimentary rocks including much limestone, but the distribution and thickness of these strata are not known. Thus, as previously suggested (Campbell, 1966; Schau, 1968), the Nicola Group appears to consist of a central part rich in volcanic and related intrusive rocks, flanked to the east and west by sedimentary rocks. The nature, thickness, extent, and contact relationships of the sedimentary facies with the central volcanic facies are only poorly known at best. There is no evidence that the sedimentary rocks of either the eastern or western facies are continuous under the volcanic pile of the central zone but rather it seems more likely that the two sedimentary successions are the lateral equivalents of that zone.

The only detailed information from the central volcanogenic part of the Nicola Belt is the work of Schau (1968) in the vicinity of Nicola Lake. In this area he outlined a succession of sedimentary and volcanic rocks which he considered to be at least 7 000 metres thick, and divided it into two depositional cycles on the basis of type of predominant phenocrysts in the volcanic units. The present work includes the core of the area mapped by Schau, but has so far been unable to confirm or expand his stratigraphy. The present mapping indicates that the central part of the Nicola Group consists of separate, parallel belts of volcanic and sedimentary rocks, the relation between which is at this time not known. Since the belts are separated by major faults and no suitable marker horizons have yet been found, the total thickness of the original volcano-sedimentary sequence cannot be estimated. Rapid facies changes of major proportions are known to occur in the Central and Eastern Belts, as can be expected in areas of proximal volcanic rocks deposited under high energy regimes. These further complicate the stratigraphic picture and preclude the opportunity of tracing specific rock sequences for large distances laterally. Locally, partial thicknesses of particularly well-layered sequences can roughly be estimated to be in the order of 2 500 to 3 000 metres (*see* Western Belt, cross-section A-A', Fig. 1). Elsewhere, and especially in the Central Belt, not even such crude estimates are possible because of the lack of marker beds and lateral discontinuity of rock units.

5

MINERAL DEPOSITS

GENERAL REMARKS

The map-area covers, virtually in its entirety, the region that for many years has been known as the Princeton–Merritt Copper Belt. Within this belt, copper prospects are numerous and range from mere occurrences of trivial size to large, though as yet uneconomical, porphyry-type deposits.

The strong control of the distribution of copper occurrences along this belt by faults of the Allison Creek and Summers Creek systems was noted by Rice (1947, pp. 90, 91) and by other early workers. Rice correctly recognized that these faults, if projected southward, would extend into the Copper Mountain area and wondered why, given this strong structural continuity, no member of the Copper Mountain intrusions had been found north of the Princeton Basin (1947, p. 91). In fact this report and other recent work (Preto, 1972, 1974, 1975, 1976; Northcote, 1974, Carr, 1962; Barr *et al.*, 1976) have shown that not only does the structural continuity extend from Copper Mountain at least as far as the Iron Mask batholith near Kamloops, but numerous intrusions of the same age and composition as those of Copper Mountain exist in this region. These intrusions are genetically related to Nicola volcanic rocks, and host many of the copper deposits.

The geological map (Fig. 1, in pocket) documents that most of the copper occurrences are in rocks of the Central Belt, and that the greatest concentration is in the vicinity of Aspen Grove where it is known as the Aspen Grove Copper Camp. This camp has seen intermittent exploration activity since the beginning of the century (*Minister of Mines, B.C.,* Ann. Rept., 1901, pp. 1179-1189) but, though a large number of occurrences have been discovered and some extensively explored, production to date has been trivial.

SUBDIVISION OF MINERAL OCCURRENCES

Most mineral showings in the map-area can be arbitrarily divided into eleven groups on the basis of mineralogy, host rock, and mode of occurrence. In addition to these a coal deposit occurs in rocks of map unit 16 in the extreme northwest corner of the map-area, a gold occurrence in altered Nicola tuffs near the contact with the Pennask batholith (AU prospect) 2 kilometres east of Pothole Lake, and a chalcocite-tetrahedrite occurrence in quartz veins within the Allison pluton (MOB prospect) along the western boundary of the map-area, 7.2 kilometres north of Allison Lake.

Group 1 – Chalcopyrite-bornite-native copper and/or chalcopyrite-pyrite disseminations in brecciated zones and along fractures in diorite and monzonite stocks and dykes of units 5 and 6, and in nearby Nicola volcanic rocks. This group includes some very large porphyry-type prospects.

Group 2 – Chalcopyrite-pyrite with or without chalcocite and bornite as disseminations and replacements in sheared Nicola volcanic rocks or diorite of unit 5 along major branches of Summers Creek–Quilchena fault.

Group 3 – Chalcopyrite, bornite, pyrite, and magnetite in breccia pipes of unit 6.

Group 4 – Chalcocite, bornite, native copper, chalcopyrite, pyrite, and hematite in fracture zones in red or green lahar of unit 1 or along or near contacts between red and green lahar.

Group 5 – Chalcocite, bornite, chalcopyrite, and pyrite in Nicola limestone and argillite.

Group 6 – Chalcocite, native copper, cuprite, bornite, chalcopyrite, pyrite, magnetite, and hematite in brecciated tops of subaerial flows.

Group 7 – Chalcocite, native copper, and hematite as disseminations and minor replacements concordant with bedding in volcanic conglomerate and lahar deposits.

Group 8 – Chalcopyrite, pyrite, and magnetite with or without bornite in epidote-garnet skarn in limestone and/or basic flows.

Group 9 – Chalcopyrite and pyrite with or without molybdenite as fracture fillings and disseminations in altered intrusive rocks of Pennask batholith.

Group 10 – Chalcopyrite and pyrite in shear and fracture zones of Allison pluton and in altered volcanic rocks included in pluton.

Group 11 – Chalcocite, bornite, chalcopyrite, and pyrite in fracture and brecciated zones in massive volcanic and volcano-sedimentary Nicola rocks.

Of these, prospects of groups 1 and 3 and specifically the Axe, Blue Jay, and Big Kid properties, clearly have the highest potential of being economic at some time in the future because of their larger size and locally better grade. The only prospect assigned to group 9 (Mint, locality 33) also appears to be large and associated with an extensive hydrothermal system, but the grade is very low.

Appendix 7 is a classification table of those mineral occurrences within the map-area for which a name and some other information could be obtained. The more important of these are described in some detail below.

DESCRIPTION OF PROPERTIES

Group 1

AXE (LOCALITY 4)

Location: The AXE, BUD, BOL, LOX, and RUM claims, totalling approximately 200, are owned by Adonis Mines Ltd. and are situated on the west side of Summers Creek, approximately 19 kilometres north of Princeton. Access is by dirt road branching eastward from Highway 5 at the north end of MacKenzie Lake, or by dirt road branching westward from the Summers Creek road, approximately 13 kilometres north of the junction of this road with Highway 5.

DESCRIPTION

History: Copper mineralization at the Axe showings is exposed in natural outcrops on the Adit zone and on steep east-facing cliffs of augite porphyry on the South zone. These showings must have been known for some time, as indicated by an old 30-metre adit driven at the Adit zone. The sequence of events which in recent years led to the property's present status can be summarized as follows:

> The claims were staked by J. A. Stinson in 1967 and 1968, and later acquired by Adonis Mines Ltd., with Mr. Stinson becoming a major shareholder and officer of the company.
>
> Soon after the claims were first staked, the Summers Creek access road to the South zone was built and eight trenches totalling 295 metres were excavated.
>
> In 1967 Meridian Mines Ltd. optioned the property, cut 3 910 metres of lines, and performed various geophysical and geochemical surveys. This company also did some bulldozing and drilled seven BQ wireline holes (M1 to M7) totalling 642 metres.

In 1968 the property was optioned by Quintana Minerals Corporation. This company excavated more trenches, and sampled and mapped the claims. It also drilled four large-diameter rotary holes (1a to R4) totalling 990 metres.

In 1969 Mr. Stinson excavated more trenches and drilled two diamond holes (A2 and A3) totalling 270 metres.

In 1969, 1970, and 1971 the property was under option to Amax Exploration, Inc. This company did further linecutting and performed more geochemical, geophysical, and geological surveys. It also drilled 51 percussion holes totalling 3 350 metres and 15 diamond holes totalling 2 730 metres.

In 1972 and 1973 Adonis Mines Ltd. did further work including more trenching, 22 NQ wireline holes totalling 3 134 metres, and 70 percussion holes totalling 2 551 metres.

No further significant work has been done on the property.

The work done to date has contributed in outlining a large porphyry system involving an area nearly 3.2 kilometres in diameter and containing at least three zones of appreciable but scattered copper and some molybdenum mineralization. In spite of the persistent and considerable efforts outlined above, the sizes and grades of the mineralized zones are only poorly known, because of the complicated geology, erratic nature of mineralization, and generally poor recovery obtained in drilling due to intense faulting and fracturing and localized deep weathering of the bedrock.

GEOLOGY

General: The Axe property belongs to a large group of copper showings including several porphyry-type deposits that are found in a narrow, northerly trending belt between Copper Mountain and Nicola Lake. All of these deposits occur within an assemblage of high-energy proximal volcanic and genetically related intrusive rocks which form a narrow, largely fault-bound Central Belt (Preto, 1974, 1975) in the Upper Triassic Nicola Group.

Figure 15 is a generalized outcrop map of the area surrounding the showings. Copper mineralization occurs in Upper Triassic Nicola volcanic rocks that are cut by a variety of intrusive rocks ranging from mafic diorite to syenite and from quartz diorite to felsic quartz porphyry. Structurally the mineralization occurs in an area where two major branches of the northerly trending Summers Creek fault come together, break up into a series of lesser east-west, northeast, and northwest-trending structures, and finally continue southeastward apparently as a single fault of seemingly lesser magnitude.

The oldest rocks within the area of Figure 15 are massive flows and breccias of augite basalt porphyry. Interlayered with these are massive to thinly bedded crystal and lithic tuffs and some volcanic sandstone and siltstone. A few small lenses of massive, locally fossiliferous, impure limestone and limestone breccia are also found interlayered with the volcanic sediments. All these rocks are part of the volcanic assemblage of the Central Belt which is well displayed for several kilometres to the north (Preto, 1974, 1975).

On the east side of Summers Creek, and across the Summers Creek fault is a succession of grey-green volcanic siltstone, greywacke, and some tuffs which are underlain by massive, purplish green pyroxene-plagioclase basalt porphyry flows and breccia. The sedimentary rocks of this succession are part of the Eastern Belt assemblage (Preto, 1974, 1975) and appear to be the distal, fine-grained equivalent of extensive laharic deposits that form the eastern slopes of Summers Creek a short distance to the north. The underlying flows and breccias of unit 2a (Fig. 15) are identical to and possibly equivalent with some of the Central Belt rocks. If this correlation proves correct, the Central Belt rocks would definitely have been uplifted with respect to those of the Eastern Belt.

In the areas of copper mineralization, and especially on the Adit and Western zones, the Nicola rocks are cut by a complex assemblage of generally fine-grained diorite and monzonite which appear to form small stocks and dyke-like bodies and locally contain small bodies of high-level intrusive breccia. At least two, and probably more, phases of these quartz-poor intrusive rocks exist on the Adit and Western zones, but their number and relationships are difficult to understand because of intense faulting and extensive alteration. By comparison with better known and similar porphyry deposits such as those of Copper Mountain or of Iron Mask batholith, these intrusive rocks are interpreted to belong to an older high-level suite which is part of the Nicola magmatic suite. In fact the two areas of unit 4a rocks (Fig. 15) on the Adit and Western zones may well represent the deeper parts of Nicola volcanoes in this area.

Volcanic and intrusive rocks in the vicinity of the mineralized zones are intensely fractured and cut by numerous faults, only the largest of which are shown on Figure 15. Rock alteration of the volcanic and intrusive rocks appears to be variable and, probably because of later faulting, highly irregular.

Copper mineralization consists mostly of widespread chalcopyrite and variable amounts of pyrite disseminated and coating fractures in volcanic and associated intrusive rocks. In highly fractured and more extensively weathered zones, such as the Adit zone, much of the near surface mineralization consists of azurite, malachite, and some chalcocite and bornite.

Brown, secondary biotite has been observed at widely separated localities as a pervasive replacement of the matrix of volcanic and associated intrusive rocks. This early stage of potassic alteration was followed and replaced by pervasive and locally intense propylitic alteration which included chloritization of mafic minerals and breakdown of plagioclase to epidote, sericite, and carbonate. A good portion of the copper mineralization was introduced at this stage since chalcopyrite and abundant pyrite are commonly found disseminated in chloritized, epidotized, and albitized volcanic and intrusive rocks or coating fractures together with chlorite, epidote, and some magnetite. Some chalcopyrite, with or without potash feldspar and chlorite, also occurs in later quartz veins which cut the altered and mineralized volcanic and intrusive rocks. Late gypsum and calcite veins may also carry some chalcopyrite.

Occasional molybdenite is found in quartz veins, usually with potash feldspar, and on slickensided fractures, and appears to postdate the bulk of the copper mineralization. Later argillic alteration is best developed along the numerous shear and fault zones and commonly reduces the rock to an unrecognizable conglomeration of altered fragments or to a clay-like paste.

In summary, formation of the copper deposits appears to be closely related in age and origin to Nicola magmatism which produced the volcanic rocks of unit 1 and the intrusive rocks of unit 4 (Fig. 15). The mineralization represents the latter stages of a series of Upper Triassic events which started with the accumulation of a volcanic pile, continued with the high-level intrusion of rocks of unit 4 (Fig. 15), and culminated with hydrothermal rock alteration and sulphide deposition. This period of mineralization is considered to be separate from, and older than, molybdenum mineralization which followed at a much later time and was probably associated with intrusive rocks of unit 7 (Fig. 15).

The western part of the area of Figure 15 is underlain by granitic rocks of the Allison pluton which range from red biotite-hornblende granite to granodiorite, mafic diorite, and gabbro. This intrusion clearly cuts Nicola rocks but does not seem to be related with the Axe deposits. Isotopic K/Ar dating (pp. 00-00) indicates that at least some phases of this complex pluton were emplaced about 200 Ma ago, or in Late Triassic/Early Jurassic time.

