70-33

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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METAMORPHIC MAP OF THE CANADIAN CORDILLERA

(Report, 4 figures and Map 1322A)

J.W.H. Monger and W.W. Hutchison

1971
Reprinted 1973

Price, $2.50

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Price subject to change without notice

Information Canada
Ottawa
1971
Reprinted 1973

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ABSTRACT

The metamorphic map of the Canadian Cordillera is subdivided into nine units based largely on the metamorphic minerals listed in the accompanying inventory. These units are (1) unmetamorphosed rocks, (1a) low-grade metamorphic rocks with no known index minerals, (2) rocks of prehnite-pumpellyite metagreywacke facies, (2a, b) rocks transitional between (2) and respectively the (3) blueschist facies and (4) greenschist facies, (5) rocks of amphibolite facies and (6) granitic rocks. Greenschist and amphibolite facies rocks of largely Barrovian type, accompanied by granitic rocks, are confined mainly to two belts, the eastern, Cassiar-Omineca-Columbia belt and the western Coast Mountains belt, that merge in the Yukon and possibly near the International Boundary in the south. Between the belts and flanking them on east and west are unmetamorphosed and low-grade rocks. This pattern results almost entirely from Mesozoic metamorphism, although there is evidence that the metamorphic history of the Cordillera extends back well into the Precambrian.

RÉSUMÉ

La carte métamorphique de la Cordillère canadienne se subdivise en neuf unités, fondées essentiellement sur les minéraux métamorphiques énumérés en annexe. Ces unités sont les suivantes: 1) roches non métamorphisées; 1 a) roches faiblement métamorphisées pour lesquelles aucun minéral caractéristique n'a été indiqué; 2) roches à prehnite-pumpellyite; 2a, b) roches de transition entre les roches 2) et respectivement, les roches à faciès de schiste bleu 3) et les roches à faciès de schiste vert 4); 5) les roches à faciès d'amphibolite; 6) et les roches granitiques. Les roches à faciès de schiste vert et d'amphibolite, principalement du type Barrovien, accompagnées de roches granitiques, se trouvent essentiellement dans deux zones, l'une à l'est, la zone Cassiar-Ominéca-Columbia, et l'autre à l'ouest, la zone de la chaîne Côtière; les zones se rejoignent au Yukon et peut-être près de la frontière internationale au sud. Entre les zones et sur leurs côtés à l'est et à l'ouest se trouvent des roches faiblement et non métamorphisées. Ces caractéristiques résultent presque entièrement de phénomènes métamorphiques du Mésozoique, bien que certaines indications prouvent que l'histoire métamorphique de la Cordillère remonte largement au Précambrien.

METAMORPHIC MAP OF THE CANADIAN CORDILLERA

INTRODUCTION

This preliminary report on the distribution of facies of regional metamorphism in the Canadian Cordillera consists of two parts. The first, an inventory of metamorphic minerals and mineral assemblages with an index map, is essentially a permanent inventory of basic data with provision made for updating as more information becomes available. The second is the metamorphic map proper which utilizes map-units comparable to the facies of medium- and high-pressure of Turner (1968). The map-units are briefly described on the map and discussed in greater detail in the text.

The distribution of units on the metamorphic map is only a first approximation. It reflects both current quantity and quality of basic data (which in this region results largely from reconnaissance mapping) and also 'fashion' in the criteria used for subdivision. However, the writers feel that on any future map based on metamorphic facies, the general pattern of the higher grade units (those corresponding to the 'classical' greenschist and amphibolite facies) will remain largely as shown (Fig. 1). Commonly rocks of these grades are recognizable in the field as metamorphic rocks, have been reported as such and most information about them pertains directly to metamorphism. By contrast, boundaries of low-grade, 'sub-greenschist facies' units (those of the pumpellyite-prehnite metagreywacke facies and rocks transitional between this and the greenschist and blueschist facies) may change considerably with future work. This is because the significance of metamorphic minerals in these lowest grade rocks has only been recognized in recent years. In the reconnaissance work done in this region the primary nature of these rocks is the feature most commonly reported and secondary minerals are cursorily treated. As a result of this lack of information boundaries between low-grade units are conjectural in many parts of the map. However, the writers feel that it is more valuable to interpret boundaries and present an interpretative map (on which the amount of interpretation can be determined by comparison with the index map and data inventory) than to give a 'patchwork' map with no interpretation, on which data are so scattered that any metamorphic pattern is not apparent.

The scale of the map, 1:5,000,000, was chosen for two reasons. Firstly there is insufficient information on many parts of the Cordillera to show details on a larger scale, although this can be done in other parts. Secondly, the base used for this compilation is the 1:5,000,000 Geological Map of Canada (Geol. Surv. Can. Map 1250A) which is the most recent map covering the Cordillera. The metamorphic map thus is directly comparable to the geological map and also the current tectonic and mineral deposits maps (Geol. Surv. Can. Maps 1251A and 1252A).

Original manuscript submitted: 6 April, 1970
Final version approved for publication: 14 September, 1970

The general organization of this report, compilation of data on low-grade rocks and historical aspects were the responsibility of Monger. Hutchison devised the machine processable form of the inventory and compiled data on high-grade rocks.

The basis for this project was metamorphic compilations of the following areas:

Area		Compiler(s)
Southeastern Alaska	-	D.A. Brew, U.S.G.S. J.G. Smith, U.S.G.S.
Queen Charlotte Islands	-	A. Sutherland Brown, B.C. Dept. of Mines and Petroleum Resources
Vancouver Island	-	J.E. Muller, G.S.C.
Coast Mountains	-	J.A. Roddick, G.S.C.
Northwest British Columbia	-	J.G. Souther, G.S.C.
Southeast British Columbia	-	J.O. Wheeler, G.S.C.
Shuswap Region	-	J.E. Reesor, G.S.C.
Cariboo Mountains	-	R.B. Campbell, G.S.C.
North-central British Columbia	-	H. Gabrielse, G.S.C.
Eastern Yukon, Northwest Territories	-	S.L. Blusson, G.S.C.
Yukon Territory	-	D.J. Tempelman-Kluit, G.S.C.

In addition to these compilations and published data, many individuals gave freely of information and provided comments and criticism. They are as follows: C.J.M. Fletcher of the University of British Columbia and K.V. Campbell, University of Washington, data on metamorphism in part of the Cariboo Mountains; E.D. Ghent, University of Calgary, comments on the Selkirk and Dogtooth Mountains, southeastern British Columbia; L.H. Green, Hanna Mining Company, distribution of map-units in the western Yukon Territory; D.W. Hyndman, University of Montana, general comments; K.C. McTaggart and S.B. Ramsbottom of the University of British Columbia, data on southwestern British Columbia; Ian Paterson, University of British Columbia, data on the Pinchi Lake area; R.A. Price, Queen's University and D.G. Cook, Geological Survey of Canada on unit boundaries in the southern Rocky Mountains. In addition data and useful discussions were had from geologists of both the British Columbia Department of Mines and Petroleum Resources and the Geological Survey of Canada. Their assistance is gratefully acknowledged.

INDEX MAP AND INVENTORY

The index map of metamorphic mineral localities (Fig. 1) consists of reference numbers together with National Topographic System 4 by 8-degree quadrangles superimposed on a half-tone copy of the metamorphic map. The reference numbers give the approximate geographic location of the metamorphic minerals and mineral assemblages listed in the inventory.

A preliminary examination of information on metamorphic rocks in the Cordillera leads to the conclusion that only a minimal amount of hard data can be consistently recorded. These data were compiled to form the inventory which is the basis of the metamorphic map. The inventory (Appendix I) is of necessity very simple and contains data on (a) location, (b) metamorphic mineralogy at that location and (c) references. These data are recorded

on 80-column punch cards (columns – 'fields' – in which the particular data items have been recorded are indicated in the Code in Appendix I).
(a) Location: This is represented first by the 4- by 8-degree NTS quadrangle numbers and then by a number (LOC) within that quadrangle. Decimal numbers following the latter number show localities from which more than one occurrence of metamorphic minerals or mineral assemblages have been reported.
(b) Mineralogy: Data on mineralogy have been coded to show (i) whether the reported minerals form an assemblage or merely an occurrence; (ii) the actual minerals present (see code in Appendix I; space has been allowed to record up to 10 minerals in columns headed MIN), and (iii) whether a mineral is always present or not (+always present, - not always present, in columns preceding minerals referred to). Textures have been omitted from this compilation but where good evidence is available these have been used to interpret two or more phases of metamorphism. Minerals formed in the first phase are followed by numeral 1, those formed in a second phase are followed by numeral 2.
(c) Reference: This is given by author's name (AUTHOR) and date (DATE) which can then be located in the bibliography (Appendix 3). If the report is unpublished and has been personally communicated to us, then this is indicated by PC after the date.

In addition to displaying basic data, the index map and inventory give some idea of the confidence to be placed in a particular part of the metamorphic map. A general idea of confidence can be obtained from the density of reference numbers on the index map. A more accurate estimate of confidence may be made from the nature of the data in the inventory and the reference. For example, an older regional study may merely record an occurrence of kyanite, whereas a newer report may be a detailed investigation of metamorphism and presents several assemblages and details of paragenesis.

Finally the occurrence of certain selected minerals is shown in Appendix 2.

METAMORPHIC MAP

As far as possible the map-units employed are based on observed mineral assemblages. Thus, the writers have attempted to make their map-units comparable to the metamorphic facies of Fyfe and Turner (1966, p. 356).

> "A metamorphic facies is a set of mineral assemblages repeatedly associated with one another in space and time, such that there is a constant and therefore predictable correspondence between the mineralogy of each rock and its bulk chemical composition."

The map-units are comparable to the various metamorphic facies of medium- to high-pressure of Turner's well-known scheme (1968) but differ in several details. Turner's classification contains seven facies of medium- to high-pressure, as well as low-pressure facies. The former are the zeolite facies, prehnite-pumpellyite metagreywacke facies, glaucophane-lawsonite schist facies, eclogite facies, greenschist facies, amphibolite facies and granulite facies. In the Canadian Cordillera (1) the low-pressure, essentially contact metamorphic facies are of local occurrence only and cannot be shown on a map of this scale; (2) one unit (1a) includes nonvolcanic, low-grade metamorphic rocks that presently cannot be fitted into Turner's scheme because of the present lack of known index minerals; (3) unit 2, largely equivalent to the prehnite-pumpellyite metagreywacke facies, also contains rocks that probably belong to the zeolite facies of Turner; (4) two units (2a, 2b) are transitional between the prehnite-pumpellyite metagreywacke facies and respectively, the glaucophane-lawsonite schist (unit 3) and greenschist facies (unit 4); (5) unit 5, analogous to much of the amphibolite facies is subdivided by the kyanite and sillimanite isograds; (6) also within unit 5 and shown by a hachured pattern is a subdivision characterized by the dominant granitoid character of the rock; (7) No definite granulite facies rocks are known and only one outcrop of rocks of the eclogite facies has been recognized.

The concept of "facies series" (Miyashiro, 1961) has not been used as the main basis for this compilation (aside from discriminating the "high-pressure" facies (units 2a, 3, E) from "intermediate-pressure" facies (units 2b, 4, 5). One reason, for example, is the occurrence of Barrovian facies series metamorphism in the northern and central part of the Shuswap terrane and possible local Buchan-Abukuma facies series metamorphism in the southern Shuswap terrane. Workers in the region (Moore, 1969; Clark, 1969; McMillan, 1970, pers. comm.) conclude that the high temperature/low pressure facies of Buchan-Abukuma type are younger and superimposed on an earlier Barrovian phase. Consequently "facies series" in that region would also have an implication of time which so far has not been included as a necessary element of "facies series" (Miyashiro, 1961; Heitanen, 1967; and Zwart, et al., 1967).

Problems arise in applying this scheme where critical mineralogical data are lacking. This is commonly the case for the very low-grade metamorphic rocks (unit 2) where the significance of critical minerals has only been realized recently. In this case, unavoidably, criteria such as textural changes and even stratigraphic age must be taken into account and used to supplement meagre mineralogical data. This problem is discussed under unit 2. Areas where mineralogical information is scarce are outlined on the index map by low density of reference numbers.

The highest average grade attained at any given locality is portrayed on the map. Local 'highs' are ignored. In the only known locality where there are two or more very different metamorphic phases, both are indicated. The example is the Vedder Mountain area, on the International Boundary 50 miles east-southeast of Vancouver, where high-grade metamorphism (unit 5) is succeeded by low-grade metamorphism (unit 2). This is shown as 5 + 2 on the map.

Characteristics of the various map-units are reviewed below and summarized in the legend of the metamorphic map. Units 2, 2a and 2b are discussed in somewhat more detail, as these units fall outside the classical metamorphic facies.

Units 1 and 1a

Unit 1 comprises consolidated but unmetamorphosed rocks and unconsolidated deposits. The former may be highly deformed, as in many parts of the Rocky Mountains. Alteration in some rocks of restricted composition included in unit 1 may be considerable, but probably took place in near surface conditions, as for example, dolomitization in carbonate rocks.

Unit 1a is a catchall for nonvolcanic lithological assemblages that are slightly metamorphosed but which contain no minerals so far recognized as diagnostic. These rocks are mainly the western outcrops of clastic Proterozoic rocks and pre-Middle Ordovician, lower Paleozoic pelitic rocks west of the Continental Divide (D.G. Cook, R.A. Price, pers. comm.). Carbonates in these sequences are grouped with the clastic rocks.

In the field, Proterozoic pelitic rocks included in unit 1a are phyllites, and coarser grained rocks are commonly semischists, with the grains broken or flattened augen and the matrix foliated. Pelitic lower Paleozoic rocks have a well-developed slaty cleavage or phyllitic foliation.

Mineralogical changes that take place probably involve changes in clay mineralogy and clastic micas and development of chlorite. Such changes have not been documented in any detail in the Canadian Cordillera but are known from similar Proterozoic rocks to the south in Montana and Idaho (Maxwell and Hower, 1967). There, in sections sampled from west to east, different polymorphs of illite accompany gradational textural changes from argillite to phyllite.

Rocks included in unit 1a span the gap between units 1 and 4 in the eastern Cordillera, are therefore equivalent to rocks of units 2 and 2b, and may be partly equivalent to rocks included in the lowest grade of unit 4 elsewhere. At the lower limit unit 1a grades imperceptibly into unmetamorphosed (unrecrystallized) rocks. At these grades evidence of metamorphism is present in pelitic rocks but absent from all others. At the upper limit unit 1a grades into rocks of unit 4, which is mainly equivalent to the greenschist facies of Turner. This is seen in Fernie map-area (82 G/NW, 82 G/SW), which lies immediately north of the International Boundary and east of longitude 116°W, where Proterozoic rocks of unit 1a grade westward and stratigraphically downward into rocks of unit 4 (G.G. Leech, pers. comm.). South of the International Boundary, Maxwell and Hower (1967) report that illite-bearing rocks pass into biotite-bearing rocks. Thus, the boundary between units 1a and 4 may (in places ?) be at a higher grade than that shown between 2b and 4 as the biotite isograd occurs well within unit 4.

Direct correlation between units 1a and 2, 2a and 2b may ultimately be possible. At present the assignment of rocks to units 2, 2a and 2b is based chiefly on the mineralogy of altered basic volcanic rocks, and because insufficient information is available on the mineralogy of the intercalated pelitic rocks they cannot be used for comparison with those of unit 1a. Ultimately comparative mineralogical studies between layered silicates in pelites included in units 2, 2a and 2b with those in unit 1a may establish some common characteristics. On textural grounds, the occurrence of semischists and phyllites in both units 2a, 2b and 1a suggests a comparable grade. A further guide may be the secondary mineralogy of the poorly described volcanic and hypabyssal rocks that occur sporadically in Proterozoic and lower Paleozoic rocks of the eastern belt.

Units 2, 2a, 2b

Unit 2 largely corresponds to the prehnite-pumpellyite metagreywacke facies of Turner (1968) and in this report is the lowest grade of metamorphism in suites containing volcanic rocks. It includes, at the lowest grades, rock probably belonging to the zeolite facies of Turner. Rocks in units 2a and 2b are transitional between the prehnite-pumpellyite metagreywacke facies and, respectively, the glaucophane-lawsonite schist facies or the greenschist facies. They belong mainly to the highest grades of the prehnite-pumpellyite metagreywacke facies of Turner but are possibly equivalent in part to the lowest grades of the glaucophane-lawsonite schist facies or the greenschist facies.

Strictly, there are insufficient mineralogical data from most parts of the map-area to assign rocks to units 2 and 2b. This is mainly due to two factors. Firstly, the metamorphic mineralogy of these units is essentially that of the greenschist facies, except that units 2 and 2b are characterized by the presence of prehnite and pumpellyite in basic rocks. Until Coombs (1960) demonstrated the significance of these minerals as indicators of metamorphic grade, their importance was not realized and they were not actively sought. Consequently they are rarely mentioned in older reports. Secondly, many secondary minerals in units 2, 2a and 2b are very fine grained, occur in complex aggregates (such as saussurite), and are commonly difficult to identify even with X-ray diffractometry. However, rocks of units 2, 2a and 2b are systematically altered but clearly not to the extent of rocks of greenschist grade (which are nearly always readily recognizable as metamorphic rocks in the field), so other criteria have to be used. In this compilation, account is taken of the degree of alteration of primary calcic feldspars, development of chlorite and known presence of diagnostic minerals in nearby rocks of the same age. These are the only criteria available on metamorphic mineralogy in many areas. Descriptions of textures are used to supplement these data as textures in these low-grade rocks appear to show a systematic variation with grade (<u>see</u> below). However all that can be definitely said of the grade of many rocks assigned to units 2, 2a and 2b is that they are "subgreenschist". They span the gap between unmetamorphosed rocks and those of greenschist grade and therefore are largely equivalent to the prehnite-pumpellyite metagreywacke facies of Turner.

The confidence to be placed in areas of units 2, 2a and 2b can be judged from the index map and Appendix 1. However this does not give the whole picture as it does not show the criteria used above, and in many places confidence may be greater than actually shown. Within unit 2, the degree of confidence is lowest in the youngest rocks (commonly of mid- to late Mesozoic age and higher in the older rocks), because generally the grade of metamorphism increases with the increasing age of the rocks.

As noted above, there is a general progressive increase in metamorphic grade from younger to older, presumably more deeply buried rocks within units 2, 2a and 2b. For example, upper Paleozoic rocks are generally in units 2a and 2b whereas Triassic and younger rocks are in unit 2. Alteration within unit 2 is less in Middle and Upper Jurassic rocks than in Triassic rocks (e.g. Duffell and Souther, 1964, pp. 20, 25). Whereas alteration of some rocks included in unit 2 may result from processes such as autometamorphism, extrusion of volcanic rocks into wet sediments, or hydrothermal activity (e.g. Duffell and McTaggart, 1952, p. 92), it seems probable because of the general progressive increase in grade with age that in most cases the secondary mineralogy in these units is dependent on increasing temperature and pressure rather than these local effects. Therefore, units 2, 2a and 2b are directly comparable with the higher grade, "classical" metamorphic facies.

Textural characteristics of units 2, 2a and 2b

In contrast to the wholly recrystallized rocks of higher metamorphic grades, primary mineralogy and texture are at least partly preserved in most rocks in units 2, 2a and 2b. The degree to which primary texture is altered is important in these units as it is necessarily used as an indicator of metamorphic grade in areas where mineralogical data are scarce or lacking (see Fig. 4). Textural criteria were first used by Turner (1935, 1938) and Hutton and Turner (1936) who divided the chlorite zone of regional metamorphism into several subzones. Coombs (1960) stated that in Otago the chlorite 1 and 2 subzones fall into the prehnite-pumpellyite metagreywacke facies and subzones 3 and 4 into the greenschist facies, and that these textural subzones should be kept distinct from metamorphic facies. In the Cordillera, degree of textural reconstitution is used as an empirical method of subdividing low-grade regional metamorphic rocks in areas where other data are lacking, but is only applicable in a general way. Exceptions are known, a well-documented one being the metamorphism of the Upper Triassic Nicola Group (Schau, 1968), and this scheme strictly can only be used for a rough field estimation of grade. Most rocks in unit 2 are texturally unchanged in hand specimens, whereas many rocks in units 2a and 2b are well foliated. Metamorphic textures in rocks of units 2a and 2b appear to depend largely on competency of the original rock, whereas textures in higher grade rocks are largely a product of growth of the secondary minerals. For example, typical competent rock in units 2a and 2b is massive basic flow rock that retains its original texture yet is mineralogically almost entirely altered. 'Ghosts' of original feldspars are now 'saussurite' and albite but the new minerals are so fine grained they have not destroyed textures. As the secondary minerals become larger they destroy the original texture. In contrast is incompetent rock such as tuff, particularly where interbedded with massive flow rock like that above. If texturally altered at low grades it may consist of sheared or flattened primary clasts composed of optically irresolvable material. At higher-grades but still within units 2a or 2b it may be a fine-grained, laminated, chlorite-white mica-albite schist with no trace of primary texture. Pelitic rocks are generally argillites in unit 2 and phyllites in units 2a and 2b. In these incompetent rocks the secondary texture is probably as much due to mechanical action as to mineral growth. More competent rocks such as sandstones tend to be macroscopically little altered below the boundary between units 2 and 2a or 2b but are commonly semischists above this boundary.

Mineralogy of unit 2

Secondary minerals characteristic of unit 2 are prehnite and pumpellyite, with sodic albite, chlorite, white mica, quartz, carbonate, epidote, zoisite, sphene, stilpnomelane and zeolites. Atypical occurrence of secondary mineralogy in rocks assigned to unit 2 is described by Muller (1967, p. 51) for altered basalt and andesite of the Triassic Mush Lake Group in Kluane map-area (115 G, 115 F, E 1/2), Yukon.

> "In most thin sections examined the plagioclase is completely albitized and epidote, chlorite, carbonate, chalcedony and prehnite are common secondary minerals. Metamorphism was not complete as much of the pyroxene and some of the labradorite plagioclase have been preserved."

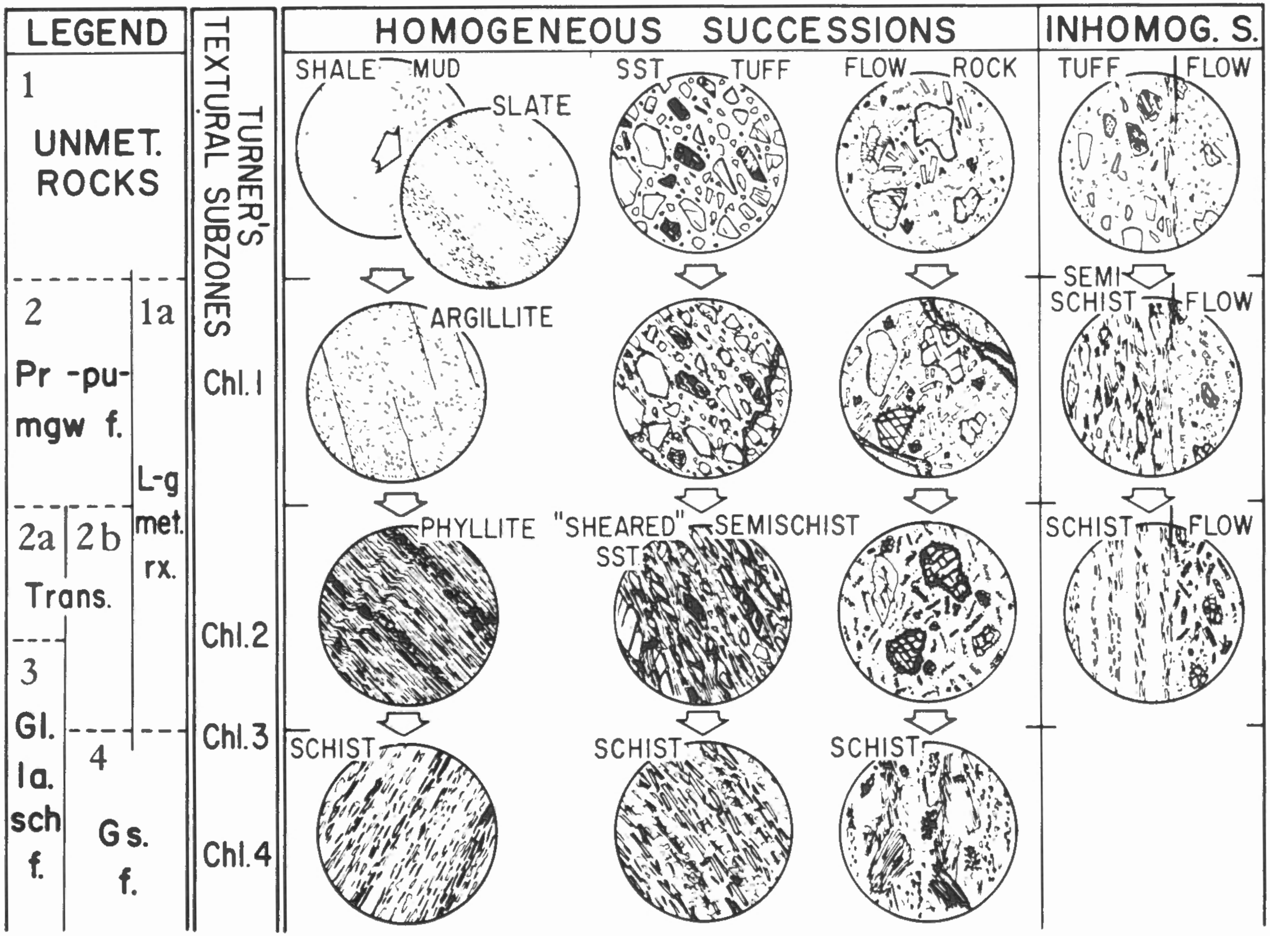

Figure 4. Progressive textural changes in low-grade regionally metamorphosed rocks in the Canadian Cordillera compared with the units used in the Metamorphic Map legend.

In these rocks apart from the presence of prehnite the secondary mineralogy is that of unit 4. However, in contrast to rocks in unit 4, these rocks contain relict pyrogenic minerals and in contrast to rocks in units 2a and 2b, relict calcic plagioclase is preserved, whereas in the higher grade rocks it is (almost) always altered to albite.

No development of zeolites comparable to that described by Coombs (1954, 1960) from New Zealand, on which the zeolite facies is based, is known from the Canadian Cordillera but may well exist. Campbell and Tipper (1969, pp. 68, 69) briefly describe zeolitic alteration of regional extent in probable Jurassic volcanic-clastic rocks in Bonaparte Lake (92 P) map-area. Schau (1968) reports zeolites in similar but slightly older rocks from the Nicola area (92 I). Other occurrences are mainly local. In western Anahim Lake map-area (93 C), H.W. Tipper (pers. comm.) found extensive development of laumontite in veins and Jurassic volcanic rocks over a zone 200 feet wide. McTaggart and Thompson (1967, p. 1206) reported laumontite in highly fractured rocks along the Fraser Valley fault zone north of Hope. This local type of occurrence is probably related to hydrothermal activity, seemingly very different from the regional conditions producing the zeolite facies of Coombs, and is too restricted to show on the map.

Mineralogy of units 2a and 2b

Units 2a and 2b are transitional between and gradational with unit 2 and units 3 and 4 respectively. Mineralogically they are similar to rocks of unit 2 with local significant additions and more extensive development of secondary minerals. Unit 2a corresponds approximately to the highest pressure, pumpellyite-chlorite facies and unit 2b to the intermediate pressure, pumpellyite-actinolite facies of Seki (1969).

Unit 2a contains sporadically developed blue amphiboles, lawsonite and actinolite. Prehnite is very rare in these rocks. Basaltic rocks in this unit from northeastern Dease Lake map-area (104 J) were described by Monger (1969, p. 14) as follows:

> "Commonly, pyrogenic plagioclase is altered to very fine-grained actinolite, epidote (?) and albite and the opaque minerals to leucoxene (?) and sphene. Other secondary minerals that are distributed across the map-area but not always present are stilpnomelane, the sodic amphiboles crossite and riebeckite, and pumpellyite. Small stubby prisms of lawsonite are scattered through the matrix of typical altered greenstones from a locality ..., but this mineral has been found nowhere else in the map-area."

Unit 2b is similar to 2a in degree of alteration but the only characteristic mineral is actinolite which may be abundantly developed. Sodic amphiboles and lawsonite are absent, but pumpellyite and prehnite are present. Relict calcic plagioclase does not seem to be preserved in either unit 2a or 2b although it is reported from rocks included in unit 2.

Apart from the presence of prehnite and pumpellyite, rocks of unit 2b are mineralogically similar to those of the low-grade part of unit 4. The problem is where to draw the boundary between units 2b and 4 in areas where pumpellyite and prehnite have not been reported. For example, in Atlin map-area (104 N) Aitken (1959, p. 28) describes a metavolcanic rock as a "formless mixture of pale green amphibole, albite, chlorite, epidote and clinozoisite" and from this description the rock could well be included in unit 4. In this case the rock is of local occurrence only and grades into less altered metavolcanics containing actinolite with prehnite that retain some original texture and are typical of unit 2b. Elsewhere such a rock might be surrounded by totally reorganized rocks that locally contain biotite. In this case it would be grouped with unit 4. This pragmatic approach is the best that can be done with the available information. The alternative is to include all rocks of units 2a and 2b in, respectively, units 3 and 4 where most of them certainly do not belong.

Unit 3

Unit 3, equivalent to the glaucophane-lawsonite schist facies of Turner, underlies a small area in Fort Fraser map-area (93 K) adjacent to the Pinchi fault zone. It contains the following minerals: glaucophane, lawsonite, quartz, chlorite, white mica, jadeitic pyroxene, sphene, aragonite, calcite, clinozoisite, pumpellyite and stilpnomelane (I. Paterson, pers. comm.). With the exception of relict pyrogenic pyroxene crystals in some metabasalts and some grains in coarse clastic rocks, rocks in unit 3 are thoroughly reconstituted.

One occurrence of 'higher pressure' rocks than these is known in Tay River area (105 K), central Yukon, where eclogite consisting of garnet, pyroxene and amphibole outcrops along a major fault in Tintina Trench. This rock is similar to eclogites in the Franciscan of California. Preliminary analyses of the garnet suggest a composition of 25 per cent grossularite, 25 per cent pyrope and 50 per cent almandine. Approximately 25 miles to the southeast, an outcrop of metaquartzite with scattered blue amphiboles is known from the same fault zone (D.J. Tempelman-Kluit, pers. comm.).

Unit 4

Unit 4 is approximately equivalent to the greenschist facies of Turner. At the lowest grade it passes into units 2b and 1a and at the highest grade into unit 5.

The characteristic mineral species are quartz, albite, muscovite, chlorite, epidote, tremolite-actinolite, sphene, and rarely, stilpnomelane, with biotite, chloritoid and paragonite in higher grades.

The boundary between rock of unit 4 and lower grade rocks has been discussed above. The boundary between units 4 and 1a is possibly at a slightly higher grade than that between units 4 and 2b, as rock of unit 1a passes (locally ?) directly into biotite-bearing rocks of unit 4.

The boundary between units 4 and 5 is taken generally at the garnet isograd. Where detailed information is available, such as that given by Read (1966) from the Lardeau map-area (82 K W 1/2), it is taken as the boundary between albite-bearing rocks and rocks with oligoclase or more calcic plagioclase.

Rocks of unit 4 are the lowest grade of classical regional metamorphism and may form extensive schist terranes. This is in contrast with units 2a and 2b, in which schists occur only rarely and locally, as in incompetent tuff beds between massive greenstones. In unit 4, secondary minerals have commonly grown so as to destroy any original texture and the minerals themselves are generally coarse enough to be identified optically. One exception to this is illustrated by Read (1966, p. 35) where primary textures are partly preserved in rocks of the upper greenschist facies.

Rocks shown as unit 4 occur in the western Yukon and are largely unit 4 but may contain some rocks more properly grouped with unit 5.

Unit 5

Unit 5 is equivalent to much of Turner's amphibolite facies and includes the highest grade regionally metamorphosed rocks in the Canadian Cordillera. Where sufficient information is available unit 5 is subdivided by the kyanite and sillimanite isograds. In places where kyanite and sillimanite have been reported but no isograds drwan, their presence is indicated by the symbols K and S.

Minerals characteristic of this facies are plagioclase, commonly more calcic than An_{15}, quartz, biotite, garnet, hornblende, clinopyroxene, chloritoid, diopside, K-feldspar, epidote, staurolite, kyanite, sillimanite and muscovite.

Within unit 5 and shown by a hachured pattern, is a subdivision of the amphibolite facies characterized by the dominance of granitic gneisses. In this compilation, hachuring has been restricted to granitic gneisses in the Shuswap Terrane of southeastern British Columbia that form the cores of the three major gneiss domes (from north to south, the Frenchman's Cap, Thor-Odin and Valhalla domes), the Malton Gneiss wedge in the northeastern part of the Shuswap Terrane and part of the Clachnacuddain Salient, 15 miles east of Revelstoke. Some of the amphibolite rocks in the Coast Mountains may also belong to this subdivision, but have not been separated.

Granulite facies rocks do not appear to be regionally developed in the Canadian Cordillera, although locally the granulite facies is closely approached and even attained in the Valhalla Gneiss dome (Reesor, 1965, p. 50) and gneisses of the Grand Forks area, south-central British Columbia (Preto, 1967, p. 83) and the Hope area, southwestern British Columbia (McTaggart and Thompson, 1967, p. 1210).

Unit 6

A characteristic of unit 5 is the presence of layers, lenses and veins of granitic and/or pegmatitic rock. In many places there is a rough correlation between the amount of granitic material in a rock and its grade of metamorphism within the amphibolite facies. For example in the Prince Rupert area, rocks of unit 5 between the kyanite and sillimanite isograds contain between 10 per cent and 20 per cent granitic material, whereas above the sillimanite isograd granitic material may be more than 50 per cent of the whole rock. Similarly in the northern part of the Shuswap metamorphic complex (whose boundary coincides generally with the sillimanite isograd) granitic material becomes abundant above the sillimanite isograd (R. B. Campbell, pers. comm.). However, around the Thor-Odin and Frenchman's Cap granitic-gneiss domes of the Shuswap Terrane, an outer envelope in (lower?) sillimanite grade is commonly dominated by pegmatite, whereas an inner envelope adjacent to the core is relatively free of pegmatite (McMillan, 1970; Reesor, 1970). In Aiken Lake map-area (94 C, W/2) rock of the Tenakihi Group is predominantly schist, up to and locally above the sillimanite isograd, whereas stratigraphically equivalent, contiguous rock of the Wolverine Complex consists in large part of granitic material, that also contains sillimanite in a few places.

Unit 6 comprises homogeneous and foliated granitic rocks. In many places throughout the Canadian Cordillera, granitic rocks can be interpreted as pre-, syn-, or post-metamorphic. Nevertheless in a greater number of places (especially within the Coast Mountains and Shuswap Terranes) the time relationships of granitic rocks to enveloping metamorphic rocks are complex, difficult to readily interpret and in most instances have not been reported. Consequently the writers have decided that available data are too incomplete to allow subdivision of this unit.