North of the Western zone, Nicola rocks are overlain, probably unconformably, by an outlier of red to maroon volcanic conglomerate and minor interbedded impure limestone and calcareous grit of map unit 6 (Fig. 15). Bedding in the conglomerate dips gently to steeply to the southwest. The age of this conglomerate is unknown, but it must be considerably younger than that of Nicola rocks since it is not affected by strong faults and considerable alteration which cut Nicola strata. Clasts in the conglomerate include green basic Nicola volcanic and grey intrusive rocks, abundant grey limestone, some acid volcanic rocks, and locally some vein quartz, but very few, if any, granitic clasts. The conglomerate is considered to be part of the Lower Cretaceous Kingsvale Group.

Granitic rocks of the Summers Creek stocks cut Nicola rocks south of the South zone and north of the Adit zone. These rocks include grey biotite-hornblende granodiorite, biotite quartz monzonite, and some pink granite. Co-existing biotite and hornblende from grey granodiorite 1.2 kilometres south of the South zone yield an average K/Ar age of 97.5±2.6 Ma. Northeast-trending quartz feldspar porphyry dykes at the Adit zone, numerous quartz veins, and some silicification and minor molybdenum mineralization in the volcanic rocks are probably related to these Cretaceous intrusive rocks and thus may be much younger than the main period of copper mineralization.

Extent of Mineralization: Though a good deal of effort and money has been spent in trying to outline one or more copper orebodies on this property, the results to date have been inconclusive and difficult to interpret. Core recovery in most diamond holes, even in those drilled with the greatest care, has been only fair to poor because of the intensely fractured and locally deeply weathered state of the rocks. Different adjustment factors have been employed by various workers in evaluating assays from diamond, percussion, and rotary holes, and the figures obtained from these highly variable and often problematic data should only be considered as a very crude estimate. The latest figures released by the company (George Cross Newsletter, September 11, 1973) are as follows:

South zone	–	41	million tons at 0.48 per cent copper
West zone	–	6.4	million tons at 0.47 per cent copper
Adit zone	–	16	million tons at 0.56 per cent copper

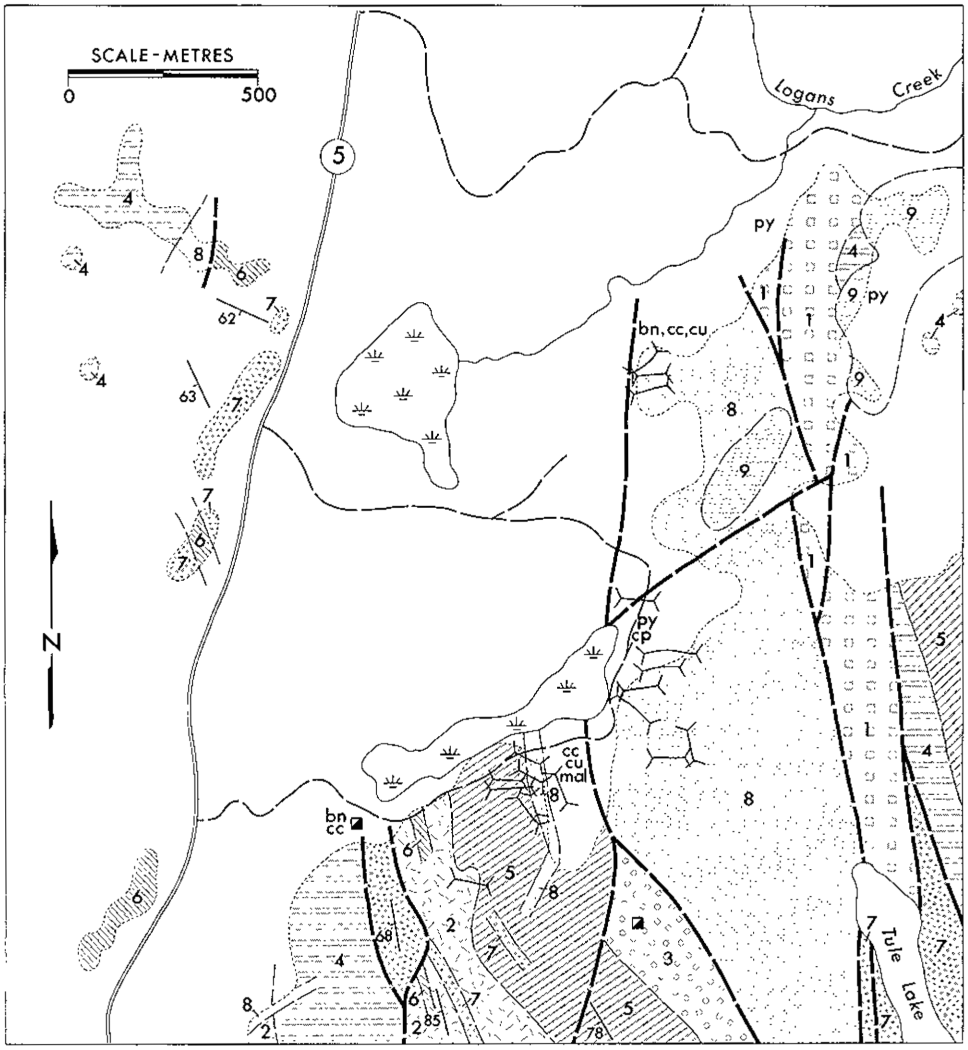
BLUE JAY (LOCALITY 6)

This property belongs to Mr. H. Nesbitt of Aspen Grove and consists of 24 mineral claims and four fractions. The showings are found in several trenches and pits approximately 1 kilometre east of Highway 5 and 1.5 to 3 kilometres south of Courtney Lake. Mineralization consists of chalcopyrite, chalcocite, bornite, and native copper and is found both in Nicola volcanic rocks and in dioritic intrusive rocks.

Figure 16 is a sketch map of the geology near the Blue Jay showings.

Mineralization consists of pyrite, chalcopyrite, bornite, chalcocite, native copper, and malachite finely disseminated and in fractures along the brecciated western margin of a northerly trending dyke-like body of fine-grained diorite and in massive red and green volcanic breccia west of the diorite.

Volcanic and intrusive rocks are cut into irregular blocks by numerous northerly, northeasterly, and northwesterly trending faults, and are pervasively altered with widespread epidote, calcite, and chlorite in both volcanic and intrusive rocks. Some quartz and, locally, secondary biotite were noted in some trenches in diorite in the southeastern part of the property.



LEGEND

9 MONZONITE

8 DIORITE – MOSTLY FINE GRAINED AND PORPHYRITIC

7 VOLCANIC SANDSTONE AND SILTSTONE

6 VOLCANIC BRECCIA – PURPLE, CRUDELY LAYERED

5 VOLCANIC BRECCIA – RED, MASSIVE

4 VOLCANIC BRECCIA – GREEN, MASSIVE

3 AUGITE PORPHYRY – RED, MASSIVE, AMYGDALOIDAL

2 AUGITE PORPHYRY – RED, AUTOBRECCIATED

1 BASALTIC ANDESITE – GREY TO GREEN, MASSIVE

BEDDING, TOPS UNKNOWN 78

FAULT, APPROXIMATE . . . .

PROSPECT (SHAFT, TRENCH) . . . .

MINERAL OCCURRENCE . . . . py, cp, bn, cc, cu, mal
(PYRITE, CHALCOPYRITE, BORNITE, CHALCOCITE, NATIVE COPPER, MALACHITE)

Figure 16. Geology of the Blue Jay property.

Several pits and trenches have been dug over the years in the diorite and in the volcanic rocks to explore the known mineralization. Recently a number of diamond-drill holes were also completed. In 1973, Craigmont Mines Limited optioned the property and drilled one diamond hole 125 metres long and 19 percussion holes totalling 1 340 metres.

The mineralization known to date on the Blue Jay property is too erratic, too scattered, and of too low grade to be economic. However, this prospect is intriguing because of the large area over which copper occurrences are known, of the large mass of high-level intrusive rock with which mineralization is associated, and of the presence of secondary potash feldspar and biotite alteration which points to the presence of a high-level intrusive hydrothermal system with associated copper mineralization and hence to the possibility of a porphyry-type deposit. For these reasons and because of the large area of overburden to the north and west of the showings, the Blue Jay property will probably attract the attention of exploration geologists for many years.

Group 3

BIG KID (LOCALITY 13)

The Big Kid prospect is centred on a wooded hill, locally known as the 'Big Kid' hill, located at the north end of Fairweather Hills, approximately 3 kilometres northwest of the centre of Alleyne Lake.

A vertical, or subvertical, breccia pipe, nearly circular in outline and approximately 300 metres in diameter underlies the hill and is flanked on all sides by a fine-grained diorite which may include recrystallized flow rocks and which, along the south side of the pipe may better be described as a light-coloured plagioclase trachyte with scattered tiny pyroxene phenocrysts.

The breccia is composed of fragments of volcanic rocks, of fine-grained diorite, and of a pinkish grey monzonite and syenomonzonite porphyry which throughout the Nicola Belt typically forms small, high-level intrusions that commonly have associated copper mineralization. The fragments in the breccia are sharply angular to subrounded in outline and range in size from 1 centimetre to, rarely, several metres in maximum dimension. They are set in an altered matrix of diorite intrusive material and finely comminuted rock. Several small dykes of fine-grained green andesite and/or basalt cut the breccia.

Parts of the breccia, especially on the north and east side of the pipe, show evidence of extensive late magmatic alteration and recrystallization. The breccia in these areas has clasts with pronounced grey and pinkish grey alteration rims, and the matrix extensively replaced by epidote, chlorite, and calcite. Irregular and sporadic mineralization involving much pyrite, magnetite, and some chalcopyrite and pyrite as disseminations, replacements, and fracture fillings in the matrix and in some of the clasts favours these zones of rock alteration, but is not proportional to the intensity of alteration. It would appear therefore that the rock alteration was either partly late magmatic and partly hydrothermal or, as differentiation at deeper levels produced a greater and greater amount of late magmatic, fluid-rich material, the proportion of volatiles in the breccia pipe gradually increased to the point where hydrothermal processes of rock alteration and associated metal transport dominated the system.

Exploration work on the Big Kid prospect dates back to the earliest days of activity in the Aspen Grove Camp.

Early work includes three adits, which range from 12 to 90 metres in length, and are located on the north and east side of the hill where mineralization is most prominent, and numerous hand trenches. In 1956 Noranda Mines, Limited optioned the property and with the aid of a bulldozer did some trenching and stripping on the west side of the hill. During this period Noranda also completed several diamond-drill holes and geophysical and geochemical surveys (Olien, 1957) but without apparent success.

The Big Kid breccia pipe clearly represents an intrusive hydrothermal system of considerable proportions and is related in age and origin to Nicola volcanism and high-level intrusion. The pipe is similar in many aspects to bodies of breccia at Copper Mountain (Preto, 1972) and in the western half of the Iron Mask batholith (*Minister of Mines, B.C.,* Ann. Rept., 1967, pp. 137-141; *B.C. Dept. of Mines & Pet. Res.,* GEM, 1972, pp. 209-220) which are known to either contain or be very close to large bodies of ore-grade copper mineralization. The erratic and sporadic nature of mineralization on the Big Kid property which has frustrated exploration efforts to date is not uncommon to breccia pipes. Regardless of the lack of success of past exploration efforts, the Big Kid prospect must therefore be rated as one of the most important prospects in the Aspen Grove Camp and must still be considered as having a considerable economic potential.

SIGNIFICANCE OF VOLCANIC–INTRUSIVE RELATIONSHIPS IN MINERAL EXPLORATION IN THE NICOLA BELT

Geological studies in recent years by members of the mineral exploration community and by staff of the Ministry of Mines and Petroleum Resources have led to the identification of a new type of porphyry deposit in the Canadian Cordillera. These alkaline suite porphyry deposits (Sutherland Brown *et al.,* 1971; Barr *et al.,* 1976) occur in the Intermontane Zone, and are spatially and genetically related to Upper Triassic Nicola, Takla, Stuhini-type volcanic assemblages and comagmatic alkaline plutons.

In the Nicola Belt the productive Copper Mountain Camp consists entirely of deposits of this type. To the north, in the Iron Mask batholith near Kamloops, another major deposit of this type, Afton, has recently commenced production. Both of these camps, and several other prospects in the Princeton–Aspen Grove area occur in settings which, using the terminology of this report, are part of the Central Belt. Indeed, the Copper Mountain Camp is on the direct southern extension of the Central Belt across the Tertiary Princeton Basin. Thus, the structural control that Rice (1947, pp. 90, 91) recognized is very prominent in the distribution of porphyry-type mineral deposits in this region. Within the Central Belt of the Nicola and farther north in the Quesnel Trough (Barr *et al.*, 1976) the small, high-level, syenitic plutons occur intermittently along narrowly defined northerly trends which closely follow major high-angle faults. Sutherland Brown (1976) has included the porphyry deposits of the alkaline suite in the volcanic subclass because invariably they are associated with porphyry intrusions which have risen to very high *levels in the crust and have intruded a coeval, and in all cases at least in part* consanguineous, volcanic pile. Such is the case, for instance, with the stock of map unit 6 east of Missezula Lake.

Because of their nearness to surface and of their close relationship to the surrounding volcanic rocks, these subvolcanic plutons can generally be located, with varying degrees of accuracy, by mapping the layered volcanic rocks, the type and size of the clasts in fragmental units and with the help of aeromagnetic maps. Mineralization may or may not be associated with every pluton, but the locating of a stock is an important initial step in outlining an exploration target. Areal mapping, such as described in this report, helps in establishing a framework within which proximal volcanic-intrusive assemblages are separated from more distal volcano-sedimentary successions. The location of major fault and fracture systems are also very important in establishing more accurately distribution of volcanic centres.