Distribution of metamorphic rocks

The most characteristic feature of the Canadian Cordillera is the two belts of granitic and high-grade metamorphic rock known on the east as the Cassiar-Omineca-Columbia belt and on the west as the Coast Mountains belt (Fig. 2). These belts merge in the Yukon and in the south come close together near the International Boundary. A possible third high-grade belt west of the northern end of the Coast Mountains forms the core of the Saint Elias Mountains in southwestern Yukon and southeastern Alaska. Low-grade metamorphic and unmetamorphosed rocks of the Intermontane belt separate the two major high-grade belts and rocks of similar grades occur west of the Coast Mountains and east of the Cassiar-Omineca-Columbia belt.

There is considerable difference between the Coast Range belt and the Cassiar-Omineca-Columbia belt in relative amounts of granitic and metamorphic rock. Much of the Coast Mountains consists largely of foliated to massive granitic rock with screens of metamorphic rock. In contrast, the eastern belt contains the extensive Shuswap metamorphic complex in the south, the Omineca metamorphic complex in the centre (the Wolverine complex of Roots, 1954, is the migmatitic part of this), and high-grade rocks in the Cassiar Mountains in the north. Compared with the Coast Mountains the amount of granite associated with these complexes is minor.

As far as is known, the predominant type of metamorphism in the high-grade belts is Barrovian, although there are exceptions. In the Cascade Mountains, just south of the International Boundary the most extensive metamorphism is Barrovian (Misch, 1968, p. 33) and this type continues to the north into the Coast Mountains. Metamorphism in the Prince Rupert area is similar. Little detailed evidence is available for the Yukon or the Cassiar Mountains, but metamorphism in the Omineca Mountains is of Barrovian type (Roots, 1954). Farther south, the northern part of the Shuswap terrane is characterized by this type of metamorphism, with garnet-grade rocks grading into kyanite and then sillimanite-bearing rocks, whereas parts of the southern Shuswap terrane and high-grade rocks in the Grand Forks area, southern British Columbia, have minerals indicative of higher temperatures and lower pressures (Reesor, 1965; Preto, 1967). Possibly this type of metamorphism followed an earlier phase of Barrovian-type metamorphism (see Moore, 1969; Clark, 1969).

In the two belts of granitic and high-grade rocks there is a crude correlation between stratigraphic level and metamorphic grade, although here isograds do transgress stratigraphic boundaries. In the northern Shuswap Terrane the bulk of the high-grade rocks are metamorphosed Proterozoic sedimentary strata even though high-grade metamorphism affects rocks as young as Upper Triassic (R.B. Campbell, pers. comm.). In the southern part of the Shuswap Terrane this stratigraphic correlation is not apparent and Paleozoic and possibly Triassic rocks are extensively involved in the metamorphism (Reesor, 1970, p. 85 and pers. comm.; Hyndman, 1968, p. 34). In the Omineca Mountains the Proterozoic Tenakihi Group is more metamorphosed than the Paleozoic and Proterozoic Ingenika Group, which in turn is more metamorphosed than the upper Paleozoic rocks (Roots, 1954).

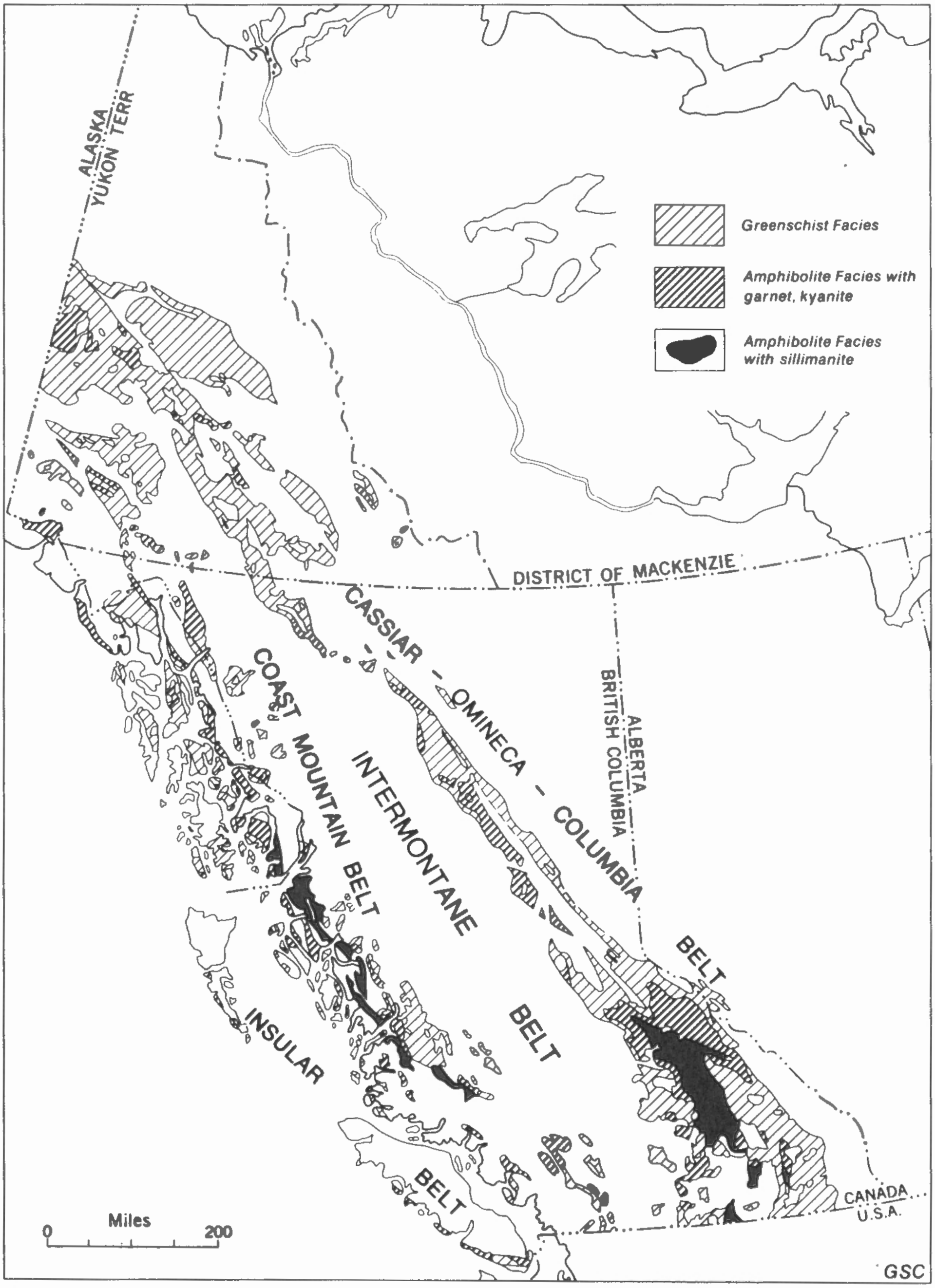

Figure 2. Distribution of facies of classical regional metamorphism in the Canadian Cordillera.

In the low-grade rocks (units 2, 2a, 2b) west of the Coast Mountains and in the Intermontane belt, isograds appear generally to coincide with stratigraphic boundaries. The grade gradually increases with age of the rocks and thus presumably the depth of burial. The metamorphism here is at least partly analogous to the "burial metamorphism" of Winkler (1965, p. 136) where "...no additional thermal energy was supplied, no 'thermal domes' were set up". For example, most upper Paleozoic rocks are in unit 2a or 2b whereas the Mesozoic rocks are in unit 2. Within unit 2, Jurassic rocks are less metamorphosed than Triassic ones.

East of the eastern belt of high-grade rocks, the boundaries between units 1 and 1a, and 1a and 4 are stratigraphic only in places. In the western Rocky Mountains, pre-Middle Ordovician pelites have a slaty cleavage or are phyllitic (and are included in unit 1a), whereas Middle Ordovician and younger pelites are argillites (and are included in unit 1) (D.G. Cook, R.A. Price, pers. comm.). In Fernie map-area (82 G, SW and NW) Proterozoic rocks grade stratigraphically downward from unit 1a to unit 4 (G.B. Leech, pers. comm.). However, northwest of the latter area, in Lardeau (east half) map-area (82 K E/2) the limits of the low-grade metamorphic units transgress stratigraphic boundaries (J.E. Reesor, pers. comm.).

The concept of paired metamorphic belts proposed by Miyashiro (1962, p. 302) is applicable to the eastern, Cassiar-Omineca-Columbia high-grade belt and adjoining low-grade rocks to the west in the Intermontane belt, but so far as is known cannot be applied to the western, Coast Mountains belt. The high-grade rocks, with Barrovian-type metamorphism are largely metamorphosed continental shelf and slope (miogeosynclinal) sediments and presumably lie at least partly on continental crust. This belt corresponds to the continentward "inner metamorphic belt" of Miyashiro. To the west, low-grade upper Paleozoic rocks underlie the eastern margin of the Intermontane belt and locally (unit 2a, Dease Lake area (104 J); unit 3, Fort Fraser area (93 K)) exhibit high-pressure, low-temperature metamorphism. This assemblage consists of basic volcanic rocks, associated ultramafics, cherts, pelites and limestones, closely resembles assemblages flooring present-day ocean basins and has no known base. It is analogous to the "outer metamorphic belt" of Miyashiro. In contrast are the Coast Mountains. The only possible rocks with "oceanic affinities" are the extensive Triassic Karmutsen basalts of Vancouver Island and Queen Charlotte Islands and the Tertiary Netchosin basalt that occupies the southernmost tip of Vancouver Island, but these rocks lie on older sialic crust and are not associated with ultramafics and cherts. The only known occurrence of high-pressure mineralogy is the presence of lawsonite in Upper Paleozoic rock at the 49th Parallel on the west side of the Cascade Mountains, but this belt disappears immediately to the north into the predominantly granitic Coast Mountains (Monger, 1966).

AGE OF METAMORPHISM

In practical terms the age of metamorphism of a terrane is defined by the maximum and minimum possible ages. The maximum age is the age of the youngest rocks affected by either the highest grade of metamorphism or by metamorphism that passes zonally into the highest grade. The minimum age is (1) the age of the oldest rocks unconformably overlying the high-grade metamorphic terrane, (2) the age of the sedimentary rock containing detritus from the metamorphic terrane, or (3) radiometric ages of minerals in either the metamorphic rocks or in cross-cutting plutons. Where the maximum and minimum ages are close together a reasonable idea of the age of metamorphism is obtained.

In most cases the maximum and minimum limits are widely spaced and it is extremely difficult to know just when an episode of metamorphism took place. Events such as episodes of folding involving generation of metamorphic minerals can be dated readily in relative terms within the terrane but it is difficult, if not impossible, to demonstrate their synchronism with folds and unconformities in surrounding, datable unmetamorphosed rocks. Radiometric 'whole rock' potassium-argon (or rubidium-strontium) ages on metamorphic rocks may give an indication of the time of formation of metamorphic minerals but more commonly may merely record the time of cooling below a certain temperature, which may be very different from their time of formation.

The following review is intended to be a guide to the ages of metamorphic episodes in the Cordillera. Direct evidence of age is given or referred to wherever possible. Inferences of age drawing upon folding episodes and unconformities in unmetamorphosed rocks contiguous to the metamorphic terrane are largely ignored.

Although Mesozoic metamorphism is almost entirely responsible for the metamorphic pattern seen today in the Canadian Cordillera, there is evidence for several earlier metamorphic episodes. The pre-Mesozoic record is very fragmentary, is known only from the eastern and western fringes of the Cordillera (Fig. 3) and relies heavily for support on radiometric dating that is generally open to interpretation. By contrast, in many places the Mesozoic metamorphism can be reasonably well-dated on structural and stratigraphic grounds. This Mesozoic metamorphism apparently reached its peak in Jurassic time in many parts of the Cordillera, but elsewhere, as in the Yukon, may have been slightly earlier, and in some places, such as in parts of the northern Coast Mountains, may have been somewhat later.

Precambrian metamorphism

In southeastern British Columbia (Fig. 3, loc. 2), the older Proterozoic (Purcell) strata are more metamorphosed than Cambrian rocks in contact with them (Leech, 1962, p. 2). It is thus possible to say that there was an episode of Proterozoic metamorphism in this region, but just when this took place is not known. The metamorphism is low grade (units 1a and 4 generally) and westwards becomes masked by the predominant Mesozoic metamorphism. It cannot be directly related to the known episode of tectonism called the East Kootenay Orogeny by White (1959, p. 62) which is recorded by the regional unconformity between Purcell strata and younger Proterozoic (Windermere) beds, although Leech (1962, pp. 5, 6) considers that this is a possibility. Radiometric age dates on micas in these low-grade rocks range from 212 m.y. to 1,310 m.y. Leech (1963, 1967, 1968) considered that this variation is produced by dating (1) detrital micas that give old age dates but which may be partly updated by later metamorphism, (2) metamorphic micas formed in Precambrian time, variably updated by Mesozoic metamorphism and (3) metamorphic micas of Mesozoic age. In northern Idaho, Reid *et al.*

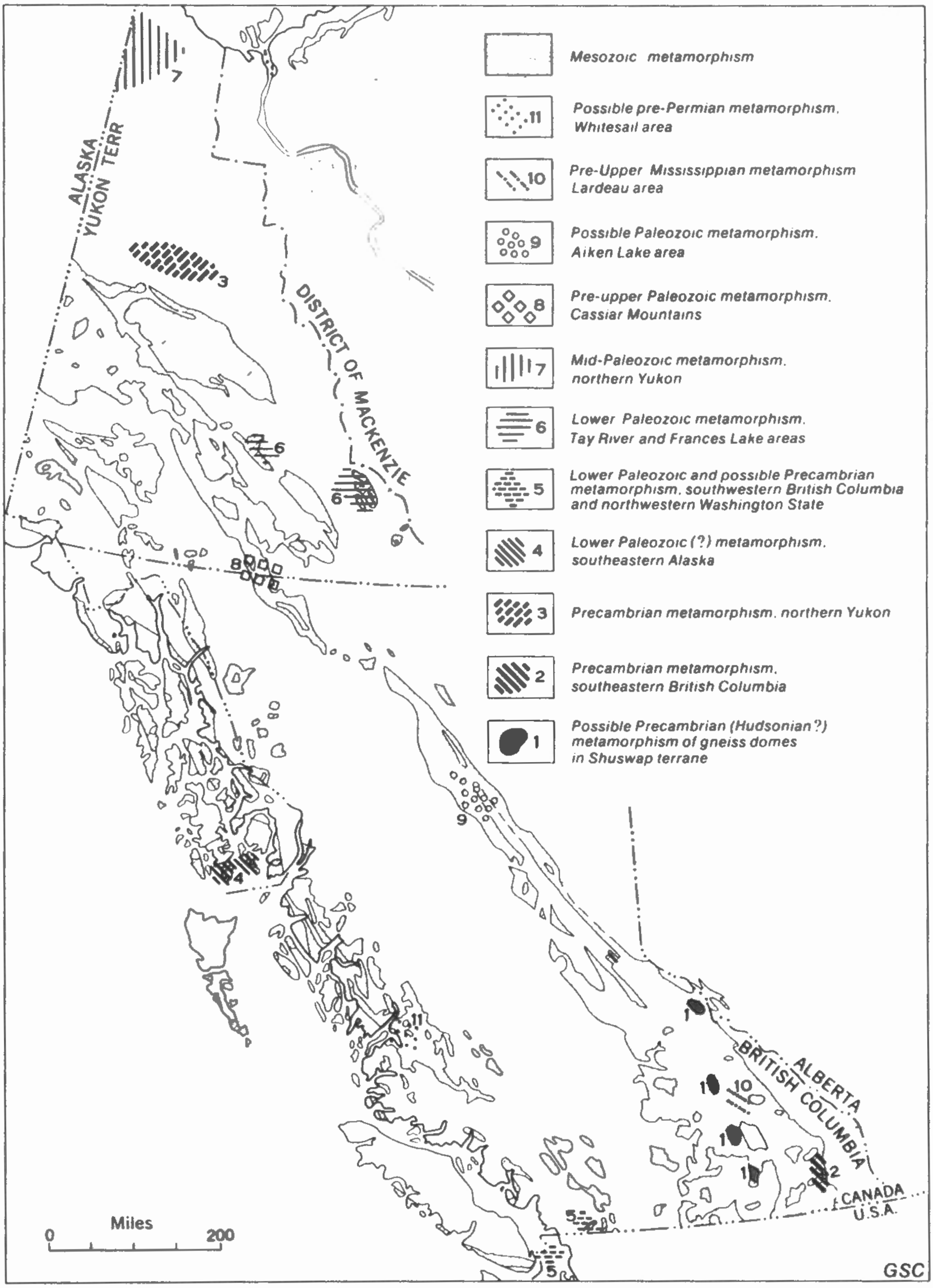

Figure 3. Index map showing approximate location of known and possible areas of pre-Mesozoic metamorphism, in relation to the predominant Mesozoic metamorphism of greenschist and amphibolite grade.

(1970) have obtained an age of 1,525 m. y. from zircons in augen gneiss that was intruded during deformation and metamorphism of the surrounding older Proterozoic rocks. Possibly some reflection of this event occurs north of the International Boundary. Recent whole-rock rubidium-strontium measurements by Ryan (1970) on a stock from southeastern British Columbia indicate an age for the stock in excess of 1,200 m.y. According to Leech (1962, p. 3) this stock intruded a pre-existing anticline in the Purcell rocks. Time of formation of the anticline is possibly the same as that of the deformation to the south.

The great metamorphic complex of the Shuswap region, which lies to the northwest of the above Proterozoic rocks and was previously thought to be a Precambrian metamorphic complex (Jones, 1959, pp. 127-133) but now is known to consist largely of Proterozoic and Paleozoic sedimentary rock metamorphosed mainly in Mesozoic time, contains gneiss domes and wedges (Fig.3, loc. 1). Ross (1970, p. 61) has speculated that these are reactivated stratigraphic equivalents of Hudsonian rocks in the Canadian Shield, that according to Burwash et al. (1964) were formed about 1,800 m.y. ago. However, Reesor (1970, p. 86) feels that rather than remobilization of an older gneissic terrane, the gneiss domes and surrounding metamorphic rocks developed during the same episode(s) of metamorphism from rocks of similar stratigraphic and structural position that have undergone varying degrees of metamorphism.

Low-grade regional metamorphism of argillaceous Proterozoic rocks in Olgivie, Richardson and northern Wernecke Mountains, northern Yukon (Fig.3, loc.3) was reported by Gabrielse (1967, p. 274).

In the San Juan Islands and Cascade Mountains of northern Washington (Fig.3, loc.5) Mattinson (1970, p. 116) has reported uranium-lead ages of 1,600-2,000 m.y. on zircon in gneiss. The significance of these ages in terms of metamorphism are not known, but similar rocks to those containing the zircon are found just north of the International Boundary in the Cascade Mountains.

Lower Paleozoic (or older ?) metamorphism

Best evidence for lower Paleozoic (and/or older ?) metamorphism comes from the western part of the Cordillera, in southeastern Alaska and the Cascade Mountains.

In the Bokan Mountain area of southern Prince of Wales Island, southeastern Alaska (Fig. 3, loc.4) early Paleozoic, probable Ordovician, quartz diorite and quartz monzonite (dated at 431,446 m.y.) discordantly intrude slate, schist, gneiss and amphibolite (Lanphere et al., 1964, MacKevitt, 1963). Metamorphism of the latter rocks would seem to be regional from their nature and must be Ordovician or older. From the same region Berg (1970) has reported a Middle (?) Silurian stock (dated at 416 m.y.) that intrudes greenshcist facies metamorphic rocks. Areal extent of this metamorphism is unknown, but if related to the regional Siluro-Devonian uplift in southeastern Alaska (Buddington and Chapin, 1929) it may be widespread.

Pre-Middle Devonian metamorphic rocks unconformably underlie upper Middle to lower Upper Devonian rocks in the San Juan Islands, northwestern Washington (Danner, 1967) (Fig.3, loc.5). Metamorphic rocks of similar lithology to the pre-Middle Devonian rocks occur on the mainland to the east and northeast as fault slices on the western side and within the axial gneiss belt of the Cascade Mountains (Misch, 1966, pp. 104-108). Mattinson (1970), on the basis of radiometric studies on zircon and sphene, has suggested that the age of metamorphism there is about 400 m.y. In Canada, such rocks are exposed on Vedder Mountain, 60 miles east-southeast of Vancouver (unit 5 + 2 on map 1322A) and farther east, on the western side of the axial granites of the Cascade Mountains. They are amphibolites, hornblendites, foliated quartz diorites and schists, originally belonging to unit 5, but downgraded to unit 2 (McMillan, 1966).

Lower Paleozoic metamorphism

There is scattered evidence for probable lower Paleozoic metamorphism on the eastern side of the Cordillera (Fig. 3, loc. 6). In Tay River (10 K) and Frances Lake (105 H) areas of central and southeastern Yukon, greenschist facies rocks of biotite grade are overlain by Devono-Mississippian clastic rocks (Tempelman-Kluit, 1968, and pers. comm., Blusson et al., 1966). In Tay River area it is probable that Ordovician to Silurian sedimentary rocks overlie the metamorphic rocks as well, although the contact is not exposed. The composition of the underlying metamorphic rocks there is such as to suggest that they were originally Cambrian strata. Thus metamorphism in this region can be dated as definitely pre-Middle Devonian, probably Cambro-Ordovician.

Mid-Paleozoic metamorphism

Low-grade metamorphism of Late Devonian (?) age producing phyllites and semischists in the Upper Devonian or older Neruokpuk Formation in the Brooks Range, northeastern Alaska, is described by Reed (1968). Similar rocks continue eastward for about 100 miles and are exposed in the northwesternmost Yukon (Norris et al., 1963) (Fig. 3, loc. 7). These are shown on map 1322A as belonging to unit 1a.

Quartz-mica-schist clasts in upper Paleozoic conglomerates in Jennings River map-area (104 O) (Gabrielse, 1969, p. 14) and schist clasts in Permian conglomerate in Wolf Lake map-area (105 B) (Poole, 1960) presumably indicate an episode of metamorphism in the Cassiar Mountains region prior to late Paleozoic time (Fig. 3, loc. 8).

In Aitken Lake map-area (94 G W/2) in Omineca Mountains, Roots (1954, p. 107) postulated an episode of post-Lower Cambrian, probable pre-Mississippian granitization and metamorphism that formed the migmatitic Wolverine metamorphic complex (Fig. 3, loc. 9). Evidence for this is that (1) the metamorphic rocks are derived from sedimentary rocks as young as Early Cambrian, and (2) in the map-area there is a possible Mississippian conglomerate containing clasts of granite and schist, seemingly derived from the metamorphic terrane. J.O. Wheeler (pers. comm.) feels that this conglomerate may be much younger because (1) it is unique in that no other Mississippian conglomerate contains plutonic clasts and (2) it is adjacent to a fault that elsewhere has Late Cretaceous or Tertiary conglomerates along it. If the conglomerate is in fact of Late Cretaceous or Tertiary age metamorphism in this region could be as young as mid-Mesozoic and thus largely contemporaneous with that of the Shuswap terrane to the south.

Farther south, in Lardeau map-area (82 K) on the eastern edge of the Shuswap Terrane, Wheeler (1968, p. 57) has reported variously oriented foliated boulders of Proterozoic (?) grit in Upper Mississippian conglomerates (Fig. 3, 10). Micas parallel to the foliations in these boulders are evidence of some intra- or post-Proterozoic, pre-Upper Mississippian metamorphism.

Finally, in Whitesail map-area (93 E) on the east side of the Coast Mountains, limestone of possible Permian age is in contact with gneissic rock (P.B. Read, unpublished report) (Fig. 3, loc. 11). If the contact there is a stratigraphic one, then the relationship indicates pre-Permian metamorphism.

Permo-Triassic (?) blueschist metamorphism

The best evidence to date indicates that rocks of blueschist and related facies (units 3, 2a) were formed in Permo-Triassic time.

In Dease Lake map-area (104 J) the grade of rocks of Late Permian age is transitional to the blueschist facies (Monger, 1969). This metamorphic mineralogy is related to the oldest of two sets of structures. By contrast, rocks of probable Late Triassic age in fault contact with these are far less metamorphosed (unit 2) and contain structures analogous to the younger of two sets of structures in the older rocks. On this basis it appears as if blueschist-type metamorphism in this area is of Permo-Triassic age. However, whole-rock potassium-argon age dates of 165 and 129 m.y. on crossite schist from this area possibly imply that the blueschist metamorphism is of Jurrassic-Cretaceous age. If this is so, then we are seeing the different effects of metamorphism and deformation at various levels in the crust.

In the Fort Fraser area (93 K) blueschists are developed in Permo-Pennsylvanian rocks adjacent to the Pinchi fault, which separates them from little metamorphosed (unit 2) Upper Triassic rocks (Ian Paterson, pers. comm.). The structural situation in this area is comparable to that near Dease Lake and possibly the dating problems are common to both areas.

Blueschist-type metamorphism is present on the west side of the Cascade Mountains in Hope map-area (92 H W/2) just south of the International Boundary in Washington State where rock ages of 259 m.y. and 218 m.y. (namely Permian and Triassic) were obtained on crossite schist (Misch, 1966, p. 109). However, Monger (1966, p. 93) found lawsonite in feldspars in probable Lower Jurassic rocks just north of the International Boundary (in area shown as unit 2a). Unfortunately it is not known whether this lawsonite is detrital or formed in situ.

Age of the metamorphism that produced eclogite and blue amphiboles along the Tintina fault zone in the Yukon is not known, but is possibly Triassic. The metamorphism may reflect movement on the fault zone at this time. (D.J. Tempelman-Kluit, pers. comm.).

In summary, most evidence favours an episode of Permo-Triassic metamorphism producing blueschist-type mineralogy, but the possibility that this may be younger (in part ?) cannot yet be excluded. Ultimately it should be possible to date this type of metamorphism precisely, as it appears to result from short-lived events such as rapid burial in a low geothermal gradient followed by rapid uplift (Ernst, 1965, p. 909) or by high pore-pressure during overthrusting (Blake et al., 1969, p. 243). The latter type of mechanism is perhaps applicable here; all blueschist-type metamorphic rocks known in the Canadian Cordillera are near major faults.

Mesozoic metamorphism

In contrast to the fragmental picture presented above, Mesozoic regional metamorphism appears to be largely responsible for the great regional high-grade complexes of the (eastern) Columbia-Omineca-Cassiar belt, the (western) Coast Mountains and possibly the St. Elias Mountains of northwesternmost British Columbia shown on Figure 2. Where this metamorphism can be dated more precisely than just 'Mesozoic' it appears to be fairly time-restricted. In addition to 'classical' regional metamorphism there is the low-grade, so-called burial metamorphism (Winkler, 1965, p. 136) that formed the rocks included in units 2 and possibly 2b that are characteristic of the Intermontane and Insular belts of British Columbia. There the apparent effect is of metamorphism increasing gradually with depth, so that upper Paleozoic rocks are more altered than Triassic rocks and so on, and it is impossible to ascribe a date of metamorphism for these rocks other than Mesozoic and possibly early Tertiary.

The problem of age of metamorphism as it relates to level of exposure is extremely difficult in Mesozoic regional metamorphism. For example, in the Cassiar Mountains metamorphism is of early Mesozoic age in a predominantly greenschist terrane. In the Shuswap terrane, 700 miles southward along strike, it is of probable Jurassic age in an amphibolite terrane. Is this difference in age real, or only apparent and due to deeper erosion in the Shuswap Terrane, exposing rocks that were metamorphosed for a longer time? Such questions cannot be answered at present, but an awareness of this problem has to accompany every discussion of age of metamorphism.

Regional metamorphism of Mesozoic age is discussed geographically in the following section.

(a) Northern Cordillera

In the Cassiar Mountains and to the northeast in the Pelly Mountains of south-central Yukon, available evidence indicates that the major episode of metamorphism is Triassic. In Jennings River (104 O) Carboniferous and (?) Permian rocks of low-grade (unit 2b) are unconformably overlain by Lower Jurassic (?) sedimentary rocks (Gabrielse, 1969). The low-grade rocks are compositionally similar and adjacent to undated greenschist and amphibolite grade rocks in the axial part of Cassiar Mountains and may represent the lowest grade part of the same metamorphic series. On the southwest side of Cassiar Mountains, in Dease Lake map area, quartz-mica schists are overlain by Upper Triassic-Lower Jurassic rocks (Gabrielse, 1969, p. 19). Potassium-argon ages of 222, 214 and 194 m. y. on micas in greenschist-grade rocks and regionally discordant Early Jurassic plutons support the stratigraphic evidence of a Triassic age of metamorphism.

Farther northwest, in the western Yukon, there is the extensive metamorphic terrane of the Yukon Group. Earlier this was thought to be a Precambrian metamorphic complex (Cairnes, 1914, p. 44) but later work has shown that it contains metamorphosed Proterozoic and Paleozoic strata (Green and Roddick, 1962, L.H. Green, pers. comm.). To the west in east-central Alaska, Foster (1968, p.6) reports that greenschist-grade rocks equivalent to the Yukon Group appear to be continuous with Upper Silurian or Lower Devonian sedimentary rocks. In Whitehorse map-area (105 D) the Yukon Group is overlain with angular unconformity by probable mid-Cretaceous rocks, and possibly by Upper Jurassic-Lower Cretaceous rocks (Wheeler, 1961, p. 28). Radiometric ages on metamorphic rocks of this terrane are as old as 202 m.y. and on plutonic rocks, 223 m.y. (Gabrielse, 1967, p. 286).

Related to time is the problem of much younger plutonism in the northern Cordillera. Does the abundance of Cretaceous and Early Tertiary plutons in the northern Cordillera (Gabrielse, 1967, p. 286) imply that (1) metamorphism continued at depth in this region until the Tertiary (2) there was a second, younger metamorphic episode accompanied by plutonism or (3) there was a later plutonic episode totally unrelated to metamorphism?

(b) Omineca Mountains

As noted above, metamorphism in Omineca Mountains was considered by Roots (1954) to be of pre-Mississippian age and that Wheeler (pers. comm.) queried this, suggesting that it could be Mesozoic. Several age dates on gneissic rocks of the same metamorphic complex from Pine Pass area (93 O) gave early Tertiary ages (Muller, pers. comm.). This may suggest that the metamorphic rocks either did not cool in this area until a very late date, or were reheated at a late date.

(c) Southeastern British Columbia

Southeastern British Columbia contains the extensive Shuswap metamorphic complex. This term has no stratigraphic connotations but refers to an assemblage of high-grade metamorphic rocks whose boundaries generally coincide with the sillimanite isograd (Reesor, 1970, p. 73).

The northern end of the Shuswap Terrane is in the Cariboo Mountains (parts of map-areas 83 D, M; 93 A, G,H) where the high-grade rocks, mainly metamorphosed Proterozoic sedimentary rocks, plunge northwards under a structurally and metamorphically concordant cover of largely Paleozoic rocks and are flanked on the west by Upper Triassic and Lower Jurassic rocks (R.B. Campbell, pers. comm.). On the west side of the complex there is a zonal gradation over a distance of 10 miles, from little metamorphosed Upper Triassic-Lower Jurassic rocks (unit 2), through Upper Traissic (?) rocks of greenschist grade to Upper Triassic (?) rocks of amphibolite grade. The amphibolite grade rocks pass into higher grade and older rocks comprising typical Shuswap terrane (Campbell and Campbell, 1970). Thus the maximum age of Shuswap metamorphism is post-Upper Triassic, probably post-Lower Jurassic. The minimum age is given by Eocene rocks exposed to south and west of Shuswap Terrane in Bonaparte Lake map-area (92 P) that contain clasts derived from the metamorphic terrane (Campbell and Tipper, 1969; R.B. Campbell, pers. comm.) and Tertiary rocks (Oligocene or Miocene) that overlie the Shuswap Terrane in Vernon map-area (82 L) (Jones, 1959). A radiometric age date as old as 143 m.y., obtained from a small pluton that discordantly intrudes greenschist-grade rocks near the northern margin of the Shuswap Terrane, indicates that there metamorphism had stopped by Late Jurassic time.

Metamorphism in the southern part of the Shuswap Terrane is post-late Paleozoic and may be of comparable age to that in the north. Reesor (1970, pp. 85, 86) concluded that metamorphism post-dated Mississippian and possibly Triassic time and pre-dated the Tertiary. The maximum age is based on the compositional similarity of known Mississippian rocks outside the Shuswap Terrane to some of the metamorphic rocks within. The minimum age based on stratigraphy is given by the great unconformity between the metamorphic terrane and overlying Tertiary rocks. Cross-cutting plutons in the Shuswap Terrane near Revelstoke and farther south near Monashee Pass give ages of 110 and 95 m.y. respectively (Wheeler, in Wanless et al., 1965, pp. 16, 17; Baadsgaard et al., in Gabrielse and Reesor, 1964, p. 137) and imply at least a pre-middle Cretaceous age for the metamorphism. At the southern end of the Shuswap Terrane, low-grade metamorphic rocks derived in part from Lower Jurassic strata apparently grade zonally into high-grade Shuswap rocks (Hyndman, 1968, pp. 33, 39). These are cut by post-metamorphic plutons that have radiometric ages of 69 and 74 m.y. and other less definitely post-metamorphic plutons with ages of 107 and 123 m.y. (Hyndman, 1968, p. 68). The time of cooling of these plutons was Cretaceous although the older rocks might have been emplaced in the Jurassic. Thus if the age of the low-grade metamorphism in this area is the same as that of the peak of the high-grade Shuswap metamorphism, then the latter is of possible Middle or Late Jurassic age.

(d) Cascade Mountains

According to Misch (1966, p. 113), the major episode of regional metamorphism in the Cascade Mountains is probably of early Mesozoic or possibly late Paleozoic age but other workers consider that it is younger, the evidence is reviewed by McTaggart (1970, p. 143). North of the International Boundary the axial gneisses of the Cascade Mountains appear to be metamorphosed upper Paleozoic rocks (McTaggart and Thompson, 1967, p. 1208). South of the International Boundary, Misch (1966, p. 113) suggested, on the basis of some lithological similarities, that the gneisses were possibly derived in part from Pennsylvanian and Permian strata. A minimum age is given by sedimentary rock of Hauterivian age (Lower Cretaceous) that outcrops on the east side of the Cascades. This rock contains metamorphic clasts derived from the axial part of the Cascade Mountains, indicating uplift and exposure of the metamorphic complex at that time (Coates, 1970, p. 151). On the west side of the Cascades granitic clasts are known from sedimentary rocks as old as Late Jurassic (Misch, 1966, p. 118) and locally detrital micas become abundant in Upper Jurassic or Lower Cretaceous sedimentary rocks north of the International Boundary, indicating exposure and erosion of a high-grade metamorphic or granitic terrane in the region (Monger, 1966, p. 95). An unequivocal minimum age is given by Eocene clastic rocks that unconformably overlie gneissic rocks in the core of the Cascades north of the International Boundary. This stratigraphic evidence for pre-Cretaceous, possibly pre-Upper Jurassic metamorphism is supported on structural grounds by the major mid-Cretaceous faults, which cut and mylonitize the axial gneisses, implying that the gneisses were cooled by this time. However evidence indicates that possibly some metamorphism may be later. McTaggart (1970, p. 20) suggested that metamorphism was closely related to mid-Cretaceous deformation, the main basis for this being the 76 m.y. potassium-argon age date of an apparently anatectic granite associated with the gneissic rock (McTaggart and Thompson, 1967, p. 1211). This late date of metamorphism is suggested by recent uranium-lead geochronological work which suggests that some gneiss just south of the International Boundary in the core of the Cascade Mountains was formed in Late Cretaceous and earliest Tertiary time (Mattinson, 1970). Possibly in the Cascades the main episode of metamorphism had ceased before the Cretaceous, but locally metamorphism continued well into the Cretaceous.