APPENDICES

APPENDIX 1. CHEMICAL ANALYSES OF NICOLA VOLCANIC ROCKS

Loc. 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	Total	R.I.
	CENTRAL BELT																	
1	PC-72- 3 (tuff)	49.06	14.81	7.55	8.32	4.32	0.67	0.77	0.19	3.63	6.38	2.08	0.25	0.10	0.21	0.01	98.34	1.578
2	PC-72- 14 (flow)	48.79	14.15	6.42	9.16	2.74	2.93	1.01	0.20	3.87	7.49	1.83	0.16	0.45	0.30	0.03	99.53	1.586
3	PC-72- 15 (flow)	49.61	15.85	5.45	7.56	3.14	3.93	0.90	0.19	2.39	6.92	2.00	0.22	0.52	0.37	0.00	99.05	1.579
4	PC-72- 26 (flow)	45.29	12.10	8.68	10.59	2.15	1.98	0.99	0.28	5.29	7.55	2.64	0.21	0.40	0.41	0.02	98.58	1.608
5	PC-72- 62 (flow)	50.90	14.33	5.92	7.13	2.78	4.16	0.91	0.31	3.60	6.63	2.14	0.15	0.35	0.48	0.00	99.79	1.574
6	PC-72-127 (flow)	50.76	15.37	4.37	4.83	4.18	3.34	0.94	0.21	1.73	8.63	2.57	0.20	2.27	0.41	0.04	99.85	1.562
7	J-33- 61 (flow)	53.17	17.64	3.28	6.74	3.81	4.68	0.67	0.21	1.05	5.91	1.44	0.11	0.33	0.41	0.02	99.47	1.548
8	N-73-252 (analcite flow)	47.70	16.10	5.51	7.83	3.88	3.95	0.74	0.24	1.94	7.75	2.78	0.29	0.82	0.69	0.03	100.25	1.576
9	N-73-258 (flow)	50.32	17.16	3.88	6.92	3.57	3.83	1.07	0.18	3.47	5.46	3.02	0.10	0.34	0.39	0.03	99.74	1.558
10	V-73-164 (flow)	58.01	16.13	3.98	6.26	4.38	2.16	0.85	0.07	0.28	6.23	1.21	0.63	0.03	0.32	0.02	100.56	1.546
11	V-73-166 (flow)	50.19	14.79	4.30	10.78	3.97	2.25	0.66	0.21	0.95	8.98	1.69	0.10	1.50	0.44	0.03	100.84	1.580
12	VP-74- 28 (flow)	56.96	17.95	3.13	2.70	5.43	2.83	0.83	0.25	3.95	3.35	2.21	0.24	1.29	0.21	0.01	101.34	1.542
13	VP-74- 32 (flow)	52.45	16.77	5.06	6.35	3.84	2.50	0.91	0.26	4.72	5.18	2.39	0.32	0.34	0.39	0.18	101.66	1.566
14	VP-74-106 (tuff)	57.22	15.99	3.84	7.96	1.51	1.07	0.94	0.21	6.20	3.96	1.72	0.16	0.14	.2	0.04	100.98	1.570
15	VP-74-145 (tuff)	59.67	14.90	3.48	5.41	1.68	2.65	0.98	0.16	6.94	1.55	3.09	0.33	0.89	.2	0.11	101.86	1.556
16	VP-74-154 (tuff)	51.62	13.16	2.79	12.25	1.74	1.88	0.82	0.25	6.60	0.83	2.60	0.25	5.46	0.27	0.03	100.55	1.576
17	SA-74-229 (flow)	52.60	16.37	5.95	6.80	4.15	0.17	1.47	0.17	5.92	2.12	3.09	0.33	1.49	0.46	0.01	102.00	1.570
18	SA-74-239 (flow)	46.10	17.18	3.00	9.74	3.40	0.68	1.98	0.20	7.79	3.99	3.25	0.32	2.85	0.48	0.02	100.98	1.600
19	SA-74-263 (flow)	55.95	12.17	3.62	6.96	3.37	0.57	2.07	0.21	9.11	2.97	2.65	0.32	0.07	0.60	0.03	100.67	1.562
20	LK-74- 47 (flow)	53.13	16.72	4.91	5.48	4.47	0.74	1.19	0.15	6.20	2.92	2.89	0.28	0.35	0.48	0.02	99.92	1.552
21	LK-74-55B (flow)	50.29	16.99	4.11	9.01	4.23	0.62	1.21	0.21	6.08	3.00	2.54	0.34	0.41	0.33	0.03	99.45	1.578
22	JN-74- 63 (flow)	53.34	16.78	3.61	5.91	4.02	4.15	0.94	0.18	1.81	7.38	1.45	0.17	0.41	0.39	0.02	100.56	1.560
23	JN-74- 68 (flow)	53.23	16.05	4.68	7.12	3.45	3.15	0.94	0.21	4.32	4.63	1.88	0.19	0.14	0.42	0.04	100.45	1.562
24	JN-74-110 (flow)	63.95	15.31	2.18	4.87	3.12	2.41	0.77	0.12	3.45	2.72	1.50	0.14	0.14	0.35	0.05	101.08	1.532
25	PC-72-267 (flow)	50.10	17.31	3.68	4.69	5.17	1.68	1.22	0.23	5.69	3.92	3.26	0.24	1.56	0.50	0.34	99.59	1.562
	EASTERN BELT																	
26	J-73- 42 (tuff)	50.87	17.98	4.01	8.13	3.40	2.61	0.80	0.21	6.61	2.09	2.12	0.10	0.04	0.37	0.05	99.39	1.568
27	N-73-237 (tuff)	54.00	18.03	2.74	6.53	5.92	0.98	0.65	0.17	2.97	3.48	2.97	0.14	0.79	0.37	0.06	99.80	1.546
28	V-73-132 (flow)	49.65	13.35	7.03	9.91	3.15	2.27	0.80	0.20	4.51	5.52	1.75	0.14	1.97	0.50	0.02	100.79	1.580
29	SA-74- 81 (tuff)	56.00	17.64	2.63	6.36	6.14	2.28	0.50	0.23	1.90	3.59	1.81	0.37	2.17	0.21	0.01	101.84	1.542
30	SA-74- 91 (flow)	53.87	17.65	4.00	6.39	4.14	4.06	0.66	0.23	3.34	4.37	2.23	0.30	0.54	0.39	0.01	102.16	1.554
31	SA-74-114 (analcite flow)	49.10	15.36	6.19	8.93	3.06	4.02	0.67	0.22	3.84	5.84	3.17	0.33	0.41	0.46	0.01	101.61	1.578
32	SA-74-116 (flow)	54.48	17.55	3.24	5.00	7.17	0.82	0.85	0.18	3.05	3.76	2.37	0.22	0.91	0.41	0.02	100.03	1.544
33	SA-74-152 (flow)	65.34	16.72	1.38	1.65	6.08	3.05	0.82	0.10	1.74	2.40	1.31	0.32	0.20	0.32	0.03	101.46	1.514
34	SA-74-154 (analcite flow)	48.78	14.22	6.44	8.81	2.13	4.77	0.66	0.26	4.53	5.24	2.56	0.23	0.83	0.50	0.02	99.98	1.578
35	SA-74-204 tuff	51.28	18.09	3.59	6.42	5.03	2.62	0.75	0.22	3.98	4.00	2.26	0.31	1.36	0.37	0.01	100.29	1.560
36	M-75-102 (flow)	49.18	14.62	6.28	8.72	2.36	3.77	0.94	0.19		11.62 total Fe_2O_3	1.20	0.14	0.15	0.41	.002	99.58	1.582
	WESTERN BELT																	
37	J-73- 10 (ash flow)	67.84	14.96	0.85	1.54	7.25	0.07	1.00	0.10	0.76	5.16	0.68	0.10	0.01	0.37	0.04	100.93	1.516
38	J-73- 14 (tuff)	58.00	15.58	1.71	3.98	7.47	0.07	1.14	0.13	2.11	8.23	1.32	0.05	1.18	0.23	0.02	101.22	1.548
39	V-73- 78 (tuff)	68.63	15.01	0.28	1.43	7.29	0.55	0.82	0.08	0.71	3.72	0.65	0.05	0.49	0.27	0.02	100.00	1.508
40	V-73- 97 (flow)	55.85	15.50	2.85	5.91	3.66	1.40	1.86	0.17	5.04	4.23	1.37	0.26	0.87	0.53	0.04	98.54	1.564

APPENDIX 2. CHEMICAL ANALYSES OF NICOLA INTRUSIVE ROCKS

Loc. 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	Total
	CENTRAL BELT – micromonzonite–microsyenite																
41	N-73-242	55.41	18.09	2.16	5.57	4.75	4.38	0.56	0.17	1.36	4.86	1.79	0.22	0.10	0.34	0.01	99.77
42	N-73-247	53.04	16.97	3.64	5.30	2.86	6.42	0.77	0.18	1.05	7.27	1.38	0.23	0.30	0.57	0.01	99.99
43	N-73-270	50.93	17.33	3.38	8.25	4.98	1.99	0.83	0.21	0.71	8.30	2.16	0.23	1.00	0.48	0.02	100.99
44	TK-73-178	55.57	17.95	2.18	5.10	4.93	4.45	0.56	0.19	1.12	4.81	1.72	0.19	0.68	0.36	0.02	99.83
	CENTRAL BELT – microdiorite																
45	LK-74- 1	52.94	17.98	3.51	6.75	3.76	2.88	0.77	0.12	4.48	2.48	1.67	0.18	2.70	0.37	0.02	100.61
46	VP-74- 75	54.76	18.32	3.02	4.42	4.26	4.70	0.64	0.09	3.38	3.12	1.63	0.17	1.20	0.24	0.02	99.97
47	VP-74- 81	55.76	17.64	3.23	5.57	3.82	3.90	0.65	0.13	3.23	3.41	1.40	0.11	1.30	0.30	0.04	100.49
48	VP-74-128	44.87	17.21	8.79	10.31	2.15	0.72	0.88	0.18	6.55	2.87	3.07	0.24	0.70	0.34	0.03	99.51
	EASTERN BELT – microsyenite																
49	SA-74- 28	58.56	19.24	1.26	3.11	7.23	2.80	0.61	0.09	0.86	4.62	1.50	0.40	0.68	0.23	0.04	101.23
50	SA-74- 31	54.85	17.62	2.73	5.65	6.13	1.81	0.56	0.17	1.66	5.93	2.06	0.43	0.82	0.55	0.01	100.98
51	SA-74- 48	56.62	17.96	2.23	6.33	4.88	1.75	0.58	0.12	3.21	1.94	2.30	0.42	1.54	0.32	0.02	100.22
52	SA-74-102	52.55	18.61	2.67	5.18	4.56	3.62	0.68	0.21	1.36	7.64	2.45	0.48	0.88	0.38	0.02	101.29
53	SA-74-210	62.68	18.23	1.53	4.09	5.81	2.68	0.42	0.16	1.53	3.02	1.62	0.25	0.41	0.30	0.01	102.74
54	VP-74- 17	63.02	17.85	1.95	5.85	3.74	2.17	0.56	0.11	1.27	4.96	1.05	0.69	0.10	0.28	0.02	103.62
55	VP-74- 18	65.77	16.98	1.21	3.38	3.55	2.96	0.46	0.07	0.63	3.69	1.02	0.57	0.27	0.30	0.02	100.88
56	VP-74-105	61.11	17.06	2.37	3.23	4.40	2.77	0.51	0.11	0.22	5.68	1.11	0.88	0.30	0.32	0.01	100.08
57	SA-74-111	56.37	18.06	3.65	6.66	3.37	1.94	0.66	0.13	2.85	3.29	3.11	0.78	0.27	0.27	0.01	100.97