(e) Coast Mountains

The Coast Mountains extend for about 1,100 miles from Vancouver to the Alaska-Yukon border. Within this belt the age of metamorphism appears to be bracketed between early Jurassic and late Cretaceous time, but locally there is evidence of an earlier metamorphic event.

Evidence of an early Mesozoic metamorphic event is found in the Stikine area of northwestern British Columbia. Souther and Armstrong (1966, p. 173) report that Middle Triassic and older strata were metamorphosed in pre-Late Triassic time. Evidence for this is best seen in the Tulsequah map-area (104 K) where Middle Triassic and older strata are of greenschist grade (unit 4) whereas younger strata are scarcely metamorphosed (unit 2). Metamorphism similarly inferred to be of possible Triassic age has been reported from the Bella Coola map-area (93 D) by Baer (1968).

A maximum age for mid-Mesozoic metamorphism is based on scarce evidence. In the Mount Waddington area (92 N), (Tipper, 1969) Prince Rupert area (103 I, J), and parts of southeastern Alaska (Buddington and Chapin, 1929) strata probably as young as late Upper Triassic and possibly Lower Jurassic have been metamorphosed up to lower amphibolite grade.

A minimum age based on stratigraphy can be set at only a few other places. In the Mount Waddington area (Tipper, 1969) metamorphosed strata are overlain by Hauterivian (Lower Cretaceous) sedimentary rocks. Farther north in Nass River area (103 P) Upper Jurassic sedimentary rocks on the eastern margin of the Coast Plutonic Complex are largely unmetamorphosed, although they locally contain pelitic stringers bearing andalusite (E. W. Grove, pers. comm.).

Additional information on the minimum age of metamorphism is provided by potassium-argon dates on plutons within or cutting the metamorphic strata. At the northern end of the Coast Mountains, near Juneau, Alaska, Forbes and Engel (1970) report potassium-argon dates on hornblende of 57 to 60 m.y. for rocks within the kyanite isograd. In the Coast Mountains south of Prince Rupert the oldest potassium-argon date within the metamorphic complex is 140 m.y. In this region the age dates fall into three regional belts; a western zone of 84 to 140 m.y., a central zone of 64 to 70 m.y. and an eastern zone of 45 m.y. It has been suggested (Hutchison, 1970) that this distribution may reflect sequential uplift and unroofing of the metamorphic complex from west to east. The scant information available therefore suggests that in the Coast Mountains the main phase of metamorphism (that affecting higher level strata) is of mid-or Late Jurassic age, but that deeper levels of the central zone were maintained at relatively high temperatures until uplifted and unroofed in Cretaceous and possibly locally in early Tertiary time.

(f) Insular belt

High-grade metamorphic rocks (units 5, 4) on the west coasts of Vancouver Island and the Queen Charlotte Islands appear to be related to Middle to Upper Jurassic plutons. On Vancouver Island Muller (1969, pp. 20, 21) reported the gradation of one pluton on the west coast into enveloping gneisses on the one hand, and its sharp, intrusive contact with nonmigmatic rocks on the other. The metamorphic rocks themselves are considered to be derived from upper Paleozoic rocks. Farther east, the plutons form discrete bodies in very low grade rocks (unit 2) and have been dated as Middle to early Late Jurassic with ages ranging from 160 to 166 m.y. In the Queen Charlotte Islands, Sutherland Brown (1968, p. 140) noted the association of amphibolite grade rocks with probable Late Jurassic plutons and suggested that the plutonic rocks were derived by melting and mobilization of Upper Triassic basaltic rocks.

CONCLUSIONS

Although this map can only be regarded as an interim presentation of data it is possible to arrive at some conclusions which may remain little changed in the future.

(1) The pattern of metamorphism seen today was largely formed in the Mesozoic, although the record of metamorphic events may extend as far back as 2,000 m. y. As far as is known the contribution of early metamorphic episodes to this pattern was relatively minor.

(2) Mesozoic metamorphism resulted in two main belts containing granite and metamorphic rock of greenschist and amphibolite facies separated and flanked on east and west by sub-greenschist facies rocks and unmetamorphosed rocks. These two belts merge in the north in the Yukon and possibly in the south near the International Boundary. They are the sites of the most intense deformation and greatest uplift.

(3) The two high-grade belts differ in the relative amounts of granitic rock and metamorphic rock they contain. The eastern, Cassiar-Omineca-Columbia belt consists largely of metamorphic rock except for its dominantly granitic southern end, whereas in the western Coast Mountains belt, granitic rock predominates.

(4) In both high-grade belts the metamorphism is dominantly of the classical Barrovian type. Exceptions occur in the southern Shuswap Terrane and the Coast Mountains, in which there is very local development of later cordierite-andalusite assemblages or high-temperature Buchan-Abukuma type metamorphism.

(5) There is a close relationship between depth of burial and grade of metamorphism. In the sub-greenschist facies rocks of the Intermontane belt and east and west of the high-grade belts the isograds in general closely follow stratigraphic boundaries. In the high-grade belts this is true in part, although here isograds commonly transgress stratigraphic boundaries.

(6) It is probable that the eastern, Cassiar-Omineca-Columbia belt, which is flanked on the west locally by blueschist-type metamorphism, is one of Miyashiro's paired belts. There is no evidence that this is so for the western Coast Mountains belt.

(7) The low-grade, sub-greenschist facies rocks appear to be systematically altered and changes in them are commonly not just local and due to hydrothermal activity or autometamorphism (although this may be true in some cases). Thus these rocks can be grouped on a pressure-temperature curve just as well as rocks long recognized as metamorphic rocks. It is hoped that this report will stimulate active searching for the critical metamorphic minerals - namely prehnite and pumpellyite - in such rocks.

Finally, the writers wish to stress again that the map is a first approximation. They realize that it probably contains errors resulting from their first-hand knowledge of only limited areas of this vast region, and the consequent probability of misinterpretations of data from parts not personally known to them. To this end, they would welcome any constructive criticism, comments and particularly data. Such correspondence will be kept on file with a view to constructing a more refined version of the map in the future and should be sent to: Head, Cordilleran Section, Geological Survey of Canada, 6th Floor, 100 West Pender Street, Vancouver 3, B.C.

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APPENDICES I to III

APPENDIX I

INVENTORY OF METAMORPHIC MINERALS

Metamorphic map of British Columbia and Yukon

Code for inventory

Cols. 1-4 NTS map number

Cols. 5-7 Compilation number

Cols. 11-13 Number of location (for that NTS area) on inventory map

Col. 15 Report number for a particular location (may have 0-9 reports for one location)

Cols. 16-17 Rock type BA = Basic
PL = Pelitic
OT = Other

Cols. 19-20 Assemblage=AS or occurrence =OC

Cols. 22-23 Map unit #

Cols. 24-25 Facies #

Cols. 27-28, 31-32, 35-36, 39-40, 43-44, 47-48, 51-52, 55-56, 59-60, 63-64
Metamorphic minerals (see code below for names)
- Means may or may not be present
& Means always present

Cols. 66-79 References Cols. 66-75 Author's name Cols. 76-77 date
* After name means et al., pc after date means personal communication

---CODE ---

AB - Albite (An$_0$-15
AC - Actinolite
AM - Amphibolite
AN - Andalusite
AP - Anthophyllite
BI - Biotite
CA - Carbonate
CB - Carbonaceous and/or graphitic
CD - Chloritoid
CL - Chlorite
CM - Clay minerals
CN - Corundum
CO - Cordierite
CP - Calcic plagioclase (An 15-100)
CR - Chondrodite
CU - Cummingtonite
CX - Clinopyroxene
CZ - Clinozoisite
DI - Diopside
DO - Dolomite
DU - Dumortierite
EP - Epidote
FI - Fibrolite
FO - Forsterite
FS - Feldspar
GA - Garnet
GC - Glaucophane
GE - Gedrite
HE - Hematite
HO - Hornblende
HY - Hypersthene
ID - Idocrase
JP - Jadeitic pyroxene
KF - Potash feldspar
KY - Kyanite
LU - Laumontite
LW - Lawsonite
MI - Mica
MU - Muscovite
OP - Orthopyroxene
PA - Paragonite
PH - Prehnite
PP - Phlogopite
PU - Pumpellyite
PX - Pyroxene
QZ - Quartz
SA - Salite
SC - Scapolite
SH - Sphene
SI - Sillimanite
SL - Spinel
SP - Stilpnomelane
ST - Staurolite
TA - Talc
TR - Tremolite
WM - White mica
WO - Wollastonite
ZE - Zeolite
ZO - Zoisite

APPENDIX 1

METAMORPHIC INVENTORY 12 MARCH 1970

This supplement replaces the original data (pages 34-43) presented in the published version of Paper 70-33

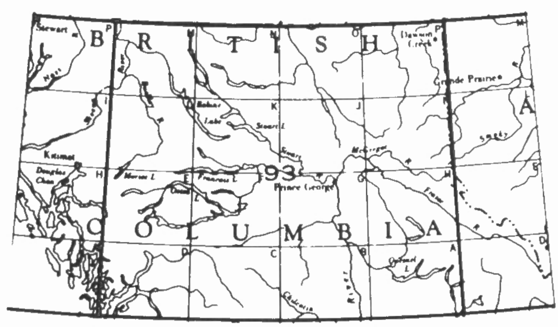
In order of Location # for each NTS (National Topographic System) Number

To find a report in inventory for a location on map

- read NTS # (eg. 92) and location # (.47) in that area. On the inventory below read down the NTS #'s (to 92 in example) and then look for the unique location number (.47).

To find a location on map from inventory

- note NTS # and location #. Look at map for unique NTS # and then the unique location number in the NTS area. To facilitate location, the alphabetic subdivision of each NTS area has been listed on the inventory after the NTS #. Each NTS area is divided into 16 sub-areas of 1° latitude and 2° longitude as follows:



Note: In the following print-out the symbol & is equivalent to the + sign referred to on page 34 of the original text.

NTS #	Loc #		Minerals	Author	Date
82D	1	AS	AC &EP &AB &QZ	PARKER	64 *
82D	1.1	AS	AC &CL &AB &EP &CZ -CA -SH	PARKER	64
82D	1.2	AS	CL &WM &AC &HO &CO &GA	PARKER	64
82D	1.3	AS	HO &CA &QZ	PARKER	64 *
82D	1.4	AS	QZ &KF &CP -BI -MU -SI -CO	PARKER	64
82D	1.5	AS	KF &BI &SI	PARKER	64
82E	2	AS	QZ &WM &BI	OKULITCH	69
82E	2.1	AS	QZ &BI &AB &EP	OKULITCH	69

NTS #	Loc #		Minerals	Author	Date
82E	2.2	AS	QZ &BI &GA &ZO &SH	OKULITCH	69
82E	2.3	AS	BI &CZ &SH &QZ &AB &WM	OKULITCH	69
82E	2.4	AS	CL &AC &CA &QZ &AB &BI	OKULITCH	69
82E	2.5	AS	HO &AC &CL &SH	OKULITCH	69
82E	2.6	AS	CA &QZ &CL	OKULITCH	69
82E	3	OC	QZ BI WM CL	DALY	12
82E	3.1	OC	AC QZ CP EP CA CL	DALY	12
82E	4	OC	CP HO QZ	REINECKE	15
82E	5	OC	CL CA QZ EP	LEROY	12
82E	6	OC	CO	PRETO	67
82E	7	OC	ST	PRETO	67
82E	8	OC	OP	PRETO	67
82E	9	AS	QZ &KF &CP -SI &BI &GA	PRETO	67
82E	9.1	AS	QZ &CP &BI &GA -CO -SI -OP -KF	PRETO	67
82E	9.2	AS	QZ &BI &CP &GA -ST -MU	PRETO	67
82E	9.3	AS	CP &CX &QZ -SC -WO -BI -SH	PRETO	67
82E	9.4	AS	CX &WO &GA &ID	PRETO	67
82E	9.5	AS	CA &CX -CP -SC -CR -PP	PRETO	67
82E	9.6	AS	CA &FO &SC &SL	PRETO	67
82E	9.7	AS	HO &CP -CX -BI -KF -QZ -SH	PRETO	67
82F	10	OC	GA &SI KF	REESOR	65*
82F	11	AS	BI &QZ &CP -GA -KF	REESOR	65*
82F	11.1	AS	BI &CP &QZ -SI -GA -KF	REESOR	65*
82F	11.2	AS	SI &GA &QZ &BI -KF	REESOR	65*
82F	11.3	AS	QZ &CP &BI -GA -SI -KF	REESOR	65*
82F	11.4	AS	HO &CP -GA -BI -QZ	REESOR	65*
82F	11.5	AS	CP &HO -QZ -GA -PX	REESOR	65*
82F	12	AS	CP &BI &QZ &KF &HO	REESOR	65*
82F	12.1	AS	CP &BI &QZ &KF	REESOR	65*
82F	13	OC	CL	CROSBY	68

NTS #	Loc #		Minerals	Author	Date
82F	13.1	AS	QZ -MU -AB -KF -CL	CROSBY	68
82F	14	AS	QZ &MU &BI -CL -KF -AB	CROSBY	68
82F	15	AS	QZ &MU &BI &GA -CL -CP	CROSBY	68
82F	15.1	AS	QZ &CA &MU &PP -KF -CP	CROSBY	68
82F	16	AS	QZ &CP &MU &BI1&CP1&SI &AB2&BI2&CL2	CROSBY	68
82F	16.1	AS	QZ &MU -CP -BI &KY1-SI -CL2	CROSBY	68
82F	16.2	AS	QZ &CP &MU &BI &CL -GA -KY -SI -CO	CROSBY	68
82F	17	AS	QZ &AB &MU &BI &GA &KY	CROSBY	68*
82F	18	AS	QZ &CP &MU &BI &CL &GA &ST	CROSBY	68
82F	18.1	AS	QZ &CP &HO -BI -CA	CROSBY	68
82F	18.2	AS	QZ &MU &CD &GA -CP -BI	CROSBY	68
82F	19	AS	QZ &MU -CP -BI -CL	CROSBY	68
82F	20	OC	QZ AN GA BI	RICE	56
82F	21	OC	QZ MU BI -GA -KY -SI	FYLES	67
82F	22	OC	QZ MU BI CP -GA -ST	FYLES	67
82F	23	OC	CP HO -BI -CL -CA -EP -SH	FYLES	67
82F	24	OC	QZ MU CL -CP -GA1-ST1-WM2-CL2	FYLES	67
82K	25	AS	QZ &MU &AB &CA -CL -CD	HYNDMAN	68
82K	25.1	AS	QZ &MU &AB &BI -CL -AC -EP -CD	HYNDMAN	68
82K	25.2	AS	QZ &MU &AB -CL1-GA1-CL2	HYNDMAN	68
82K	25.3	AS	QZ &AB &CA &MU -CL	HYNDMAN	68
82K	25.4	AS	QZ &AB &BI &CL -MU	HYNDMAN	68
82K	25.5	AS	AN2&QZ &CP &WM &AC &CA &EP	HYNDMAN	68
82K	26	AS	AB &BI &AC &EP &QZ -MU -CA -KF -CL	HYNDMAN	68
82K	26.1	AS	AB &AC &BI &QZ -CL -CA	HYNDMAN	68
82K	26.2	AS	AB &QZ &BI -MU -CA -CL -EP	HYNDMAN	68
82K	26.3	AS	AB &QZ &WM &CA -EP -CL	HYNDMAN	68
82K	26.4	AS	AB &QZ &DO &MU -AC -CA	HYNDMAN	68
82K	27	AS	AB &EP &CL &CA	*HYNDMAN	68
82K	27.1	AS	AB &QZ &CA &CL -WM -EP -TA	*HYNDMAN	68

NTS #	Loc #		Minerals	Author	Date
82K	27.2	AS	AB &EP &QZ &WM &CA &BI -CL	*HYNDMAN	68
82K	27.3	AS	AB &AC -CL	*HYNDMAN	68
82K	28	AS	QZ &CP &BI &MU &SI	HYNDMAN	68
82K	28.1	AS	QZ &CP &BI &SI &GA -MU -ST1	HYNDMAN	68
82K	28.3	AS	QZ &CP &BI	HYNDMAN	68
82K	28.4	AS	QZ &CP &KF &BI &MU	HYNDMAN	68
82K	28.5	AS	QZ &CP &KF &BI	HYNDMAN	68
82K	28.6	AS	QZ &KF &CP &BI &MU &HO &AN &KY &ST &CD	HYNDMAN	68
82K	29	AS	CP &QZ &BI &KF &AM -SH -EP	HYNDMAN	68
82K	29.1	AS	QZ &KF &BI -CP -SH	HYNDMAN	68
82K	29.2	AS	QZ &CP &BI &GA	HYNDMAN	68
82K	29.3	AS	QZ &BI -MU -CP	HYNDMAN	68
82K	29.4	AS	QZ &MU &BI &ST -CP -GA -CD	HYNDMAN	68
82K	30	AS	QZ &CP &BI &KF &GA &SI -SH	HYNDMAN	68
82K	30.1	AS	QZ &BI &KF &CP &MU &SI	HYNDMAN	68
82K	31	OC	WM	REESOR	57
82K	32	AS	BI &MU &AB &QZ	REESOR	70
82K	33	AS	CL &MU &AB &QZ	REESOR	70
82K	34	AS	QZ &MU &CA1&CL &CA2-AB2	READ	*66
82K	34	AS	QZ &AB &MU &CA -CA	READ	66
82K	35	AS	QZ &KF &BI &MU &CZ	READ	66
82K	35.1	AS	QZ &AB &BI &MU -CL	READ	66
82K	35.2	AS	AB &QZ &BI &CA	READ	66
82K	35.3	AS	AB &QZ &BI &CL &CA	READ	66
82K	35.4	AS	CL &BI &CA -EP -AC	*READ	66
82K	35.5	AS	CL &BI &MU &AB -SP	READ	66
82K	35.6	AS	BI &MU &AB &EP	READ	66
82K	35.7	AS	SP &CL &CA &AB	READ	66
82K	35.8	AS	TR &CL &MU &CA &AB	READ	66
82K	36	OC	GA CP BI MU EP CZ -CD	READ	66

NTS #	Loc #		Minerals	Author	Date
82K	36.1	OC	GA CP BI MU EP CZ -CD -ST -AN	READ	66
82K	36.2	AS	CX &TR &KF &CA &CP -MU	READ	66
82K	36.3	AS	BI &MU &CL &QZ &CP -EP -AC	READ	66
82K	37	OC	CL MU	FYLES	62
82K	38	OC	CL MU CD BI AM	FYLES	64
82K	39	OC	GA ST BI	FYLES	64
82K	40	OC	CD	FYLES	64
82K	41	OC	QZ MU	FYLES	64
82L	42	OC	CL	FYSON	70
82L	43	OC	GA	FYSON	70
82L	44	OC	SI	FYSON	70
82L	45	OC	GA ST	FYSON	70
82L	46	OC	GA &SI &KF	REESOR	70*
82L	47	OC	WM CA ZO FP CL AB QZ	JONES	59
82L	48	OC	QZ WM CL CA ZO AB EP -BI	JONES	59
82L	49	OC	SI GA BI	JONES	59
82L	50	OC	KY	JONES	59
82L	51	OC	KY	JONES	59
82L	52	OC	KY	JONES	59
82L	53	OC	KY ST	JONES	59
82L	69	AS	QZ &CP &KF &GA &SI	FROESE	70
82M	54	OC	QZ CP KF BI SI KY	WHEELER	64
82M	55	OC	QZ WM	WHEELER	64
82M	56	AS	SI KF CP QZ	MCMILLAN	70
82M	57	AS	SI KF MU KY	MCMILLAN	70
82M	58	AS	SI KF MU	MCMILLAN	70
82M	59	OC	QZ BI MU GA	CAMPBELL	63
82M	59.1	OC	QZ KF CP BI	CAMPBELL	63
82M	59.2	OC	CP HO QZ	CAMPBELL	63
82M	60	OC	QZ CP KF BI KY GA	WHEELER	64

NTS #	Loc #		Minerals	Author	Date
82M	61	OC	QZ CP KF BI SI GA	WHEELER	64
82M	62	OC	QZ CP KF BI GA	WHEELER	64
82M	63	OC	QZ CP KF BI GA SI	WHEELER	64
82N	64	OC	QZ BI MU GA KY	WHEELER	62
82N	65	OC	QZ BI MU GA ST AN KY	WHEELER	62
82N	66	OC	WM	WHEELER	62
82N	67	OC	BI CL -CD -PA	JONES	70
82N	68	AS	QZ &MU &CL	SIMONY&	70
82N	68.1	AS	QZ &CA &DO	SIMONY&	70
83D	1	OC	GA	CAMPBELL	67A
83D	2	OC	KY ST	CAMPBELL	67A
83D	3	OC	KY ST	CAMPBELL	67A
83D	4	OC	SI	CAMPBELL	67A
83D	5	OC	SI	CAMPBELL	67A
83D	6	OC	GA	CAMPBELL	67A
92A	1	AS	HO &BI &CP &QZ &SH	HAWKINS	68 *
92A	1.1	AS	HO &CP &CX &SH -QZ -BI -KF	HAWKINS	68
92A	1.2	AS	BI &KF &CP &QZ &FI	HAWKINS	68
92A	1.3	AS	SA &HO &CP &GA -BI -CA -SH -QZ	HAWKINS	68
92A	2	OC	CX CP QZ	MISCH	66
92A	2.1	OC	AC EP	MISCH	66
92A	2.2	OC	CR	MISCH	66
92A	2.3	OC	GA ST BI CP -KY	MISCH	66
92A	2.4	O	BI HO CU GA CP QZ -MU -AC -ST -KY	MISCH	66
92G	3	OC	CP HO BI	RODDICK	65
92G	3.1	AS	CP &QZ &KF &BI	RODDICK	65
92G	4	AS	CP &HO -QZ -KF	RODDICK	65
92G	4.1	AS	CP &QZ &CX	RODDICK	65
92G	5	AS	CP &HO	RODDICK	65
92G	5.1	AS	QZ &CX &EP -ZO	RODDICK	65

NTS #	Loc #		Minerals	Author	Date
92G	6	AS	QZ &CP &BI &OP	RODDICK	65
92G	6.1	AS	QZ &HO &BI &QZ	RODDICK	65
92G	7	OC	CP BI	RODDICK	65
92G	8	AS	CP &BI &QZ &GA -CZ	RODDICK	65
92G	9	AS	CP &HO	PHEMISTER	45
92G	9.1	OC	AB FP AM	*PHEMISTER	45
92G	10	AS	CP &HO &QZ -KF	PHEMISTER	45
92G	11	OC	BI	BOSTOCK	63
92G	12	OC	AM CA QZ WM FP CL	BACON	57
92G	12.1	OC	AM AB BI FP CL	*BACON	57
92H	13	AS	QZ &CP &CL &BI &GA &SI -KY &WM -ST	REAMSBOTT.	69PC
92H	13.1	AS	QZ &CP &CL &BI -GA -EP -HO -WM	REAMSBOTT.	69PC
92H	13.2	AS	QZ &CP &BI &GA -HO -WM -EP	REAMSBOTT.	69PC
92H	13.3	AS	QZ &CP &BI &HO &FP	REAMSBOTT.	69PC
92H	13.4	AS	QZ &CP &CL &BI &GA &GE -KF	REAMSBOTT.	69PC
92H	13.5	AS	QZ &CP &KF &BI &WM	REAMSBOTT.	69PC
92H	13.6	AS	QZ &AB &CL &BI &GA -EP &WM	REAMSBOTT.	69PC
92H	13.7	AS	QZ &CP &BI &GA &WM &SI -CL	REAMSBOTT.	69PC
92H	13.8	AS	QZ &CP &ZO &HO &CX &CA &WM	REAMSBOTT.	69PC
92H	13.9	AS	QZ &CP &BI &GA &ST -WM -CL	REAMSBOTT.	69PC
92H	14	AS	QZ &AB &EP &CL &WM	REAMSBOTT.	69PC
92H	15	OC	AB AM	LOWES	69PC
92H	16	OC	AB HO	LOWES	69PC
92H	17	OC	CP HO	LOWES	69PC
92H	18	OC	ST KY SI	LOWES	69PC
92H	19	OC	SI	LOWES	69PC
92H	20	OC	AN1 ST2 GA2 MU2 KY2	READ	60
92H	21	OC	GA BI SI	MCTAGGART	67
92H	22	OC	BI GA SI -MU	RODDICK	69
92H	22.1	OC	BI ST	RODDICK	69

NTS #	Loc #		Minerals	Author	Date
92H	23	OC	BI GA ST KY	RODDICK	69
92H	24	AS	CP &QZ &GA &BI -SI -CL	HUTCHISON	69PC
92H	25	AS	CP &QZ &GA &ST &KY &BI -CL -SH	HUTCHISON	69PC
92H	26	AS	BI &GA &ST &QZ &CP -KY -MU	SANTER	69 *
92H	27	OC	HO CP	MCMILLAN	66 *
92H	27.1	OC	HO CZ CP QZ SH	MCMILLAN	66 *
92H	27.2	OC	HO GA WM QZ AB	MCMILLAN	66 *
92H	27.3	OC	GA SH AB WM QZ CL EP	MCMILLAN	66 *
92H	27.4	OC	HO AB WM ZO -QZ -AB -PH	MCMILLAN	66 *
92H	28	OC	AB EP CL -PU -LW -CA	MONGER	66
92H	29	AS	AB HO EP QZ CL	MONGER	66
92H	30	AS	HO CP SH	MONGER	66
92H	31	AS	CX &CP	MCTAGGART	67
92H	31.1	AS	CX &HO &CP	MCTAGGART	67
92H	31.2	AS	HO &GA &BI &CP	MCTAGGART	67
92H	31.3	AS	CP &QZ &BI &GA &ST &KY	MCTAGGART	67
92H	32	OC	AB AC ZO CL CA -PH -PU -SP	MCTAGGART	67
92H	32.1	OC	CP1 AM1 GA1 BI2 CL2 WM2 AC2	MCTAGGART	67 *
92I	33	OC	MU CL BI EP AC	HOLLISTER	66
92I	34	OC	AN KY ST GA CP QZ	HOLLISTER	66
92I	34.1	OC	AN1 KY2 SI3	HOLLISTER	69 *
92I	35	OC	AB QZ ZO WM CL PH PU EP	SCHAU	68
92I	35.1	OC	AB QZ ZO EP WM CL AC CA -PU	SCHAU	68 *
92I	35.2	OC	QZ WM LU	SCHAU	68
92I	36	OC	BI EP QZ AB CL -CA -WM	SCHAU	68
92I	36.1	OC	HO AC1 QZ1 AB1-EP1-BI1 CL2	SCHAU	68
92I	37	OC	QZ BI HO	DUFFELL	52
92I	38	OC	QZ WM BI -EP -CL -WM -GA	DUFFELL	52
92G	39	OC	CL	MATHEWS	58
92L	40	OC	AN	BANCROFT	13

NTS #	Loc #		Minerals	Author	Date
92L	41	OC	CL BI -HO -CP	HUTCHISON	69PC
92L	42	OC	CL BI	HUTCHISON	69PC
92M	43	OC	BI CL EP	HUTCHISON	69PC
92M	43.1	OC	HO CP	HUTCHISON	69PC
92M	44	OC	CP HO BI	RODDICK	68
92M	45	OC	SI BI GA	RODDICK	68
92M	46	OC	CL &EP	HUTCHISON	69PC
92N	47	OC	KY	MATHEWS	57
92N	48	OC	GA BI SI	RODDICK	68
92N	49	OC	GA BI	RODDICK	68
92N	50	OC	GA BI MU -CL	&RODDICK	68
92N	51	OC	AB CL EP	RODDICK	68
92O	52	OC	AB EP WM -PH	TRETTIN	61
92P	53	OC	BI CP GA SI	CAMPBELL	69
92P	54	OC	QZ MU BI CL CP -KF -EP -GA	CAMPBELL	69
92P	55	OC	HO EP ZO CP -CA	CAMPBELL	69
92P	55.1	OC	QZ WM CB -CA	CAMPBELL	69
92P	56	OC	CP CL EP QZ -CA -AM -WM -BI	CAMPBELL	69
92P	56.1	OC	CP AM EP CL	CAMPBELL	69
92P	57	OC	QZ MU BI -GA	CAMPBELL	69
92P	58	OC	AM CL EP CA AB WM -QZ -PH	CAMPBELL	69
92P	59	OC	CL -CA -PH -QZ -ZE	CAMPBELL	69
92P	60	OC	CL -CA -ZE	CAMPBELL	69 *
92F	61		PU PH -LU	SURDAM	66
92B	62	OC	QZ AB AM ZO	CLAPP	17
92B	62.1	OC	QZ AB AM CL EP ZO BI CA	CLAPP	17
92B	62.2	OC	QZ BI GA ST SI AN	CLAPP	17
92B	63	OC	QZ AB EP QZ CA	CLAPP	17
92B	64	OC	KY	CLAPP	14
92B	65		HO CP	LIBBY	68

NTS #	Loc #		Minerals	Author	Date
93A	1	OC	GA	CAMPBELL	70
93A	2	OC	KY ST GA	CAMPBELL	70
93A	3	OC	SI	CAMPBELL	70
93A	4	OC	BI	CAMPBELL	70
93A	5	OC	GA BI	CAMPBELL	70
93A	6	OC	SI	CAMPBELL	70
93A	7	OC	KY ST	CAMPBELL	70
93A	8	OC	KY ST	CAMPBELL	70
93A	9	OC	GA	CAMPBELL	70
93A	10	AS	QZ &KY &MU -BI	CAMPBELL	69
93A	11	AS	QZ &ST &MU &CP -BI -KY	CAMPBELL	69
93A	12	AS	QZ &GA -BI -MU -CP -CL	CAMPBELL	69
93A	12.1	AS	QZ &HO -GA -BI -CP -CA	CAMPBELL	69
93A	13	AS	QZ &CD &MU &AB GA	CAMPBELL	69
93A	14	AS	QZ &BI -MU -AB CA	CAMPBELL	69
93A	14.1	AS	QZ &MU -MI &CA	CAMPBELL	69
93A	14.2	AS	QZ &WM -AB -CA -CL	CAMPBELL	69
93D	15	OC	SI GA BI	BAER	68
93D	16	OC	CL -EP	BAER	67
93E	17	OC	CL EP AC	READ	63
93E	18	OC	BI GA HO	READ	63
93E	19	AS	AB &CL &EP &BI &QZ	STUART	60
93E	19.1	AS	AB &CL &EP &QZ &AM	STUART	60
93E	19.2	AS	AB &CL &EP	STUART	60
93E	20	AS	CP &QZ &KF &MU &BI &EP &HO -GA	STUART	60
93E	20.1	AS	HO &BI &EP &CP &QZ	STUART	60
93H	21	AS	QZ &MU &CL -CD	SUTHERLAND	57
93H	21.1	AS	QZ &MU &BI -AB	SUTHERLAND	57
93H	22	OC	CP CL CA EP	SUTHERLAND	63
93H	23	OC	QZ AB KF MU BI CL -GA	SUTHERLAND	63

NTS #	Loc #		Minerals	Author	Date
93J	24	OC	GA	MULLER	69
93J	25	OC	MI GA CL	MULLER&	69
93J	26	OC	CL WM	MULLER&	69
93K	27	AS	GC &LW &QZ -CL -WM -CA	PATERSON	69PC
93K	27.1	AS	JP &LW &QZ &CL -GC	PATERSON	69PC
93K	27.2	AS	GC &LW &PX &SH -CL -CA -PU -SP	PATERSON	69PC
93K	27.3	AS	GC &LW &CZ &CA	PATERSON	69PC
93K	28	AS	CL EP QZ CA	PATERSON	69PC
93K	28.1	AS	CL AB EP SH CA PH	PATERSON	69PC
93K	29	AS	AC &CZ &CL &AB &SH	PATERSON	69PC
93K	30	AS	CL &AB &CA &SP &SH	PATERSON	69PC
93N	31	OC	HO AB EP QZ CA CL	ARMSTRONG	49
93N	32	OC	AM CL FS	ARMSTRONG	49
93N	33	OC	EP ZO CA HO CL	ARMSTRONG	49
93N	34	OC	CL EP QZ	ARMSTRONG	49
93N	35	OC	QZ CP MU BI GA KF	ARMSTRONG	49
93N	36	OC	QZ CP KF BI MU GA	ARMSTRONG	49
93O	37	OC	CL WM -BI	MULLER	61PC
93O	38	OC	QZ BI MU FS -GA	MULLER	61PC
93O	39	OC	GA	MULLER	69PC
93A	40	AS	QZ &HO &CL -BI &CA -EP	FLETCHER	69PC
93A	41	AS	QZ &AB &CL &WM -BI	FLETCHER	69PC
93A	42	AS	QZ &CP &CL &BI &GA -CA -KF &WM	FLETCHER	69PC
93A	43	AS	QZ &CP &BI &WM &GA &KY -ST	FLETCHER	69PC
93A	44	AS	QZ &CP &BI &WM &CL &GA	FLETCHER	69PC
93A	45	AS	QZ &CP &BI &WM &GA -CL -ST	FLETCHER	69PC
93A	46	AS	QZ &CP &CX &CA &EP &KF	FLETCHER	69PC
93A	47	AS	QZ &CP &BI &WM &GA &KY -SI -ST -CL	FLETCHER	69PC
93A	48	AS	QZ &CP &BI &WM &GA &ST &SI -CL	FLETCHER	69PC
93A	49	AS	QZ &AB &MU &CL	FLETCHER	69PC

NTS #	Loc #		Minerals	Author	Date
94C	1	AS	QZ &BI &MU &CP -GA -KY -ST -SI	ROOTS	54
94C	2	AS	QZ &BI &MU &FS -EP -CL	ROOTS	54
94C	3	AS	QZ &BI &MU &GA -KY -SI	ROOTS	54
94C	4	AS	QZ &BI &MU &GA -KY -SI	ROOTS	54
94C	5	AS	QZ &BI MU -GA -FS	ROOTS	54
94C	6	AS	QZ &WM &CL -BI	ROOTS	54
94C	7	AS	QZ &WM &CL -BI -GA	ROOTS	54
94C	8	OC	WM CL	ROOTS	54
94C	9	AS	QZ AB KF BI MU -SI	ROOTS	54
94C	9.1	AS	HO CP BI	ROOTS	54
94C	10	OC	QZ BI MU CP GA -CA	DOLMAGE&	28
94C	11	OC	QZ CP BI GA KF	DOLMAGE&	28
94D	12	AS	AM CP	LORD	48
94D	13	AS	CA CL ZO	LORD	48
94D	14	AS	FS CL EP	LORD	48
94D	15	AS	EP ZO CA WM	LORD	48
94L	16	OC	WM CL	GABRIELSE	62PC
94L	17	OC	QZ MI GA	GABRIELSE	62PC
103A	1	OC	SI GA BI	BAER	68
103A	2	OC	GA BI	BAER	68
103C	3	AS	HO &PC &QZ -CL -BI -CZ	*SUTHERLAND	68
103C	3.1	OC	HO PC	SUTHERLAND	68
103F	4	OC	HO PC	SUTHERLAND	68
103H	5	AS	AB &QZ &WM &CL &EP &BI	RODDICK	IP
103H	5.1	OC	AC CL EP	RODDICK	IP
103H	6	OC	SI ST GA AN	RODDICK	IP
103H	7	OC	KY	RODDICK	IP
103H	8	AS	KY &ST &CP &GA &BI	HUTCHISON	69PC
103H	9	OC	SI	RODDICK	IP
103H	10	OC	GA BI	RODDICK	IP