APPENDIX 3

C.I.P.W. NORMS OF NICOLA VOLCANIC ROCKS

Location No.	Field No.	Quartz	Orthoclase	Albite	Nepheline	Anorthite	Corundum	Ca Clinopyroxene	Mg Clinopyroxene	Fe Clinopyroxene	Enstatite	Ferrosilite	Forsterite	Fayalite	Wollastonite	Magnetite	Hematite	Ilmenite	Rutile	Apatite	Calcite	Weight % anorthite in plagioclase	Colour Index
CENTRAL BELT																							
1	PC-72- 3 (tuff)	0.00	3.96	36.55	0.00	19.03	0.00	8.76	7.50	0.06	2.42	0.02	6.23	0.05	0.00	9.25	0.00	1.46	0.01	0.50	0.00	34.24	37.31
2	PC-72- 14 (flow)	0.00	17.32	23.18	0.00	17.65	0.00	10.84	9.33	0.00	2.89	0.00	2.64	0.00	0.00	9.54	0.91	1.92	0.01	0.72	0.00	43.22	39.28
3	PC-72- 15 (flow)	0.00	23.23	24.35	1.20	17.54	0.00	7.36	6.34	0.00	0.00	0.00	5.07	0.00	0.00	5.09	3.41	1.71	0.01	0.89	0.00	41.87	30.14
4	PC-72- 26 (flow)	0.00	11.70	18.19	0.00	17.51	0.00	13.57	10.97	0.93	0.87	0.07	6.85	0.64	0.00	10.95	0.00	1.88	0.01	0.98	0.00	49.05	49.15
5	PC-72- 62 (flow)	0.00	24.56	23.52	0.00	14.33	0.00	7.51	6.47	0.00	8.05	0.00	0.16	0.00	0.00	8.96	0.45	1.73	0.01	1.15	0.00	37.85	34.40
6	PC-72-127 (flow)	0.00	19.74	35.36	0.00	13.30	0.00	3.35	2.88	0.00	6.95	0.00	0.74	0.00	0.00	0.00	8.63	3.66	0.02	0.98	0.00	27.33	27.43
7	J-73- 61 (flow)	0.00	27.66	29.69	1.38	17.20	0.00	5.69	4.90	0.00	0.00	0.00	2.29	0.00	0.00	1.44	4.92	1.27	0.01	0.98	0.00	36.68	21.06
8	N-73-252 (analcite flow)	0.00	23.34	18.43	7.79	14.84	0.00	7.90	6.79	0.00	0.00	0.00	4.85	0.00	0.00	4.11	4.92	1.41	0.00	0.00	1.86	44.60	31.15
9	N-73-258 (flow)	0.00	22.63	29.29	0.49	19.50	0.00	5.15	4.40	0.04	0.00	0.00	3.69	0.04	0.00	7.92	0.00	2.04	0.01	0.93	0.00	39.97	24.22
10	V-73-164 (flow)	8.21	12.77	37.05	0.00	17.96	0.00	4.62	3.97	0.00	5.94	0.00	0.00	0.00	0.00	0.00	6.23	0.59	0.01	0.77	0.00	32.65	21.77
11	V-73-166 (flow)	0.00	13.30	28.62	2.69	15.88	0.00	12.37	10.71	0.00	0.00	0.00	0.00	0.00	2.12	1.15	8.19	1.26	0.01	1.05	0.00	35.69	36.78
12	VP-74- 28 (flow)	6.35	16.75	45.77	0.00	4.19	4.20	0.00	0.00	0.00	7.82	2.97	0.00	0.00	0.00	4.96	0.00	1.62	0.00	0.58	2.89	8.40	21.98
13	VP-74- 32 (flow)	1.35	14.77	32.49	0.00	21.13	0.00	2.38	1.75	0.40	10.85	2.49	0.00	0.00	0.00	7.51	0.00	1.73	0.00	0.93	0.77	39.41	27.51
14	VP-74-106 (tuff)	20.31	6.32	12.77	0.00	33.68	0.00	1.52	0.86	0.59	8.70	5.97	0.00	0.00	0.00	5.74	0.00	1.79	0.00	0.48	0.32	72.50	25.41
15	VP-74-145 (tuff)	21.49	15.66	14.21	0.00	19.91	1.97	0.00	0.00	0.00	8.67	9.85	0.00	0.00	0.00	2.25	0.00	1.86	0.00	0.48	2.02	58.35	25.00
16	VP-74-154 (tuff)	14.97	11.02	14.68	0.00	21.82	0.00	2.01	0.84	1.18	6.14	8.76	0.00	0.00	0.00	1.33	0.00	1.60	0.00	0.67	11.80	59.78	22.60
17	SA-74-229 (flow)	5.86	1.00	35.11	0.00	21.31	1.54	0.00	0.00	0.00	14.82	8.53	0.00	0.00	0.00	3.07	0.00	2.80	0.00	1.10	3.39	37.78	31.22
18	SA-74-239 (flow)	4.00	4.02	28.76	0.00	27.17	0.89	0.00	0.00	0.00	7.47	7.74	0.00	0.00	0.00	5.79	0.00	3.77	0.00	1.15	6.48	48.57	28.38
19	SA-74-263 (flow)	13.78	3.37	28.51	0.00	16.39	0.00	5.78	2.60	3.13	6.42	7.73	0.00	0.00	0.00	4.31	0.00	3.94	0.00	1.44	0.16	36.50	34.75
20	LK-74- 47 (flow)	4.36	4.37	37.81	0.00	21.84	0.56	0.00	0.00	0.00	12.23	7.01	0.00	0.00	0.00	4.23	0.00	2.26	0.00	1.15	0.80	36.61	27.21
21	LK-74-55B (flow)	0.04	3.66	35.78	0.00	25.53	0.00	6.04	3.47	2.26	6.68	4.37	0.06	0.04	0.00	4.36	0.00	2.30	0.00	0.79	0.95	41.64	30.70
22	JN-74- 63 (flow)	0.14	24.53	34.01	0.00	15.47	0.00	3.65	3.14	0.00	5.85	0.00	0.00	0.00	0.00	3.11	5.24	1.79	0.00	0.93	0.93	31.27	23.06
23	JN-74- 68 (flow)	2.03	18.62	29.19	0.00	18.99	0.00	5.33	3.93	0.86	7.73	1.69	0.00	0.00	0.00	6.71	0.00	1.79	0.00	1.01	0.32	30.42	28.56
24	JN-74-110 (flow)	23.06	14.24	26.39	0.00	20.64	0.00	0.15	0.09	0.05	5.34	2.77	0.00	0.00	0.00	3.94	0.00	1.46	0.00	0.84	0.32	43.88	13.90
25	PC-72-267 (flow)	0.00	9.93	43.74	0.00	19.05	0.00	0.40	0.24	0.14	2.67	1.51	4.39	2.74	0.00	5.68	0.00	2.32	0.02	1.20	0.00	30.35	21.38
EASTERN BELT																							
26	J-73- 42 (tuff)	0.00	15.42	28.76	0.00	26.08	0.00	4.97	2.52	2.30	1.88	1.71	3.91	3.94	0.00	3.03	0.00	1.52	0.01	0.89	0.00	47.55	26.59
27	N-73-237 (tuff)	0.32	5.79	50.08	0.00	19.72	0.00	4.30	3.17	0.70	3.65	0.81	0.00	0.00	0.00	5.05	0.00	1.24	0.01	0.89	0.00	28.25	19.77
28	V-73-132 (flow)	0.00	13.42	26.65	0.00	15.57	0.00	12.72	9.91	1.36	0.93	0.13	4.67	0.71	0.00	8.00	0.00	1.52	0.01	1.20	0.00	36.89	41.28
29	SA-74- 81 (tuff)	1.11	13.47	51.94	0.00	13.83	0.00	1.10	0.95	0.00	5.60	0.00	0.00	0.00	0.00	4.67	0.37	0.95	0.00	0.50	4.93	21.03	13.72
30	SA-74- 91 (flow)	0.00	23.99	35.02	0.00	17.57	0.00	3.43	2.66	0.38	2.14	0.31	3.62	0.57	0.00	6.34	0.00	1.26	0.00	0.93	1.23	33.41	20.81
31	SA-74-114 (analcite flow)	0.00	23.76	18.80	3.84	16.29	0.00	9.40	7.67	0.56	0.00	0.00	5.43	0.43	0.00	8.47	0.00	1.27	0.00	1.10	0.93	46.43	33.93
32	SA-74-116 (flow)	0.00	4.85	60.66	0.00	13.27	0.00	1.30	1.02	0.14	0.74	0.10	4.42	0.66	0.00	5.45	0.00	1.62	0.00	0.98	2.07	17.95	15.88
33	SA-74-152 (flow)	13.13	18.05	51.48	0.00	4.81	1.65	0.00	0.00	0.00	3.44	0.00	0.00	0.00	0.00	3.21	0.18	1.56	0.00	0.77	0.47	8.53	10.07
34	SA-74-154 (analcite flow)	0.00	28.19	14.93	1.67	15.14	0.00	9.78	7.40	1.34	0.00	0.00	6.05	1.21	0.00	7.60	0.00	1.26	0.00	0.00	1.89	50.35	35.91
35	SA-74-204 (lahar)	0.00	15.48	42.31	0.13	19.03	0.00	0.76	0.53	0.16	0.00	0.00	5.90	2.01	0.00	5.80	0.00	1.43	0.00	0.89	3.09	31.03	17.00
WESTERN BELT																							
37	J-73- 10 (ash flow)	21.89	0.41	61.33	0.00	5.23	1.04	0.00	0.00	0.00	2.12	0.00	0.00	0.00	0.00	0.00	5.16	1.61	0.00	0.89	0.00	7.85	9.96
38	*J-73- 14 (flow)*	*5.91*	*0.41*	*63.19*	*0.00*	*8.77*	*0.00*	*3.97*	*3.42*	*0.00*	*0.84*	*0.00*	*0.00*	*0.00*	*0.00*	*3.50*	*5.82*	*2.17*	*0.01*	*0.55*	*0.00*	*12.19*	*20.02*
39	V-73- 78 (tuff)	21.41	3.25	61.67	0.00	5.33	0.47	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	3.72	1.50	0.00	0.65	0.00	7.96	6.47
40	V-73- 97 (flow)	13.46	8.27	30.96	0.00	21.72	0.00	1.74	1.16	0.44	5.94	2.25	0.00	0.00	0.00	6.13	0.00	3.54	0.02	1.27	0.00	41.23	21.90

APPENDIX 4

C.I.P.W. NORMS OF NICOLA INTRUSIVE ROCKS

Location No.	Field No.	Quartz	Orthoclase	Albite	Nepheline	Anorthite	Corundum	Ca Clinopyroxene	Mg Clinopyroxene	Fe Clinopyroxene	Enstatite	Ferrosilite	Forsterite	Fayalite	Wollastonite	Magnetite	Hematite	Ilmenite	Rutile	Apatite	Calcite	Weight % anorthite in plagioclase	Colour Index
CENTRAL BELT – micromonzonite–microsyenite																							
41	N-73-242	0.00	25.88	38.08	1.14	15.09	0.00	5.00	4.30	0.00	0.00	0.00	0.76	0.00	0.00	2.76	2.96	1.07	0.00	0.00	0.23	28.38	17.31
42	N-73-247	0.00	37.94	23.44	0.41	14.49	0.00	4.15	3.57	0.00	0.00	0.00	3.85	0.00	0.00	1.15	6.48	1.46	0.00	0.00	0.68	38.20	21.17
43	N-73-270	0.00	11.76	39.00	1.69	19.05	0.00	6.53	5.62	0.00	0.00	0.00	1.96	0.00	0.00	0.00	8.30	1.50	0.04	0.00	2.27	32.81	24.51
44	TK-73-178	0.00	26.30	41.62	0.04	13.70	0.00	3.06	2.64	0.00	0.00	0.00	1.96	0.00	0.00	1.99	3.44	1.07	0.00	0.00	1.55	24.76	14.53
CENTRAL BELT – microdiorite																							
45	LK-74- 1	5.50	17.02	31.81	0.00	16.42	2.66	0.00	0.00	0.00	8.74	4.91	0.00	0.00	0.00	3.60	0.00	1.46	0.00	0.00	6.14	34.04	21.75
46	VP-74- 75	0.13	27.78	36.04	0.00	14.34	0.97	0.00	0.00	0.00	7.52	2.57	0.00	0.00	0.00	4.52	0.00	1.22	0.00	0.00	2.73	28.47	17.17
47	VP-74- 81	4.49	23.05	32.32	0.00	19.41	0.02	0.00	0.00	0.00	8.04	2.04	0.00	0.00	0.00	4.94	0.00	1.24	0.00	0.00	2.95	37.53	16.53
48	VP-74-128	0.00	4.26	18.19	0.00	35.17	0.00	4.85	3.24	1.22	5.87	2.20	8.95	3.70	0.00	4.16	0.00	1.67	0.00	0.00	1.59	65.91	37.73
EASTERN BELT – microsyenite																							
49	SA-74- 28	0.00	16.55	61.16	0.00	11.13	0.23	0.00	0.00	0.00	0.18	0.00	2.07	0.00	0.00	1.00	3.93	1.16	0.00	0.00	1.55	15.39	8.67
50	SA-74- 31	0.00	10.70	51.86	0.00	15.21	0.00	3.20	2.76	0.00	4.00	0.00	0.03	0.00	0.00	3.73	3.36	1.07	0.00	0.00	1.86	22.68	18.56
51	SA-74- 48	7.89	10.38	41.28	0.00	19.92	0.72	0.37	0.22	0.13	5.34	3.20	0.00	0.00	0.00	2.82	0.00	1.09	0.00	0.30	3.52	32.53	14.31
52	SA-74-102	0.44	21.40	38.62	0.00	18.45	0.42	0.25	0.22	0.00	5.17	0.00	0.88	0.00	0.00	2.38	6.00	1.30	0.00	0.38	1.91	32.33	16.99
53	SA-74-210	9.14	15.84	49.15	0.00	15.74	0.00	0.82	0.71	0.00	3.10	0.00	0.00	0.00	0.00	3.71	0.46	0.80	0.00	0.00	0.93	24.25	9.57
54	VP-74- 17	18.42	12.82	31.64	0.00	25.50	0.00	1.21	1.04	0.00	3.81	0.00	0.00	0.00	0.00	2.47	3.26	1.07	0.00	0.00	0.23	44.62	12.68
55	VP-74- 18	25.49	17.49	30.03	0.00	15.06	0.00	0.00	0.00	0.00	3.01	0.00	0.00	0.00	0.00	0.70	3.21	0.88	0.00	0.00	0.61	33.40	10.32
56	VP-74-105	15.29	16.37	37.22	0.00	14.13	1.64	0.00	0.00	0.00	5.90	0.00	0.00	0.00	0.00	0.00	5.68	0.47	0.27	0.00	0.68	27.51	14.29
57	SA-74-111	10.63	11.41	28.30	0.00	27.91	0.00	0.32	0.44	0.04	8.86	1.41	0.00	0.00	0.00	4.68	0.00	1.29	0.00	0.79	0.92	49.65	17.39

NOTE: Norms calculated by program M.S.C.C.I.P.W. of the British Columbia Ministry of Energy, Mines and Petroleum Resources, Victoria. Leucite, acmite, and chromite values are zero for all samples.

APPENDIX 5

PETROGRAPHIC OUTLINE OF CHEMICALLY ANALYSED NICOLA ROCKS

LOCATION NO.	FIELD NO.	PETROGRAPHIC OUTLINE
1	PC-72-3	Flow. Fine-grained, red, pyroxene basalt. R.I. of glass 1.578. Hawaiite, sodic alkali basalt series.
2	PC-72-14	Dyke. Fine-grained, reddish grey, pyroxene basalt. R.I. of glass 1.586. Alkali basalt, potassic series.
3	PC-72-15	Flow. Red pyroxene-plagioclase andesite porphyry. R.I. of glass 1.570. Trachybasalt, potassic alkali series.
4	PC-72-26	Flow. Fine-grained, maroon pyroxene basalt porphyry. R.I. of glass 1.608. Alkali basalt, potassic series.
5	PC-72-62	Flow. Weakly epidotized, purplish grey pyroxene-plagioclase basalt porphyry. R.I. of glass 1.574. Trachybasalt, potassic alkali series.
6	PC-72-127	Flow. Reddish grey, hematitic, autobrecciated plagioclase andesite. R.I. of glass 1.562. Trachybasalt, potassic alkali series.
7	J-73-61	Flow. Reddish grey, hematitic augite andesite porphyry. R.I. of glass 1.548. Trachybasalt, potassic alkali series.
8	N-73-252	Flow. Purplish analcite-augite basalt porphyry. 10% pink euhedral analcite phenocrysts, 20% augite phenocrysts. R.I. of glass 1.570. Trachybasalt, potassic alkali series.
9	N-73-128	Flow. Green, fine-grained, porphyritic andesite. R.I. of glass 1.558. Trachybasalt, potassic alkali series.
10	V-73-164	Flow. Reddish grey, fine-grained andesite. R.I. of glass 1.546. Tholeiitic andesite, average series.
11	V-73-166	Flow. Red, hematitic augite basalt porphyry. Some secondary epidote and carbonate. R.I. of glass 1.580. Trachybasalt, potassic alkali series.
12	VP-74-28	Flow. Green, fine-grained, porphyritic plagioclase. R.I. of glass 1.542. Tholeiitic andesite, K-poor series.
13	VP-74-32	Flow. Green, fine-grained plagioclase andesite porphyry. Saussuritic. R.I. of glass 1.566. Tholeiitic andesite, average series.
14	VP-74-106	Tuff. Green, fine-grained, andesitic, bedded. R.I. of glass 1.570. Tholeiitic basalt, K-rich series.
15	VP-74-145	Tuff. Green, fine-grained, thinly bedded. R.I. of glass 1.556. Tholeiitic basalt, average series.
16	VP-74-154	Tuff. Green-grey, fine-grained. R.I. of glass 1.576. Tholeiitic basalt, K-rich series.
17	SA-74-229	Flow. Greenish grey porphyritic pyroxene-plagioclase andesite. Mildly saussuritized. R.I. of glass 1.570. Tholeiitic basalt, K-poor series.
18	SA-74-239	Flow. Dark green, amygdaloidal plagioclase basalt porphyry. Calcite-filled amygdales. R.I. of glass 1.600. Hawaiite, sodic alkali basalt series.
19	SA-74-263	Flow. Dark green, fine-grained, amygdaloidal plagioclase basalt porphyry. R.I. of glass 1.582. Tholeiitic andesite, K-poor series.
20	LK-74-47	Flow. Dark green plagioclase-pyroxene andesite porphyry. R.I. of glass 1.552. Tholeiitic andesite, K-poor series.
21	LK-74-55B	Flow. Dark green plagioclase-pyroxene basalt porphyry. R.I. of glass 1.578. Hawaiite, sodic alkali basalt series.
22	JN-74-63	Flow. Purple, massive pyroxene-plagioclase andesite porphyry. R.I. of glass 1.560. Trachybasalt, potassic alkali series.
23	JN-74-68	Flow. Green, massive plagioclase andesite porphyry. R.I. of glass 1.562. Tholeiitic andesite, average series.
24	JN-74-110	Flow. Green, massive plagioclase andesite porphyry. R.I. of glass 1.532. Tholeiitic andesite, average series.

APPENDIX 5 *(Continued)*

PETROGRAPHIC OUTLINE OF CHEMICALLY ANALYSED NICOLA ROCKS		
LOCATION NO.	FIELD NO.	PETROGRAPHIC OUTLINE
25	PC-72-267	Purplish green, autobrecciated plagioclase andesite. R.I. of glass 1.562. Hawaiite, sodic alkali basalt series.
26	J-73-42	Hornfelsed tuff. Fine-grained, green tuff with secondary brown biotite and green actinolitic hornblende. R.I. of glass 1.568. Trachybasalt, potassic alkali series.
27	N-73-237	Tuff. Crowded pyroxene-plagioclase crystal tuff with a few tiny rock chips. Very little matrix. R.I. of glass 1.546. Mugearite, sodic alkali basalt series.
28	V-73-132	Flow. Purplish green, massive plagioclase-pyroxene basalt porphyry. R.I. of glass 1.580. Alkali basalt, potassic series.
29	SA-74-81	Plagioclase crystal tuff with some lithic fragments. R.I. of glass 1.542. Mugearite, sodic alkali basalt series.
30	SA-74-91	Flow. Green, massive augite-plagioclase andesite. Mildly saussuritized. R.I. of glass 1.554. Trachybasalt, potassic alkali series.
31	SA-74-114	Flow. Massive green analcite-augite basalt porphyry. 10-12% euhedral phenocrysts of reddish analcite, 15-20% euhedral augite phenocrysts. R.I. of glass 1.578. Trachybasalt, potassic alkali series.
32	SA-74-116	Flow. Fine-grained, pinkish grey plagioclase andesite porphyry. R.I. of glass 1.544. Mugearite, sodic alkali basalt series.
33	SA-74-152	Flow. Fine-grained pinkish grey plagioclase latite porphyry. R.I. of glass 1.514. Calc-alkaline rhyolite, K-poor series.
34	SA-74-154	Flow. Massive, dark green analcite-augite basalt porphyry. 5-7% euhedral analcite phenocrysts, 10-22% euhedral augite phenocrysts. R.I. of glass 1.578. Alkali basalt, potassic series.
35	SA-74-204	Pinkish green, plagioclase-rich crystal tuff/sandstone in lahar. R.I. of glass 1.560. Trachybasalt, potassic alkali series.
36	M-75-102	Flow. Massive, purple augite-basalt porphyry. 20-25% subhedral augite phenocrysts. R.I. of glass 1.582.
37	J-73-10	Tuff. Reddish, plagioclase-rich, flow-banded lithic crystal tuff. No pyroxene. Abundant broken plagioclase crystals. R.I. of glass 1.516. Tholeiitic rhyolite, K-poor series.
38	J-73-14	Tuff. Massive, poorly layered, reddish andesitic crystal tuff. Some epidote. R.I. of glass 1.548. Mugearite sodic alkali basalt series.
39	V-73-78	Tuff breccia. Red plagioclase dacite porphyry tuff breccia. Poorly flow banded. Abundant broken plagioclase and some quartz phenocrysts. R.I. of glass 1.508. Tholeiitic rhyolite, K-poor series.
40	V-73-97	Flow. Grey-green, massive pyroxene-plagioclase andesite porphyry. R.I. of glass 1.564. Tholeiitic andesite, average series.
41	N-73-242	Pinkish grey, hematitic pyroxene micromonzonite porphyry.
42	N-73-247	Purple, hematitic, pyroxene micromonzonite porphyry.
43	N-73-270	Reddish grey, hematitic, pyroxene micromonzonite porphyry.
44	TK-73-178	Pink pyroxene microsyenite porphyry.
45	LK-74-1	Green-grey porphyritic pyroxene microdiorite.
46	VP-74-75	Microdiorite. Saussuritized. Hornblende-actinolite replaces pyroxene.
47	VP-74-81	Green-grey porphyritic pyroxene microdiorite.
48	VP-74-128	Green, saussuritic pyroxene microdiorite.
49	SA-74-28	Microsyenite-micromonzonite porphyry. Poorly twinned plagioclase phenocrysts. Considerable epidote in matrix. R.I. of glass 1.522.
50	SA-74-31	Reddish pyroxene microsyenite. R.I. of glass 1.542.

APPENDIX 5 *(Continued)*

PETROGRAPHIC OUTLINE OF CHEMICALLY ANALYSED NICOLA ROCKS

LOCATION NO.	FIELD NO.	PETROGRAPHIC OUTLINE
51	SA-74-48	Pinkish green plagioclase porphyry. R.I. of glass 1.538.
52	SA-74-102	Microsyenite porphyry. Saussuritized. Poorly preserved plagioclase and pyroxene phenocrysts. R.I. of glass 1.556.
53	SA-74-210	Reddish pyroxene microsyenite porphyry.
54	VP-74-17	Fine-grained, brownish augite micromonzonite porphyry. Zoned plagioclase phenocrysts range from An_{32} to An_{55} in composition. R.I. of glass 1.536.
55	VP-74-18	Fine-grained, brownish hornblende micromonzonite porphyry. Abundant phenocrysts of well-twinned labradorite An_{65}. R.I. of glass 1.516.
56	VP-74-105	Fine-grained, purplish, saussuritized micromonzonite porphyry. R.I. of glass 1.528.
57	SA-74-111	Pink pyroxene micromonzonite porphyry. 20% mafic minerals. R.I. of glass 1.550.

NOTE: Formal names of volcanic rocks as obtained from treatment of chemical data with Irvine and Baragar's (1971) computer program.

APPENDIX 6. CHEMICAL ANALYSES OF ROCKS OF MAP UNITS 10 AND 11

UNIT 10

Loc. No.	Field No.	SiO_2	Al_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	Total Fe as Fe_2O_3	H_2O+	H_2O-	CO_2	P_2O_5	S	Total	R.I.
58	C-75- 34 (tuff)	55.02	17.53	3.62	7.21	3.50	1 50	0.82	0.16	7.72	1.0	0.23	1.4	0.32	<0.002	100.03	1.558
59	M-75- 83 (flow)	57.55	18.85	2.18	6.64	3.61	1.77	0.88	0.12	6.19	0.61	0.17	0.74	0.37	<0.002	99.68	1.546
60	M-75-189 (flow)	70 80	14.53	0.33	1.48	5.28	2.92	0.35	0 10	2.14	0.58	0 11	1.14	0.20	<0.002	99.96	1.500
61	PT-75-267 (tuff)	67.97	14.84	0.88	2.31	5.19	1 55	0.60	0.11	3.53	1.20	0.12	1.80	<0.20	0.009	102.31	1.506
62	PT-75-305 (flow)	50.30	20.50	3.90	9.56	3.25	0.59	0.75	0.15	7 06	1.38	0.21	1 43	0.22	0.003	99.30	1.566
63	T- 11 (flow)	68.84	14.57	0.53	1.48	4.90	3.13	0.45	0.08	2.51	0.33	0 12	0.84	0.21	0.003	97.99	1.506
64	VP-75- 12 (flow)	49.21	20.38	2.45	7 30	4.12	0.48	0.90	0.22	9.91	1.82	0.24	1.8	0.37	0.003	9.20	1.578
65	VP-75-130 (tuff)	65.36	15.79	1.32	3.12	4.09	2.90	0.80	0.11	4.39	1.08	0.16	0.72	0.23	0.002	100.07	1.516

UNIT 11

Loc. 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	Total	R.I.
66	N-73- 42 (flow)	57.80	15.65	2.64	5.63	3.83	1.77	1.58	1 59	2.45	6.68	1.46	0.10	0.16	0.60	0.03	101.97	1.556
67	V-73- 33 (intrusive)	50.92	17.58	4.51	6.16	5.44	0.12	1.40	0.18	3 55	5.58	3.74	0.16	0.01	0.32	0.02	99.69	1.566
68	V-73- 46 (flow)	52.51	17.08	4.63	9.42	2.92	0.56	1.29	0.18	5.36	4.68	1.23	0.30	0.85	0.39	0.01	101.41	1.580

APPENDIX 7

PETROGRAPHIC OUTLINE OF CHEMICALLY ANALYSED ROCKS OF MAP UNITS 10 AND 11		
LOCATION NO.	FIELD NO.	PETROGRAPHIC OUTLINE
58	C-75-34	Lithic tuff, greenish grey, fine grained. R.I. of glass 1.558.
59	M-75-83	Flow. Greenish grey, fine-grained, porphyritic plagioclase andesite. 30% plagioclase phenocrysts. R.I. of glass 1.546.
60	M-75-189	Flow. Brownish grey, strongly banded aphanitic rhyolite with 3-5% feldspar phenocrysts. R.I. of glass 1.500.
61	PT-75-267	Ash flow tuff. Buff-grey, strongly banded tuff with clasts of fine-grained porphyritic rhyolite. 10% phenocrysts of pinkish grey feldspar in matrix and clasts. 10% greenish clasts of collapsed pumice. R.I. of glass 1.506.
62	PT-75-305	Flow. Greenish grey, fine-grained, porphyritic plagioclase andesite. 25% plagioclase phenocrysts. R.I. of glass 1.566.
63	T-11	Flow. Maroon, strongly flow-banded rhyolite with intensely contorted layering. 2-3% pinkish grey feldspar phenocrysts. R.I. of glass 1.506.
64	VP-75-12	Flow. Greenish grey, fine-grained, porphyritic plagioclase andesite. 35% tiny plagioclase phenocrysts. R.I. of glass 1.578.
65	VP-75-130	Lithic tuff. Dark grey to brownish grey dacitic lithic tuff. 5% tiny plagioclase phenocrysts in matrix and clasts. R.I. of glass 1.516.
66	N-73-42	Flow. Reddish brown plagioclase porphyry. Fine-grained massive matrix. 15% plagioclase phenocrysts 5-10 millimetres long, commonly in clusters. R.I. of glass 1.556.
67	V-73-33	Intrusive, brownish grey augite plagioclase porphyry. Fine-grained, massive matrix. 20% tabular plagioclase phenocrysts 5-10 millimetres long. 10% augite phenocrysts 2-3 millimetres in diameter. R.I. of glass 1.566.
68	V-73-46	Flow. Reddish brown, fine-grained with a few tiny pyroxene phenocrysts. R.I. of glass 1.580.

APPENDIX 8. TABLE OF MINERAL PROPERTIES

LOC. NO.	NAME	MINERAL INVENTORY NUMBER	METAL	METALLIC MINERALS	HOST ROCK	WORKINGS	DRILLING	PRODUCTION RECORD	SUMMARY DESCRIPTION, RESERVES	REFERENCES*
	GROUP 1									
1	BOOMERANG	92H/NE-87†	Cu, Ag, Au	cc, bn	Microdiorite (and limestone ?)	Some trenches	----	----	Sulphides along fractures in diorite (and limestone ?)	MMAR, 1901, p. 1183
2	MISS	92H/NE-132	Cu	cp, bn, py	Subaerial trachybasalt flows	----	----	----	Sulphides as fine disseminations in flows near high level monzonite stock	----
3	STRIKE, LORNA, MDA	92H/NE-115, 118	Cu	cp, py	Diorite	Several trenches	Several DDH and PDH	----	Sulphides as disseminations and fracture fillings in altered microdiorite	GEM, 1974, p. 125; 1975, p. E 76
4	AXE	92H/NE-40, 142, 143	Cu, Mo	cp, mo, py	Nicola volcanic rocks, diorite, monzonite; molybdenite with quartz porphyry dykes	Many bulldozer trenches	Numerous DDH and PDH	----	Porphyry-type mineralization in three separate zones totalling ≈49 000 000 t >0.3% Cu	MMAR, 1968, p. 203; GEM, 1969, p. 279; 1970, p. 389; 1971, p. 280; 1975, p. G 54
5	PIP, OK	92H/NE-114	Cu, Mo	cp, py, mt, mo	Augite porphyry, diorite, quartz porphyry dykes	Several trenches	3 DDH, 4 RDH, 23 PDH	----	Sulphides in augite porphyry cut by diorite and by quartz porphyry dykes	GEM, 1972, p. 127
6	BLUE JAY	92H/NE-105	Cu	Cu, cc, bn, cp, py	Monzonite - diorite, brecciated augite porphyry, volcanic breccia	Old adit, pits, and trenches	1 DDH (124 m) and 19 PDH (1 341 m) in 1973	----	Porphyry-type mineralization in brecciated western side of diorite and in nearby volcanic rocks	GEM, 1971, p. 286; 1973, p. 159
	GROUP 2									
7	AL	92H/NE-121	Cu	cp, py	Allison intrusive rocks	Test pit	----	----	Minor sulphides in narrow shears in Allison intrusive rocks	GEM, 1973, p. 147
8	ME	92I/SE-165	Cu, Mo, Ag	cp, bn, py, and some mo	Nicola basaltic flows and tuffs	Old pits and shaft	1 DDH, 4 PDH	----	Sulphides in sheared flows and tuffs along branches of Quilchena fault	MMAR, 1967, p. 167; GEM, 1973, p. 164
9	DOR	92H/NE-36	Cu, Ag	cp, cc	Augite porphyry flows	Old pits	----	----	Sulphides in fractures in augite porphyry flows	GEM, 1973, p. 159
10	COPPER STAR	92H/NE-36	Cu, Ag	cp, cc, native Cu	Augite porphyry flows	Old shaft and pits	----	41 t @ 8.7% Cu, 62.4 g Ag	Sulphides in fractures and epidotized augite porphyry flows	MMAR, 1915, pp. 223, 226; GEM, 1970, p. 378; 1971, p. 286; 1972, p. 139; 1973, p. 159; G.S.C., Mem., 243–93
11	KR	92H/NE-54	Cu	cp, py	Nicola volcanic rocks	Several trenches	At least 3 DDH in 1966	----	Mineralization in fractured massive flows near a branch of the Summers Creek fault	MMAR, 1966, p. 175; Assess. Rept. 517, 530, 985
12	RUM	92H/NE-99	Cu, Fe?	cp, bn, cc, py	Nicola volcanic rocks and diorite	Several trenches	Some DDH	----	Sulphides in fracture zones in diorite and volcanic rocks near branches of Summers Creek fault	GEM, 1971, p. 281; Assess. Rept. 3365
	GROUP 3									
13	BIG KID	92H/NE-76	Cu	bn, py, cp	Intrusive breccia	3 adits, several trenches	Several DDH in 15-m intervals	----	Mineralization in high level intrusive breccia pipe	MMAR, 1901, p. 1182; Olieu (1957)
	GROUP 4									
14	TAB	92H/NE-52	Cu	cc, mal, or	Autobrecciated augite-plagioclase andesite porphyry	----	----	----	Mineralization in fracture zones in andesite porphyry	----
15	GOLDEN SOVEREIGN	92H/NE-72	Cu	cc, Cu	Red Nicola breccia and flows	Old cut and winze	----	----	Chalcocite and native copper in fracture in red breccia	MMAR, 1901, p. 1181; G.S.C., Mem. 243–94
16	BIG DUTCHMAN	92H/NE-71	Cu	cc, Cu	Red Nicola breccia and flows	Old cuts	----	----	Chalcocite and native copper in fractures in red breccia	MMAR, 1901, p. 1181; G.S.C., Mem. 243–94