NTS #	Loc #		Minerals	Author	Date
103H	11	OC	BI CL	RODDICK	IP
103H	12	OC	CL EP AM	RODDICK	IP
103I	13	AS	CP &QZ &SI &KF -GA -MU	HUTCHISON	IP
103I	13.1	AS	AN &HO -BI -QZ	HUTCHISON	IP
103I	14	AS	CP &QZ &MU &SI -KF -GA	HUTCHISON	IP
103I	15	AS	CP &QZ &KF &KY &GA -CL	HUTCHISON	IP
103I	16	AS	QZ &CP &KF &BI -MU	HUTCHISON	PC
103I	16.1	AS	QZ &CP &BI &GA -SI -MU -KF	HUTCHISON	PC
103I	17	AS	QZ &CP &KF &BI -MU	HUTCHISON	IP
103I	17.1	AS	QZ &CP &SI &BI -GA -MU -KF	HUTCHISON	IP
103I	17.2	AS	QZ &CP &SI &BI &MU -GA &CO	HUTCHISON	IP
103I	17.3	AS	QZ &CP &CU &CO &GA &BI	HUTCHISON	IP
103I	18	OC	EP CL BI AM	&DUFFELL	64
103J	19	AS	QZ &AM &AB -EP -CZ -BI -CL	*HUTCHISON	67
103J	20	AS	QZ &CL &BI &WM -CA	HUTCHISON	IP
103J	20.1	AS	QZ &AB &CL &WM	HUTCHISON	IP
103J	21	AS	QZ &CP &MU &BI &GA -CL -ST -CD	HUTCHISON	IP
103J	21.1	AS	QZ &CP &BI &HO &GA	HUTCHISON	IP
103J	22	AS	QZ &CP &BI &MU -GA -KY -KF	HUTCHISON	IP
103J	22.1	AS	CP &HO -BI -QZ	HUTCHISON	IP
103I	23	AS	CP &QZ &BI -GA -MU -KF	HUTCHISON	IP
103J	24	AS	CP &QZ &BI &GA -KF -SI	HUTCHISON	PC
103J	24.1	AS	CP &CX -CA -QZ -HO -KF -BI	HUTCHISON	IP
103J	24.2	OC	SI BI MU ST CO	HUTCHISON	PC
103J	25	OC	QZ SI MU CO KF	HUTCHISON	PC
103J	26	OC	SI MU KF	HUTCHISON	PC
103J	27	OC	SI KF	HUTCHISON	PC
103K	28	OC	EP CL	BUDDINGTON	29
103K	29	OC	SI QZ	BUDDINGTON	29
103K	29.1	OC	CP &MU &EP -HO	&BUDDINGTON	29

NTS #	Loc #		Minerals	Author	Date
103K	30	OC	SI GA	BUDDINGTON	29
1030	31	AS	KY GA BI CP QZ	SMITH	70PC
1030	31.1	AS	HO BI CP -QZ -GA	SMITH	70PC
1030	32	AS	SI BI CP QZ GA	SMITH	70PC
1030	33	OC	KY	BUDDINGTON	29
1030	34	OC	ST	BUDDINGTON	29
103P	35	OC	AM	HANSON	35
1030	36	AS	EP CL AB -QZ -MU	BERG	69
1030	36.1	AS	EP CL AB QZ MU AC CA HE BI	BERG	69
103N	37	OC	MU BI CL	GREENWOOD	69
103N	38	OC	EP CL CA PH	SAINSBURY	61
103J	39	OC	AB CL CA -BI -EP	MACKEVETT	63
1030	40	OC	GA BI EP QZ CP	WRIGHT	5PC
103J	41	AS	GA BI MU HO	CLARK	70PC
103J	41.1	AS	HO BI GA MU	CLARK	70PC
104C	1	OC	ST	BUDDINGTON	29
104C	2	OC	SI	BUDDINGTON	29
104C	3	OC	ST KY	BUDDINGTON	29
104C	4	OC	ST KY	BUDDINGTON	29
104C	5	OC	SI	BUDDINGTON	29
104C	6	OC	ST KY MU	BUDDINGTON	29
104C	7	OC	QZ BI MU CD	&BUDDINGTON	29
104C	8	AS	CP &GA &BI1&MU1&BI2&KY2&ST2	&BUDDINGTON	29
104E	9	OC	QZ AB EP	LATHRAM	65
104E	9.1	OC	CP HO	LATHRAM	65
104F	10	OC	KY	BUDDINGTON	29
104F	10.1	OC	CP HO	BUDDINGTON	29
104F	11	OC	GA BI MU	BUDDINGTON	29
104F	12	AS	CP &QZ &BI -MU -GA	&BUDDINGTON	29
104F	13	OC	QZ BI MU	BUDDINGTON	29

NTS #	Loc #		Minerals	Author	Date
104F	14	OC	QZ BI CL WM	&BUDDINGTON	29
104F	15	OC	AB AM BI GA MU	&BUDDINGTON	29
104P	16	OC	QZ BI MU GA	GABRIELSE	62PC
104P	17	OC	CL WM	GABRIELSE	62PC
104P	18	AS	QZ &BI &MU -GA	GABRIELSE	63
104P	18.1	AS	QZ CP KF BI MU	GABRIELSE	63
104P	19	OC	CL	GABRIELSE	63
104P	20	OC	AC ZO CZ AB CA CL SH	GABRIELSE	63
104P	20.1	OC	AB CL CZ AC -CA -PH	GABRIELSE	63
104J	21	OC	AB CL AC EP WM -SH -GC -LW -SP -PU	MONGER	69
104J	21.1	AS	QZ GC	MONGER	69
104J	22	AS	CL AB MU	MONGER	69
104J	23	OC	EP HO AC AB CL EP	WATSON	44
104O	24	AS	QZ CL WM	GABRIELSE	69
104O	25	AS	QZ &AB &MU	GABRIELSE	69
104O	25.1	AS	QZ &AB &EP &MI	GABRIELSE	69
104O	25.2	AS	AB &EP &AC &CL &MI	GABRIELSE	69
104O	25.3	AS	QZ &AB &EP &BI	GABRIELSE	69
104O	26	OC	QZ MU BI HO	GABRIELSE	69
104L	27	AS	QZ &CP &BI &GA -HO -KY -ST	&BUDDINGTON	29
104N	28	OC	AB CL EP CZ -AC	AITKEN	59
104N	29	OC	QZ HO CP CL -EP -SP -PH	AITKEN	59
104N	30	OC	HO EP CL BI	AITKEN	59
104N	30.1	AS	CA &MU &CL	AITKEN	59
104N	30.2	AS	QZ &MU &BI	AITKEN	59
104N	30.3	AS	QZ &DU &GA	AITKEN	59
104O	31	AS	QZ &BI &MU -GA -CP -KF	WATSON	44
104O	31.1	AS	QZ BI HO CP	WATSON	44
104O	32	AS	CL AB EP QZ -AC -CA -BI	WATSON	44
104O	33	OC	AB CL	GABRIELSE	69

NTS #	Loc #		Minerals							Author	Date
104B	34	OC	SI	CP	QZ	BI	HO			MACKEVETT	63
104B	34.1	OC	HO	DI	CP					MACKEVETT	63
104C	35	OC	KY	BI	GA	QZ				GAULT	53
104D	36	OC	CL							OVENSHINE	70PC
104C	37	OC	QZ	MI	PC					BUDDINGTON	29
104C	38	OC	CL	MU						BUDDINGTON	29
104C	39	OC	CL	MU	TR	EP	CA	AB	SP	MUFFLER	67
104F	40	OC	KY	GA	BI	PC	QZ	-ST		BREW	70PC
104D	41	AS	EP	MU	CL	AB	QZ	-PH	-SP	BREW	70PC
104D	41.1	AS	EP	MU	CL	AB	QZ	-CA	-SP	BREW	70PC
104D	41.2	AS	MU	EP	CA	PH	CL	AB	QZ	BREW	70PC
104F	42	OC	AC							LATHRAM	65
104F	42.1	AS	CL	EP	AB	-MU				LATHRAM	65
104E	43	OC	CL	QZ	AB					BERG	63
104F	44	AS	DI	PC	HO					MACKEVETT	64
104F	44.1	AS	DI	GA	WO	QZ				MACKEVETT	64
104F	44.2	OC	QZ	PC	HO	BI	-ST	-GA	-MU	MACKEVETT	64
104F	44.3	OC	HO	PC	QZ	BI				MACKEVETT	64
104E	45	AS	QZ	PC	HO	BI				LATHRAM	65
104E	45.1	AS	PC	GA	PX					LATHRAM	65
104E	46	AS	QZ	PC	KF	BI	-HO			LONEY	63B
104E	46.1	AS	PC	HO	BI					LONEY	63B
104E	46.2	AS	CA	DI						LONEY	63B
104E	46.3	AS	CA	TA						LONEY	63B
104E	47	OC	AB	EP	CL	AC	PH	CA	SP	LONEY	63B
104E	47.1	OC	CL	MU	EP	CA	AC	QZ	AB	LONEY	63B
104E	48	OC	CL	CA	AB	QZ				LONEY	63A
104E	48.1	OC	CL	CA	AB	EP	MU			LONEY	63A
104E	48.2	OC	CL	EP	-AC					LONEY	63A
104L	49	OC	EP	QZ	CL	HO				KNOPF	11

NTS #	Loc #		Minerals	Author	Date
104L	49.1	OC	CA EP CL	KNOPF	11
104K	50	OC	EP AC CL CA	FORBES	59
104L	51	AS	DI HO PC	FORBES	59
104L	52	AS	QZ MU BI PC GA CL SP	FORBES	59
104L	52.1	AS	MU QZ BI PC GA ST	FORBES	59
104L	52.2	AS	BI QZ MU PC KY GA ST	FORBES	59
104L	52.3	AS	PC QZ KY BI SI GA	FORBES	59
104L	53	AS	AC AB CL EP QZ SP CA	FORBES	59
104L	54	OC	CA EP AB QZ	BREW-FORD	70PC
104L	55	OC	AC	LATHRAM	65
104L	55.1	AS	CL EP AB -MU	LATHRAM	65
104L	56	OC	CL	LONEY	70PC
104L	57	OC	GA HO PC -QZ	BREW	70PC
104M	61	OC	PX HO BI PC QZ	BREW	70PC
104M	62	OC	MI PC QZ	BARKER	52
104M	63	OC	HO PC QZ	ROBERTSON	55
105B	1	OC	AB CL	POOLE	56
105B	2	OC	AB EP CZ CL WM QZ -BI	POOLE	56
105B	3	AS	AB &EP &AC &BI &CL	POOLE	56
105B	3.1	OC	QZ &AB &EP &MI	POOLE	56
105B	3.2	AS	AB &QZ &EP &CL &BI &SH	POOLE	56
105B	4	OC	WM	POOLE	56
105C	5	OC	HO AC CL AB ZO CZ	MULLIGAN	63
105C	5.1	AS	AB &EP &AM	MULLIGAN	63
105C	5.2	AS	AB &CL &BI &EP -QZ -WM	MULLIGAN	63
105C	5.3	AS	QZ &CP &BI &EP &GA -SH	MULLIGAN	63
105C	6	AS	QZ &HO -AB -KF -BI -CL -EP -CZ -GA	MULLIGAN	63
105D	6	AS	QZ CP KF BI WM -HO -GA -SH	WHEELER	61
105D	6.1	AS	HO EP CP SH	WHEELER	61
105C	7	OC	QZ WM	MULLIGAN	63

NTS #	Loc #		Minerals	Author	Date
105D	7	OC	CL CA AC EP AB WM	WHEELER	61
105D	7.1	OC	CL CA CZ -HO -PH -EP	WHEELER	61
105D	7.2	OC	CZ CA ZO -HO	WHEELER	61
105C	8	OC	CL CA AC PH	MONGER	69
105D	8	OC	AB CL AC EP ZO CZ MU BI QZ	WHEELER	61 *
105E	9	OC	CL EP WM QZ	BOSTOCK	38
105E	9.1	OC	HO CL EP	BOSTOCK	38
105E	10	OC	HO	BOSTOCK	38
105L	11	AS	QZ CP BI KF MU -GA -AN -ST	CAMPBELL	67B
105L	11.1	AS	HO &CP -DI	CAMPBELL	67B
105L	11.2	AS	QZ &CL &WM	CAMPBELL	67B
105L	12	AS	QZ &CL &WM -BI -HO -EP -GA	CAMPBELL	67B
105L	12.1	AS	QZ &AB &HO &BI EP CL WM -CA	CAMPBELL	67B
105L	12.2	AS	AB &EP &CL -QZ -HO -BI	CAMPBELL	67B
105L	13	AS	QZ &CP &WM &CL &BI -GA	CAMPBELL	67B
105L	14	AS	HO &CP &BI &EP &QZ &CL -CA -GA	CAMPBELL	67B
105L	15	AS	QZ &WM &CL	CAMPBELL	67B
105L	15.1	AS	AB &CL &EP -HO -QZ	CAMPBELL	67B
105L	16	AS	AB EP CL -HO -QZ -CA -WM	CAMPBELL	67B*
105L	17	OC	EP CA AC	CAMPBELL	67B
105L	18	OC	AB WM CA CL -BI -AM	CAMPBELL	67B
105L	19	OC	AB CL WM CM	CAMPBELL	67B
105M	20	OC	QZ MI CL	BOSTOCK	47
105M	21	OC	QZ MI CL	BOSTOCK	47
114I	58	OC	ST AN -GA	ROSSMAN	63
114I	58.1	OC	HO PC	ROSSMAN	63
114I	59	OC	ST GA BI PC QZ	BREW	70PC
114I	60	OC	CA CL	MERTIE	31
115A	1	OC	QZ MI -GA	KINDLE	53
115A	1.1	OC	QZ BI -CP	KINDLE	53

NTS #	Loc #		Minerals	Author	Date
115A	1.2	OC	QZ WM AN	KINDLE	53
115B	2	OC	BI GA	SHARP	56
115B	2.1	AS	QZ &CP &BI &HO	&SHARP	56
115B	2.2	AS	QZ &CP &HO &ZO &CX &MU	&SHARP	56
115B	2.3	OC	BI GA AN	SHARP	56
115C	3	OC	HO	PLAFKER	57
115F	4		QZ MU CL	MULLER	67
115F	5	AS	AB QZ CA AC EP ZO	MULLER	67
115F	5.1	OC	QZ AB WM CL CA EP	MULLER	67
115F	6	OC	AB CL EP CA	MULLER	67
115F	6.1	OC	CL EP AB AC CA QZ	MULLER	67
115F	7	OC	AB EP CL WM CA PH	MULLER	67
115F	8	AS	QZ CP BI CL GA	MULLER	67
115F	9	AS	CP QZ BI HO -GA	MULLER	67
115F	10	AS	QZ CP WM BI ST -GA	MULLER	67
115F	11	AS	QZ WM CL	MULLER	67
115F	12	AS	QZ AB MU CL -BI	MULLER	67
115F	12.1	AS	HO CP AB EP -GA	MULLER	67
115I	13	OC	QZ FS HO BI	BOSTOCK	36
115I	13.1	OC	BI QZ FS	BOSTOCK	36
115I	14	OC	WM CL	BOSTOCK	36
115I	15	OC	QZ FS BI HO -KF	BOSTOCK	36
115K	16	AS	QZ &BI &WM &CL CA -GA	COCKFIELD	21
115K	16.1	AS	QZ AB KF WM CL -ZO EP -CA -BI	COCKFIELD	21
115K	17	AS	HO CP PX BI ZO EP SH CA	COCKFIELD	21
115K	18	OC	QZ1 KF1 CP1 BI1 MU1-HO1-EP1 WM2 CL2	COCKFIELD	21
115K	19	OC	QZ BI WM -SI	CAIRNES	15
115P	20	OC	HO MI QZ FS	BOSTOCK	48
115P	21	OC	QZ MI	BOSTOCK	48

APPENDIX II

SELECTED MINERAL OCCURRENCES

SILLIMANITE (SI) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
82D	1.4	AS	QZ +KF +CP -BI -MU -SI -CO	Parker	64
82D	1.5	AS	KF +BI +SI	Parker	64
82E	9	AS	QZ +KF +CP -SI +BI +GA	Preto	67
82E	9.1	AS	QZ +CP +BI +GA -CO -SI -OP -KF	Preto	67
82F	10	OC	GA +SI KF	Reesor	65*
82F	11.1	AS	BI +CP +QZ -SI -GA -KF	Reesor	65*
82F	11.2	AS	SI +GA +QZ +BI -KF	Reesor	65*
82F	11.3	AS	QZ +CP +BI -GA -SI -KF	Reesor	65*
82F	16	AS	QZ +CP +MU +BI1+CP1+SI +AB2+BI2+CL2	Crosby	68
82F	16.1	AS	QZ +MU -CP -BI +KY1-SI -CL2	Crosby	68
82F	16.2	AS	QZ +CP +MU +BI +CL -GA -KY -SI -CO	Crosby	68
82F	21	OC	QZ MU BI -GA -KY -SI	Fyles	67
82K	28	AS	QZ +CP +BI +MU +SI	Hyndman	68
82K	28.1	AS	QZ +CP +BI +SI +GA -MU -ST1	Hyndman	68
82K	30	AS	QZ +CP +BI +KF +GA +SI -SH	Hyndman	68
82K	30.1	AS	QZ +BI +KF +CP +MU +SI	Hyndman	68
82L	44	OC	SI	Fyson	70
82L	46	OC	GA +SI +KF	Reesor	70*
82L	49	OC	SI GA BI	Jones	59
82L	69	AS	QZ +CP +KF +GA +SI	Froese	70
82M	54	OC	QZ CP KF BI SI KY	Wheeler	64
82M	56	AS	SI KF CP QZ	McMillan	70
82M	57	AS	SI KF MU KY	McMillan	70
82M	58	AS	SI KF MU	McMillan	70
82M	61	OC	QZ CP KF BI SI GA	Wheeler	64
82M	63	OC	QZ CP KF BI GA SI	Wheeler	64
83D	4	OC	SI	Campbell	67a
83D	5	OC	SI	Campbell	67a
92H	13	AS	QZ +CP +CL +BI +GA +SI -KY +WM -ST	Reamsbott	69pc
92H	13.7	AS	QZ +CP +BI +GA +WM +SI -CL	Reamsbott	69pc
92H	18	OC	ST KY SI	Lowes	69pc
92H	19	OC	SI	Lowes	69pc
92H	21	OC	GA BI SI	MaTaggart	+67
92H	22	OC	BI GA SI -MU	Roddick	+69
92H	24	AS	CP +QZ +GA +BI -SI -CL	Hutchison	69pc
92I	34.1	OC	AN1 KY2 SI3	Hollister	69*
92M	45	OC	SI BI GA	Roddick	68
92N	48	OC	GA BI SI	Roddick	68
92P	53	OC	BI CP GA SI	Campbell	69
92B	62.2	OC	QZ BI GA ST SI AN	Clapp	17

SILLIMANITE (SI) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
93A	3	OC	SI	Campbell	70
93A	6	OC	SI	Campbell	70
93D	15	OC	SI GA BI	Baer	68
93A	47	AS	QZ +CP +BI +WM +GA +KY -SI -ST -CL	Fletcher	69pc
93A	48	AS	QZ +CP +BI +WM +GA +ST +SI -CL	Fletcher	69pc
94C	1	AS	QZ +BI +MU +CP -GA -KY -ST -SI	Roots	54
94C	3	AS	QZ +BI +MU +GA -KY -SI	Roots	54
94C	4	AS	QZ +BI +MU +GA -KY -SI	Roots	54
94C	9	AS	QZ AB KF BI MU -SI	Roots	54
103A	1	OC	SI GA BI	Baer	68
103H	6	OC	SI ST GA AN	Roddick	ip
103H	9	OC	SI	Roddick	ip
103I	13	AS	CP +QZ +SI +KF -GA -MU	Hutchison	ip
103I	14	AS	CP +QZ +MU +SI -KF -GA	Hutchison	ip
103I	16.1	AS	QZ +CP +BI +GA -SI -MU -KF	Hutchison	pc
103I	17.1	AS	QZ +CP +SI +BI -GA -MU -KF	Hutchison	ip
103I	17.2	AS	QZ +CP +SI +BI +MU -GA +CO	Hutchison	ip
103J	24	AS	CP +QZ +BI +GA -KF -SI	Hutchison	pc
103J	24.2	OC	SI BI MU ST CO	Hutchison	pc
103J	25	OC	QZ SI MU CO KF	Hutchison	pc
103J	26	OC	SI MU KF	Hutchison	pc
103J	27	OC	SI KF	Hutchison	pc
103K	29	OC	SI QZ	Buddington	29
103K	30	OC	SI GA	Buddington	29
103O	32	AS	SI BI CP QZ GA	Smith	70pc
104C	2	OC	SI	Buddington	29
104C	5	OC	SI	Buddington	29
104B	34	OC	SI CP QZ BI HO	MacKevett	
104L	52.3	AS	PC QZ KY BI SI GA	Forbes	59
115K	19	OC	QZ BI WM -SI	Cairnes	15

KYANITE (KY) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
82F	16.1	AS	QZ +MU -CP -BI +KY1-SI -CL2	Crosby	68
82F	16.2	AS	QZ +CP +MU +BI +CL -GA -KY -SI -CO	Crosby	68
82F	17	AS	QZ +AB -MU +BI +GA +KY	Crosby	68*
82F	21	OC	QZ MU BI -GA -KY -SI	Fyles	67
82K	28.6	AS	QZ +KF +CP +BI +MU +HO +AN +KY +ST +CO	Hyndman	68

KYANITE (KY) OCCURRENCES (Con't)

NTS #	Loc #		Minerals	Author	Date
82L	50	OC	KY	Jones	59
82L	51	OC	KY	Jones	59
82L	52	OC	KY	Jones	59
82L	53	OC	KY ST	Jones	59
82M	54	OC	QZ CP KF BI SI KY	Wheeler	64
82M	57	AS	SI KF MU KY	McMillan	70
82M	60	OC	QZ CP KF BI KY GA	Wheeler	64
82N	64	OC	QZ BI MU GA KY	Wheeler	62
82N	65	OC	QZ BI MU GA ST AN KY	Wheeler	62
83D	2	OC	KY ST	Campbell	67a
83D	3	OC	KY ST	Campbell	67a
92A	2.3	OC	GA ST BI CP -KY	Misch	66
92A	2.4	O	BI HO CU GA CP QZ -MU -AC -ST -KY	Misch	66
92H	13	AS	QZ +CP +CL +BI +GA +SI -KY +WM -ST	Reamsbott	+69pc
92H	18	OC	ST KY SI	Lowes	69pc
92H	20	OC	AN1 ST2 GA2 MU2 KY2	Read	60
92H	23	OC	BI GA ST KY	Roddick	+69
92H	25	AS	CP +QZ +GA +ST +KY +BI -CL -SH	Hutchison	69pc
92H	26	AS	BI +GA +ST +QZ +CP -KY -MU	Santer	69*
92H	31.3	AS	CP +QZ +BI +GA +ST +KY	McTaggart	67
92I	34	OC	AN KY ST GA CP QZ	Hollister	66
92I	34.1	OC	AN1 KY2 SI3	Hollister	69*
92N	47	OC	KY	Mathews	57
92B	64	OC	KY	Clapp	14
93A	2	OC	KY ST GA	Campbell	70
93A	7	OC	KY ST	Campbell	70
93A	8	OC	KY ST	Campbell	70
93A	10	AS	QZ +KY +MU -BI	Campbell	69
93A	11	AS	QZ +ST +MU +CP -BI -KY	Campbell	69
93A	43	AS	QZ +CP +BI +WM +GA +KY -ST	Fletcher	69pc
93A	47	AS	QZ +CP +BI +WM +GA +KY -SI -ST -CL	Fletcher	69pc
94C	1	AS	QZ +BI +MU +CP -GA -KY -ST -SI	Roots	54
94C	3	AS	QZ +BI +MU +GA -KY -SI	Roots	54
94C	4	AS	QZ +BI +MU +GA -KY -SI	Roots	54
103H	7	OC	KY	Roddick	ip
103H	8	AS	KY +ST +CP +GA +BI	Hutchison	69pc
103I	15	AS	CP +QZ +KF +KY +GA -CL	Hutchison	ip
103J	22	AS	QZ +CP +BI +MU -GA -KY -KF	Hutchison	ip
103O	31	AS	KY GA BI CP QZ	Smith	70pc
103O	33	OC	KY	Buddington	29
104C	3	OC	ST KY	Buddington	29
104C	4	OC	ST KY	Buddington	29

KYANITE (KY) OCCURRENCES (Con't)

NTS #	Loc #		Minerals	Author	Date
104C	6	OC	ST KY MU	Buddington	29
104C	8	AS	CP +GA +BI1+MU1+BI2+KY2+ST2	Buddington	29
104F	10	OC	KY	Buddington	29
104L	27	AS	QZ +CP +BI +GA -HO -KY -ST	Buddington	29
104C	35	OC	KY BI GA QZ	Gault	+53
104F	40	OC	KY GA BI PC QZ -ST	Brew	70pc
104L	52.2	AS	BI QZ MU PC KY GA ST	Forbes	59
104L	52.3	AS	PC QZ KY BI SI GA	Forbes	59

STAUROLITE (ST) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
82E	7	OC	ST	Preto	67
82E	9.2	AS	QZ +BI +CP +GA -ST -MU	Preto	67
82F	18	AS	QZ +CP +MU +BI +CL +GA +ST	Crosby	68
82F	22	OC	QZ MU BI CP -GA -ST	Fyles	67
82F	24	OC	QZ MU CL -CP -GA1-ST1 -WM2-CL2	Fyles	67
82K	28.1	AS	QZ +CP +BI +SI +GA -MU -ST1	Hyndman	68
82K	28.6	AS	QZ +KF +CP +BI +MU +HO +AN +KY +ST +CD	Hyndman	68
82K	29.4	AS	QZ +MU +BI +ST -CP -GA -CD	Hyndman	68
82K	36.1	OC	GA CP BI MU EP CZ -CD -ST -AN	Read	66
82K	39	OC	GA ST BI	Fyles	64
82L	45	OC	GA ST	Fyson	70
82L	53	OC	KY ST	Jones	59
82N	65	OC	QZ BI MU GA ST AN KY	Wheeler	62
83D	2	OC	KY ST	Campbell	67a
83D	3	OC	KY ST	Campbell	67a
92A	2.3	OC	GA ST BI CP -KY	Misch	66
92A	2.4	O	BI HO CU GA CP QZ -MU -AC -ST -KY	Misch	66
92H	13	AS	QZ +CP +CL +BI +GA +SI -KY +WM -ST	Reamsbott	+69pc
92H	13.9	AS	QZ +CP +BI +GA +ST -WM -CL	Reamsbott	+69pc
92H	18	OC	ST KY SI	Lowes	69pc
92H	20	OC	AN1 ST2 GA2 MU2 KY2	Read	60
92H	22.1	OC	BI ST	Roddick	+69
92H	23	OC	BI GA ST KY	Roddick	+69
92H	25	AS	CP +QZ +GA +ST +KY +BI -CL -SH	Hutchison	69pc
92H	26	AS	BI +GA +ST +QZ +CP -KY -MU	Santer	69*

STAUROLITE (ST) OCCURRENCES (Con't)

NTS #	Loc #		Minerals	Author	Date
92H	31.3	AS	CP +QZ +BI +GA +ST +KY	McTaggart	67
92I	34	OC	AN KY ST GA CP QZ	Hollister	66
92B	62.2	OC	QZ BI GA ST SI AN	Clapp	17
93A	2	OC	KY ST GA	Campbell	70
93A	7	OC	KY ST	Campbell	70
93A	8	OC	KY ST	Campbell	70
93A	11	AS	QZ +ST +MU +CP -BI -KY	Campbell	69
93A	43	AS	QZ +CP +BI +WM +GA +KY -ST	Fletcher	69pc
93A	45	AS	QZ +CP +BI +WM +GA -CL -ST	Fletcher	69pc
93A	47	AS	QZ +CP +BI +WM +GA +KY -SI -ST -CL	Fletcher	69pc
93A	48	AS	QZ +CP +BI +WM +GA +ST +SI -CL	Fletcher	69pc
94C	1	AS	QZ +BI +MU +CP -GA -KY -ST -SI	Roots	54
103H	6	OC	SI ST GA AN	Roddick	ip
103H	8	AS	KY +ST +CP +GA +BI	Hutchison	69pc
103J	21	AS	QZ +CP +MU +BI +GA -CL -ST -CD	Hutchison	ip
103J	24.2	OC	SI BI MU ST CO	Hutchison	pc
103O	34	OC	ST	Buddington	29
104C	1	OC	ST	Buddington	29
104C	3	OC	ST KY	Buddington	29
104C	4	OC	ST KY	Buddington	29
104C	6	OC	ST KY MU	Buddington	29
104C	8	AS	CP +GA +BI1+MU1+BI2+KY2 +ST2	Buddington	29
104L	27	AS	QZ +CP +BI +GA -HO -KY -ST	Buddington	29
104F	40	OC	KY GA BI PC QZ -ST	Brew	70pc
104F	44.2	OC	QZ PC HO BI -ST -GA -MU	MacKevett	64
104L	52.1	AS	MU QZ BI PC GA ST	Forbes	59
104L	52.2	AS	BI QZ MU PC KY GA ST	Forbes	59
105L	11	AS	QZ CP BI KF MU -GA -AN -ST	Campbell	67b
114I	58	OC	-ST AN -GA	Rossman	63
114I	59	OC	ST GA BI PC QZ	Brew	70pc
115F	10	AS	QZ CP WM BI ST -GA	Muller	67

ANDALUSITE (AN) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
82F	20	OC	QZ AN GA BI	Rice	56
82K	25.5	AS	AN2+QZ +CP +WM +AC +CA +EP	Hyndman	68

ANDALUSITE (AN) OCCURRENCES (Con't)

NTS #	Loc #		Minerals	Author	Date
82K	28.6	AS	QZ +KF +CP +BI +MU +HO +AN +KY +ST +CD	Hyndman	68
82K	36.1	OC	GA CP BI MU EP CZ -CD -ST -AN	Read	66
82N	65	OC	QZ BI MU GA ST AN KY	Wheeler	62
92H	20	OC	AN1 ST2 GA2 MU2 KY2	Read	60
92I	34	OC	AN KY ST GA CP QZ	Hollister	66
92I	34.1	OC	AN1 KY2 SI3	Hollister	69*
92L	40	OC	AN	Bancroft	13
92B	62.2	OC	QZ BI GA ST SI AN	Clapp	17
103H	6	OC	SI ST GA AN	Roddick	ip
103I	13.1	AS	AN +HO -BI -QZ	Hutchison	ip
105L	11	AS	QZ CP BI KF MU -GA -AN -ST	Campbell	67b
114I	58	OC	-ST AN -GA	Rossman	63
115A	1.2	OC	QZ WM AN	Kindle	53
115B	2.3	OC	BI GA AN	Sharp	56

CORDIERITE (CO) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
82D	1.2	AS	CL +WM +AC +HO +CO +GA	Parker	64
82D	1.4	AS	QZ +KF +CP -BI -MU -SI -CO	Parker	64
82E	6	OC	CO	Preto	67
82E	9.1	AS	QZ +CP +BI +GA -CO -SI -OP -KF	Preto	67
82F	16.2	AS	QZ +CP +MU +BI +CL -GA -KY -SI -CO	Crosby	68
103I	17.2	AS	QZ +CP +SI +BI +MU -GA +CO	Hutchison	ip
103I	17.3	AS	QZ +CP +CU +CO +GA +BI	Hutchison	ip
103J	24.2	OC	SI BI MU ST CO	Hutchison	pc
103J	25	OC	QZ SI MU CO KF	Hutchison	pc

PREHNITE (PH) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
92H	27.4	OC	HO AB WM ZO -QZ -AB -PH	McMillan	66*
92H	32	OC	AB AC ZO CL CA -PH -PU -SP	McTaggart	67

PREHNITE (PH) OCCURRENCES (Con't)

NTS #	Loc #		Minerals	Author	Date
92I	35	OC	AB QZ ZO WM CL PH PU EP	Schau	68
92O	52	OC	AB EP WM - PH'	Trettin	61
92P	58	OC	AM CL EP CA AB WM -QZ -PH	Campbell	69
92P	59	OC	CL - CA - PH - QZ - ZE	Campbell	69
92F	61		PU PH - LU	Surdam	66
93K	28.1	AS	CL AB EP SH CA PH	Patterson	69pc
103N	38	OC	EP CL CA PH	Sainsbury	61
104P	20.1	OC	AB CL CZ AC - CA - PH	Gabrielse	63
104N	29	OC	QZ HO CP CL - EP - SP - PH	Aitken	59
104D	41	AS	EP MU CL AB QZ - PH - SP	Brew	70pc
104D	41.2	AS	MU EP CA PH CL AB QZ	Brew	70pc
104E	47	OC	AB EP CL AC PH CA SP	Loney	63b
105D	7.1	OC	CL CA CZ - HO - PH - EP	Wheeler	61
105C	8	OC	CL CA AC PH	Monger	69
115F	7	OC	AB EP CL WM CA PH	Muller	67

PUMPELLYITE (PU) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
92H	28	OC	AB EP CL - PU - LW - CA	Monger	66
92H	32	OC	AB AC ZO CL CA - PH - PU - SP	McTaggart	67
92I	35	OC	AB QZ ZO WM CL PH PU EP	Schau	68
92I	35.1	OC	AB QZ ZO EP WM CL AC CA - PU	Schau	68*
92F	61		PU PH - LU	Surdam	66
93K	27.2	AS	GC +LW +PX +SH - CL - CA - PU - SP	Paterson	69pc
104J	21	OC	AB CL AC EP WM - SH - GC - LW - SP - PU	Monger	69

LAWSONITE (LW) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
92H	28	OC	AB EP CL - PU - LW - CA	Monger	66
93K	27	AS	GC +LW +QZ - CL - WM - CA	Paterson	69pc

LAWSONITE (LW) OCCURRENCES (Con't)

NTS #	Loc #		Minerals	Author	Date
93K	27.1	AS	JP +LW +QZ +CL -GC	Paterson	69pc
93K	27.2	AS	GC +LW +PX +SH -CL -CA -PU -SP	Paterson	69pc
93K	27.3	AS	GC +LW +CZ +CA	Paterson	69pc
104J	21	OC	AB CL AC EP WM -SH -GC -LW -SP -PU	Monger	69

GLAUCOPHANE (GC) OCCURRENCES

NTS #	Loc #		Minerals	Author	Date
93K	27	AS	GC +LW +QZ -CL -WM -CA	Paterson	69pc
93K	27.1	AS	JP +LW +QZ +CL -GC	Paterson	69pc
93K	27.2	AS	GC +LW +PX +SH -CL -CA -PU -SP	Paterson	69pc
93K	27.3	AS	GC +LW +CZ +CA	Paterson	69pc
104J	21	OC	AB CL AC EP WM -SH -GC -LW -SP -PU	Monger	69
104J	21.1	AS	QZ GC	Monger	69

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