17	GOLDEN GATE	92H/NE-80	Cu	Cu, cp, bn, cc, py, cup	Red and green laharic breccia	Old cuts	Some recent DDH	------	Sulphides along fractures in red breccia near contact with green breccia	MMAR, 1901, p. 1182
18	BANK OF ENGLAND	92H/NE-83	Cu, Au, Ag	cc, bn, cp	Massive green Nicola lahar	Old cuts and pits	13 DDH in 1974 totalling 863 m	------	Sulphides in fracture zone in massive green lahar	MMAR, 1901, p. 1182; G.S.C., Mem. 243–94
19	CINCINATTI	92H/NE-84	Cu	cc, bn, cp, Cu, cup	Massive green Nicola lahar	≈91-m tunnel, old cuts		------	Sulphides in fracture zone in massive green lahar	MMAR, 1901, p. 1182; G.S.C., Mem. 243–94
20	GEORGIE	92H/NE-81	Cu	cc, native Cu	Massive red lahar	Old pits, 9-m adit	------	------	Mineralization in fracture zones in red lahar	MMAR, 1901, p. 1183; G.S.C., Mem. 243–94
21	LYTTON	92H/NE-82	Cu	cc, cp, bn	Massive red lahar	Old cuts	------	------	Mineralization in fracture zones in red lahar	MMAR, 1901, p. 1183; G.S.C., Mem. 243–94
22	TOM CAT	92H/NE-86	Cu, Fe?	cc, mt, bn, Cu, hm	Green laharic breccia	Old pits, some recent trenches	------	------	Mineralization in fractures and disseminated in green laharic breccia near contact with red breccia	G.S.C., Mem. 243–95
23	PORTLAND, COVINGTON, VICKSBURG, QUEBEC	92H/NE-88	Cu	cc, mt, hm	Green and red laharic breccia	Old shaft, cuts, and drift	------	------	Mineralization in fracture zone in red and green laharic breccia	G.S.C., Mem. 243–95; MMAR, 1901, p. 1182
24	VANCOUVER, VICTORIA	92H/NE-90	Cu	cc	Red laharic breccia and volcanic sediments	Old pits	------	------	Sulphides in fractures in red breccia and volcanic sediments	G.S.C., Mem. 243–95
25	BOSS	92H/NE-130	Cu	cc, cp, some Cu	Massive green Nicola laharic breccia	Stripping and some trenching	2 DDH totalling 70 m	------	Sulphides averaging 0.24% Cu over an area of 60 x 30 m in green laharic breccia north of monzonite stock	GEM, 1972, p. 135; 1973, p. 156
26	ESP	92H/NE-131	Cu	py, cc	Nicola volcanic rocks	------	------	------	Very minor mineralization in fractures in Nicola flows and red breccias	GEM, 1972, p. 135; 1973, p. 155
	GROUP 5									
27	DAGO, OPEN	92H/NE-109	Cu	bn, cp, some Cu	Argillite, limestone	Several trenches	14 DDH totalling 1 926 m in 1972	------	Sulphides in argillite, limestone, and other tuffaceous sediments near contact between sedimentary and volcanic sequence	GEM, 1972, p. 137; Assess. Rept. 3789
	GROUP 6									
28	PORCUPINE	92I/SE-54	Cu	cc, cp, bn, Cu, cup	Subaerial basalt flows	15-m inclined shaft	7 DDH	------	Sulphides in brecciated flow top	MMAR, 1963, p. 54
	GROUP 7									
29	SHAMROCK	92H/NE-92	Cu	cc, mal, cp	Volcanic conglomerate and lahar	Short adit, old cuts, several recent trenches	3 DDH in 1963; 6 DDH in 1973	Small shipment @ 5.78% Cu	Disseminated chalcocite along bedding fractures in volcanic conglomerate and lahar	GEM, 1969, p. 278; 1972, p. 128; 1973, p. 148; G.S.C., Mem. 243–92
	GROUP 8									
30	SOO	92I/SE-51	Cu, Fe	cp, py, mt	Skarn in limestone	Several trenches	Several DDH	------	Sulphides and magnetite in epidote - garnet skarn in limestone	MMAR, 1961, p. 43
31	RALPH	92I/SE-122	Cu	bn, cp, py, mt	Andesitic flows and tuffs	Old cuts, recent trenches	Some DDH	------	Mineralization in intensely epidotized flows and tuffs	B.C. Min. Energy, Mines & Pet. Res. property file
32	JUNE	92H/NE-61	Cu	py, cp, mt	Green Nicola augite porphyry flows	Old cuts, some recent trenches	Recent DDH and PDH	------	Sulphides along east-west fracture system in epidote-garnet skarn in augite porphyry	MMAR, 1966, p. 169
	GROUP 9									
33	MINT	92I/SE-50	Cu, Mo	cp, py, mo	Pennask quartz monzonite	------	------	------	Porphyry system in Pennask quartz monzonite, argillic and phyllic alteration, quartz veins with sulphides	B.C. Min. Energy, Mines & Pet. Res. property file

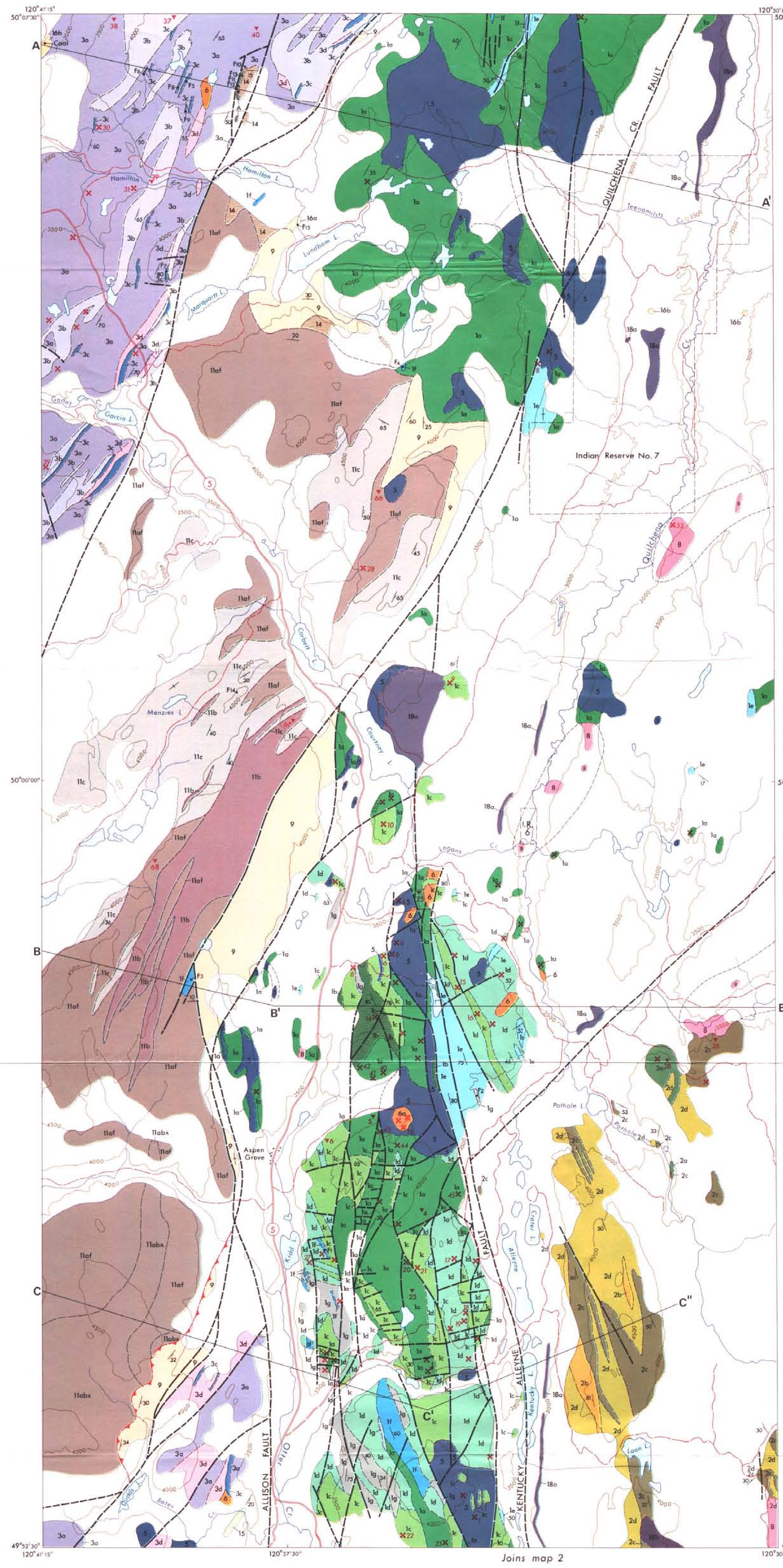
APPENDIX 8. TABLE OF MINERAL PROPERTIES – *Continued*

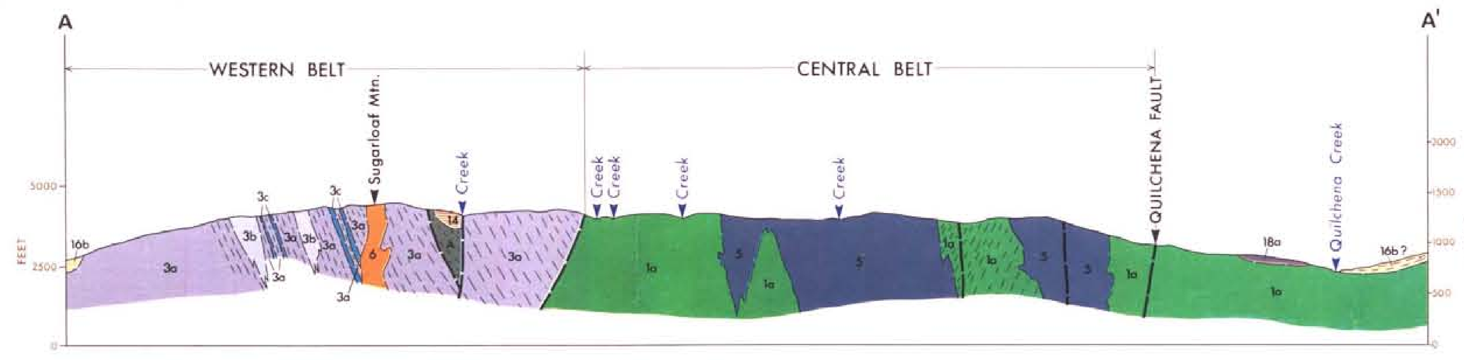
LOC. NO.	NAME	MINERAL INVENTORY NUMBER	METAL	METALLIC MINERALS	HOST ROCK	WORKINGS	DRILLING	PRODUCTION RECORD	SUMMARY DESCRIPTION, RESERVES	REFERENCES*
	GROUP 10									
34	AL	92I/SE-120	Cu	cp, mal	Augite porphyry	Some trenches	------	------	Sulphides in east-west quartz veins along north-south fault zone in augite porphyry	B.C. Min. Energy, Mines & Pet. Res. property file
35	PINE	92H/NE-3	Cu	cp, py	Granite and quartz monzonite of Allison pluton	Several trenches	3 DDH totalling 641 m in 1969	------	Sulphides as fine disseminations and along easterly striking fractures in Allison intrusive rocks near Allison fault	MMAR, 1969, p. 278; GEM, 1973, p. 146; 1974, p. 121
36	P	92H/NE-116	Cu	cp, py	Allison intrusive rocks	------	------	------	Minor mineralization along fractures in granitic rocks	B.C. Min. Energy, Mines & Pet. Res. property file
37	AT	92H/NE-120	Cu	cp, py	Altered Nicola volcanic rocks in Allison pluton	Several trenches	------	------	Sulphides in altered Nicola volcanic rocks surrounded by Allison diorite	GEM, 1973, p. 141
38	FAN	92H/NE-113	Cu	py, cp	Allison granite, altered Nicola volcanic rocks	------	------	------	Pyrite and traces of chalcopyrite in Allison granite and altered Nicola rocks	GEM, 1970, p. 389; 1972, p. 130; 1973, p. 142
	GROUP 11									
39	ELL	92I/SE-82	Cu	py, cp, bn, hm	Silicified and brecciated limestone	Old shaft and crosscut	------	------	Sulphide in brecciated and silicified limestone	B.C. Min. Energy, Mines & Pet. Res. property file
40	BIG SIOUX	92H/NE-73	Cu, Ag	cp, py, cc, bn	Massive Nicola basaltic andesite and breccia	Old shafts, cuts, pits, and numerous recent trenches	Several DDH and PDH	≈41 t @ ≈12% Cu; 68.0 g Ag, 0.57 g Au	Sulphides in zones of fracturing, serpentinuous alteration and silicification in massive volcanic rocks	MMAR, 1901, p. 1181; G.S.C., Mem. 243–93
41	GIANT	92H/NE-74	Cu	cp, py, cc	Massive Nicola breccia and flows	Old cuts, some recent trenches	------	------	Sulphides along fractures in massive Nicola breccia and flows	MMAR, 1901, p. 1181; G.S.C., Mem. 243–94
42	MAGGIE	92H/NE-75	Cu	cp, bn, py	Massive Nicola flows	Old shaft	------	------	Sulphides in fractures in massive flows	MMAR, 1901, p. 1183
43	BLUE BIRD	92H/NE-77	Cu	cc (?)	Massive Nicola volcanic rocks	Old cut and pits	------	------	Sulphides in fracture zones in massive volcanic rocks	MMAR, 1901, p. 1183
44	COPPER BELLE	92H/NE-78	Cu	cc, bn, cp	Nicola augite porphyry	Old pits	------	------	Chalcocite, bornite, chalcopyrite in fractured augite porphyry	MMAR, 1901, p. 1183
45	COPPER STANDARD	92H/NE-79	Cu	bn, cc, hm, mt	Massive red Nicola augite porphyry flows	Old cuts	Some recent DDH	------	Sulphides and magnetite along fractures in massive flows	MMAR, 1901, p. 1183
46	BUNKER HILL	92H/NE-89	Cu	cc, bn, cp, py	Brecciated pyroxene plagioclase andesite	Old pits, some recent trenches	------	------	Sulphides in brecciated and altered massive flows	B.C. Min. Energy, Mines & Pet. Res. property file
47	DAISY	92H/NE-91	Cu	cp, hm, mal, mt	Red lahar	Old adits and cuts, recent trenching	Some recent DDH	------	Sulphides in fracture zones in red lahar near the Summers Creek fault	G.S.C., Mem. 243–95
48	CINDY	92H/NE-126	Cu, Pb	py, cp, some gn	Massive and brecciated Nicola flows	------	------	------	Sulphides in Nicola volcanic rocks near small bodies of microdiorite	GEM, 1973, p. 148; 1974, p. 121
49	ANITA	92H/NE-139	Cu	py, cp	Massive and brecciated basalt flows	------	------	------	Sulphide in Nicola rocks near dioritic dykes and Allison pluton	GEM, 1974, p. 120
50	BO	92H/NE-106	Cu	bn, cp	Diorite, andesitic flows	------	------	------	Andesitic flows intruded by diorite and cut by Summers Creek fault; some sulphides in carbonate veins	GEM, 1971, p. 281

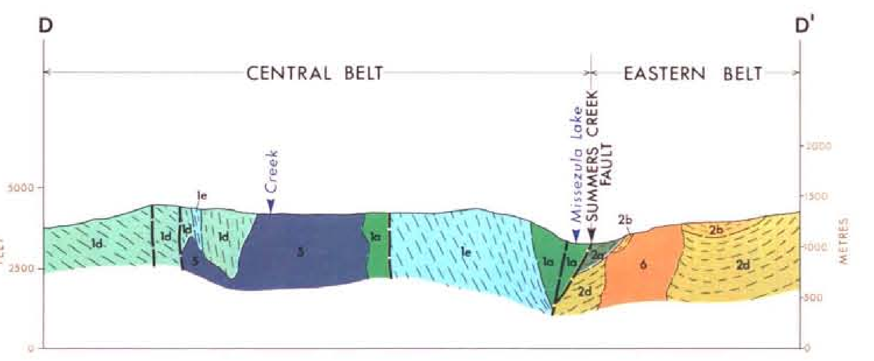
* Asst. Rept. – Assessment Report;
MMAR – *Minister of Mines and Petroleum Resources*, Annual Report;
GEM – *Geology, Exploration and Mining in British Columbia* (page designations: G – *Geology in British Columbia*; E – *Exploration in British Columbia*);
G.S.C., Mem. – *Geological Survey of Canada*, Memoir.

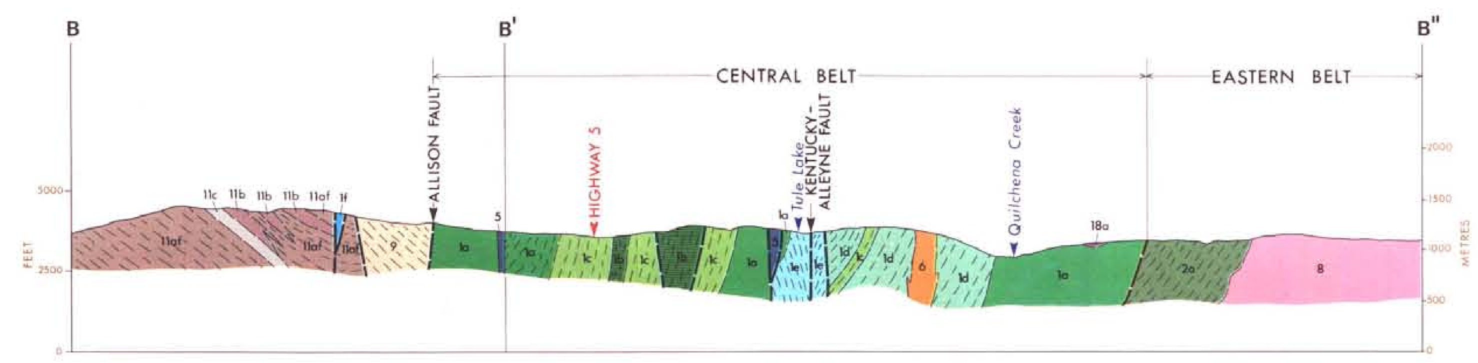
† 92H/NE-87 – Mineral Inventory identification number refers to map 92H/NE, property division 87;
further information may be obtained from the Resource Data Section, Geological Division, Mineral Resources Branch, Ministry of Energy, Mines and Petroleum Resources.

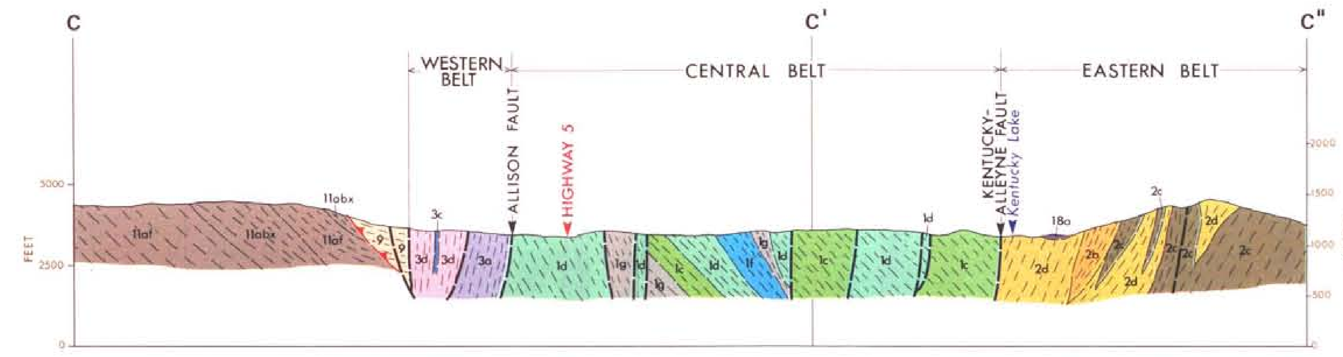
MAP 1

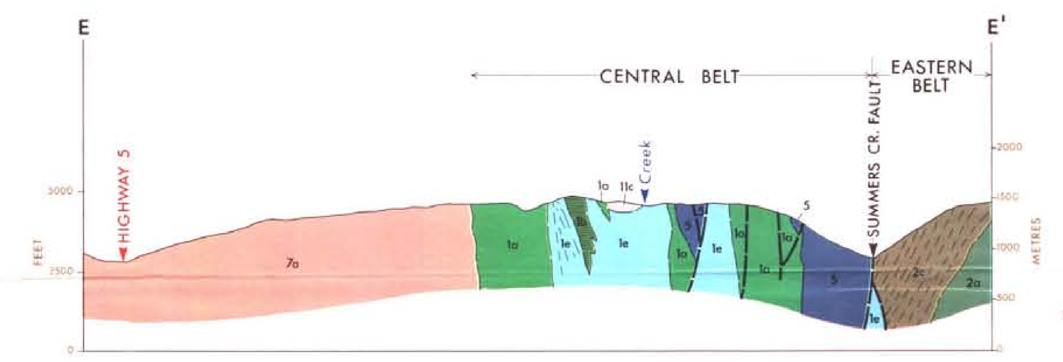












MAP 2

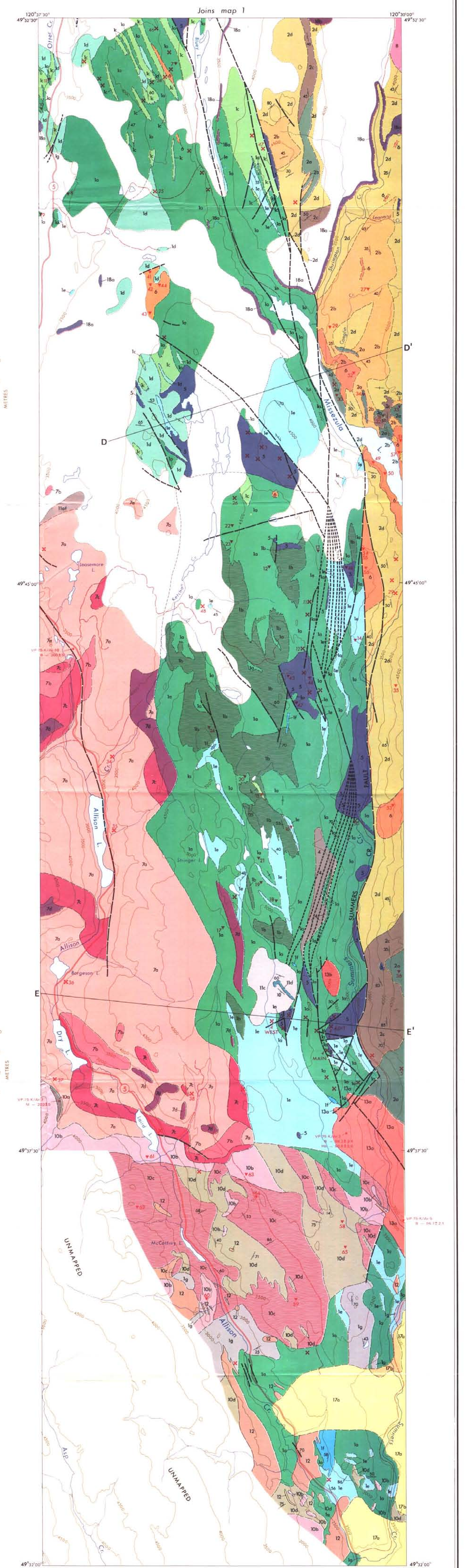


Figure 1

GEOLOGY OF THE NICOLA GROUP BETWEEN MERRITT AND PRINCETON

V. A. PRETO 1972 - 1975

LEGEND

PLEISTOCENE AND RECENT

18 VALLEY BASALT

- 18a RED AND GREY, VESICULAR OLIVINE BASALT
- 18b MEDIUM-GRAINED GABBRO AND BASALT

MIDDLE EOCENE

17 PRINCETON GROUP

- 17a BOULDER CONGLOMERATE, GRIT, SANDSTONE, AND SILTSTONE
- 17b REDDISH BASALTIC AND/OR ANDESITIC FLOWS AND FLOW BRECCIA; LAHARIC BRECCIA

PALEOCENE

16 COLDWATER BEDS

- 16a POORLY CONSOLIDATED BOULDER CONGLOMERATE AND GRIT WITH PLANT REMAINS
- 16b SANDSTONE, SHALE, AND COAL-BEARING BEDS

POST LOWER CRETACEOUS

- 15 BOULDER CONGLOMERATE WITH REDDISH HEMATITIC MATRIX AND CLASTS PREDOMINANTLY DERIVED FROM UNIT 11
- 14 BOULDER CONGLOMERATE WITH ABUNDANT GRANITIC CLASTS

UPPER CRETACEOUS (CENOMANIAN)

13 SUMMERS CREEK STOCKS

- 13a GREY BIOTITE-HORNBLENDE GRANODIORITE, PINKISH GREY BIOTITE QUARTZ MONZONITE, AND MINOR PINK GRANITE
- 13b HORNBLENDE DIORITE, QUARTZ DIORITE, AND GRANODIORITE

POST LOWER CRETACEOUS

- 12 ALLISON CREEK STOCKS: MOSTLY PINK TO GREY LEUCOGRANITE, SYENODIORITE, MONZONITE, GRANODIORITE, AND QUARTZ DIORITE; MINOR MAFIC MICRODIORITE; INCLUDES INTENSELY SILICIFIED AND ALTERED VOLCANIC ROCKS

LOWER CRETACEOUS

10, 11 KINGSVALE GROUP

- 11a PLAGIOCLASE-RICH, REDDISH BROWN AND MAROON FLOWS (11af), TUFFS AND BRECCIAS (11abx) OF ANDESITIC TO BASALTIC COMPOSITION
- 11b PLAGIOCLASE AND AUGITE-PLAGIOCLASE ANDESITE AND BASALT PORPHYRY SILLS AND/OR FLOWS
- 11c REDDISH VOLCANIC CONGLOMERATE, GRIT, SANDSTONE, AND SHALE
- 11d GREY, LOCALLY BEDDED, IMPURE LIMESTONE AND CALCAREOUS GRIT
- 10a BASAL BOULDER CONGLOMERATE-RICH INCLASTS OF UNITS 1 AND 7
- 10b GREY TO MAROON, FLOW-BANDED DACITIC AND RHYOLITIC SUBAERIAL FLOWS AND ASH FLOWS
- 10c GREY TO MAROON, PLAGIOCLASE-RICH ANDESITIC TO DACITIC FLOWS AND FLOW BRECCIA; MINOR LITHIC AND/OR CRYSTAL TUFF
- 10d GREY TO REDDISH GREY AND BROWN LAHARIC DEPOSITS, TUFF, AND TUFF BRECCIA ENTIRELY OR LARGELY COMPOSED OF CLASTS OF UNITS 10b, 10c, AND 7

UPPER JURASSIC TO LOWER CRETACEOUS

- 9 CHERT PEBBLE AND COBBLE CONGLOMERATE; MINOR INTERBEDDED GRIT AND SANDSTONE

LOWER JURASSIC OR LATER

- 8 PENNASK BATHOLITH: BIOTITE-HORNBLENDE GRANODIORITE AND QUARTZ MONZONITE

UPPER TRIASSIC TO LOWER JURASSIC

7 ALLISON LAKE PLUTON

- 7a REDDISH TO REDDISH GREY BIOTITE-HORNBLENDE GRANITE AND QUARTZ MONZONITE
- 7b GREY HORNBLENDE GRANODIORITE
- 7c GREY TO DARK GREY HORNBLENDE DIORITE, GABBRO, AND QUARTZ DIORITE
- 7d METAVOLCANIC ROCKS WITHIN OR NEAR THE PLUTON
- 6 PINK AND GREY MONZONITE AND SYENITE, MEDIUM-GRAINED AND GENERALLY PORPHYRITIC; FINE-GRAINED GREY DACITE
  - 6a MONZONITE AND SYENITE BRECCIA
- 5 DIORITE, QUARTZ DIORITE, MONZONITE, AND DIORITE BRECCIA; MINOR FINE-GRAINED HORNBLENDE PORPHYRY
- 4 LEUCOCRATIC, PYRITIC QUARTZ PORPHYRY, LOCALLY HIGHLY SHEARED AND MYLONITIZED

LOWER TO MIDDLE JURASSIC

CORRELATION UNCERTAIN

- A BUFF-WEATHERING GREY, CALCAREOUS SILTSTONE, SANDSTONE, AND GRIT, WITH INTERLAYERED BUFF-WEATHERING SILTY LIMESTONE

UPPER TRIASSIC

1, 2, 3 NICOLA GROUP

WESTERN BELT

- 3a PLAGIOCLASE ANDESITE TO DACITE FLOWS, MINOR BRECCIA
- 3b ANDESITIC TO DACITIC BRECCIA AND TUFF
- 3c GREY, MASSIVE TO CHERTY LIMESTONE, COMMONLY FOSSILIFEROUS
- 3d CALCAREOUS VOLCANIC CONGLOMERATE, SANDSTONE, AND SILTSTONE; MINOR TUFF AND BRECCIA

EASTERN BELT

- 2a PURPLE AND GREY, LOCALLY ANALCITE-BEARING, AUGITE PLAGIOCLASE TRACHYANDESITE AND TRACHYBASALT PORPHYRY FLOWS AND MINOR FLOW BRECCIA
- 2b REDDISH TO GREENISH GREY CRYSTAL, LITHIC, AND LAPILLI TUFF
- 2c VOLCANIC SANDSTONE AND SILTSTONE, MINOR TUFF
- 2d MASSIVE TO CRUDELY LAYERED LAHAR DEPOSITS, MINOR CONGLOMERATE

CENTRAL BELT

- 1a REDDISH TO GREEN AUGITE-PLAGIOCLASE ANDESITE AND BASALT FLOWS; OCCASIONAL ANALCITE-BEARING TRACHYBASALT
- 1b AUTOBRECCIATED EQUIVALENTS OF 1a
- 1c RED VOLCANIC BRECCIA AND LAHAR DEPOSITS, MOSTLY MASSIVE
- 1d GREEN VOLCANIC BRECCIA AND LAHAR DEPOSITS, MOSTLY MASSIVE
- 1e CRYSTAL AND LITHIC TUFF, GENERALLY WELL BEDDED
- 1f BEDDED TO MASSIVE, GREY, FOSSILIFEROUS REEFOID LIMESTONE AND RELATED CALCAREOUS SEDIMENTARY ROCKS
- 1g WELL-BEDDED SILTSTONE, SANDSTONE, AND ARGILLITE; MINOR GRITSTONE AND PEBBLE CONGLOMERATE

SYMBOLS

- AREA OF PREVALENT OUTCROP
- GEOLOGICAL BOUNDARY: DEFINED, APPROXIMATE
- FAULT: APPROXIMATE, ASSUMED
- ZONE OF INTENSE SHEARING
- THRUST FAULT
- ATTITUDE OF BEDDING: TOPS KNOWN, TOPS UNKNOWN, VERTICAL — 85, 48
- ATTITUDE OF SCHISTOSITY — 60
- PROSPECT AND/OR MINERAL OCCURRENCE — NUMBER REFERS TO PROSPECTS LISTED IN APPENDIX 8. — X 37
- LOCATION OF CHEMICALLY ANALYSED ROCKS — NUMBER REFERS TO ANALYSES, C.I.P.W. NORMS, AND DESCRIPTIONS IN APPENDICES 1 TO 7. — ▼62
- FOSSIL LOCALITY — •F12
- K/Ar ISOTOPIC AGE IN Ma — B = BIOTITE; Hb = HORNBLENDE; M = MUSCOVITE — VP-75-K/Ar-2, B — 98.2±2.6, Hb — 96.8±2.6
- PAVED HIGHWAY
- SECONDARY ROAD

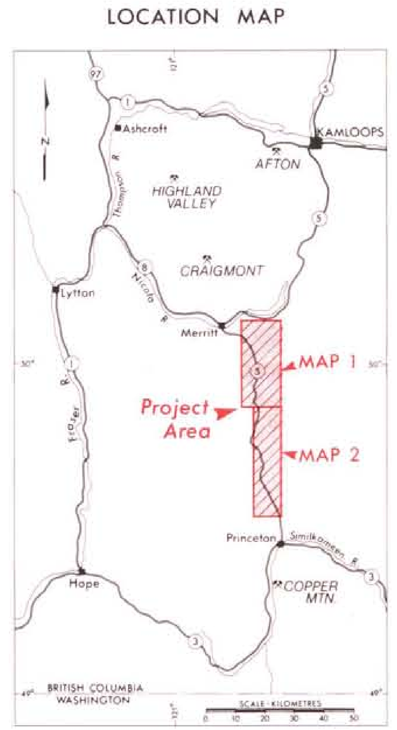
SCALE — 1:50 000

0 1 2 3 4 5

KILOMETRES

CONTOUR INTERVAL — 500 FEET

LOCATION MAP



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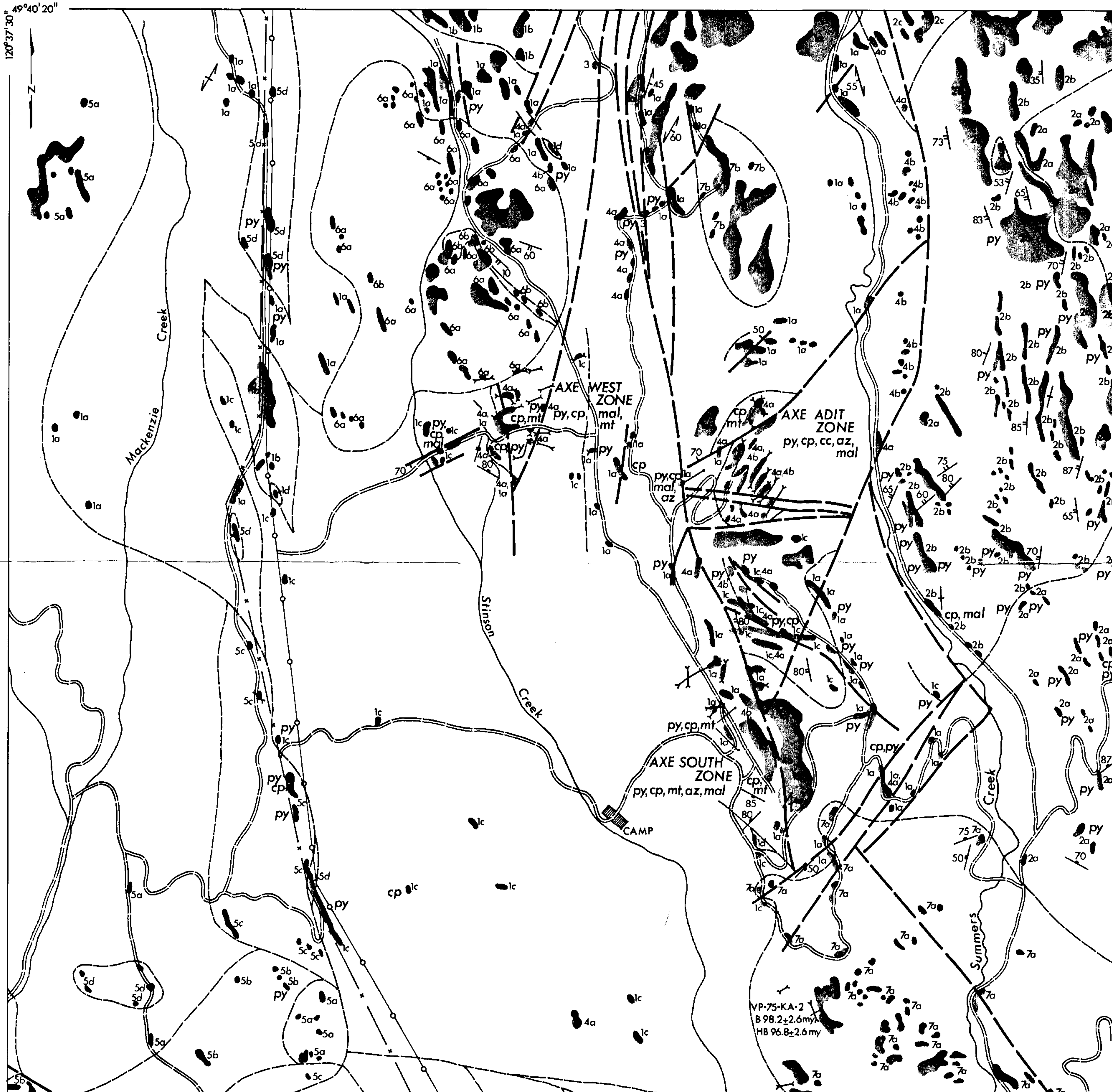

FIGURE 15

GENERALIZED OUTCROP GEOLOGY OF THE SUMMERS CREEK PROSPECT (AXE) ADONIS MINES LTD.

LEGEND

CRETACEOUS

7

- 7a – GREY BIOTITE–HORNBLENDE GRANODIORITE, PINKISH GREY BIOTITE QUARTZ MONZONITE, AND MINOR PINK GRANITE
- 7b – HORNBLENDE DIORITE, QUARTZ DIORITE, AND GRANODIORITE

AGE UNKNOWN

6 **VOLCANIC CONGLOMERATE AND LIMESTONE**

- 6a – RED VOLCANIC BOULDER CONGLOMERATE
- 6b – GREY, LOCALLY BEDDED, IMPURE LIMESTONE AND CALCAREOUS GRIT

UPPER TRIASSIC TO LOWER JURASSIC

5 **ALLISON PLUTON**

- 5a – REDDISH TO REDDISH GREY BIOTITE–HORNBLENDE GRANITE AND QUARTZ MONZONITE
- 5b – GREY HORNBLENDE GRANODIORITE
- 5c – GREY TO DARK GREY HORNBLENDE DIORITE, GABBRO, AND QUARTZ DIORITE
- 5d – METAVOLCANIC ROCKS WITHIN OR NEAR THE PLUTON

4 **DIORITE INTRUSIONS**

- 4a – DIORITE, QUARTZ DIORITE, MONZONITE, AND DIORITE BRECCIA
- 4b – PORPHYRY DYKES

3 **SHEARED AND MYLONITIZED, LEUCOCRATIC QUARTZ PORPHYRY**

UPPER TRIASSIC

NICOLA GROUP

EASTERN BELT

2 **BASALTIC FLOWS AND BRECCIA, SILTSTONE, GREYWACKE, AND LAHARIC DEPOSITS**

- 2a – PURPLISH GREEN PYROXENE–PLAGIOCLASE BASALT PORPHYRY FLOWS, FLOW BRECCIA, AND MINOR TUFF BRECCIA, LOCALLY INTENSELY RECRYSTALLIZED
- 2b – GREY–GREEN, MASSIVE TO BEDDED VOLCANIC SILTSTONE AND GREYWACKE, LOCALLY TUFFACEOUS
- 2c – MASSIVE TO CRUDELY BEDDED GREY–GREEN LAHARIC DEPOSITS

CENTRAL BELT

1 **MASSIVE FLOWS, BRECCIA, TUFF, AND LIMESTONE**

- 1a – MASSIVE DARK GREEN BASALTIC AND ANDESITIC FLOWS WITH PLAGIOCLASE AND/OR PYROXENE PHENOCRYSTS
- 1b – AUTOBRECCIATED EQUIVALENTS OF 1a
- 1c – MASSIVE TO THINLY BEDDED GREEN CRYSTAL AND LITHIC TUFF LOCALLY RICH IN FELSIC FRAGMENTS; MINOR VOLCANIC SANDSTONE AND SILTSTONE
- 1d – BEDDED TO MASSIVE, GREY, FOSSILIFEROUS, IMPURE LIMESTONE AND LIMESTONE BRECCIA

cp = CHALCOPYRITE
cc = CHALCOCITE
mal = MALACHITE
az = AZURITE
py = PYRITE
mt = MAGNETITE

SYMBOLS

AREA OF PREDOMINANT OUTCROP
FAULT
JOINT, FRACTURE SET: VERTICAL, INCLINED
PRIMARY FOLIATION: VERTICAL, INCLINED
BEDDING: VERTICAL, INCLINED, RIGHT SIDE UP
PROSPECT: TRENCH, ADIT
POWER TRANSMISSION LINE
GEOLOGICAL CONTACT: DEFINED, ASSUMED
NATURAL GAS PIPELINE
SAMPLE LOCATION, MINERAL USED, AND APPARENT AGE IN Ma .... VP-75-KA-2 B 98.2±2.6 Ma HB 96.8±2.6 Ma

0 1
SCALE-KILOMETRES

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