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GEOLOGY AND MINERAL EXPLORATION POTENTIAL OF THE QUESNEL TROUGH, BRITISH COLUMBIA

by

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GIVE TO TOM.

Abstract

The Quesnel Trough is underlain by a thick sequence of mainly Upper Triassic and Lower Jurassic volcanic-clastic and sedimentary rocks that lie between the highly deformed Proterozoic and Paleozoic rocks in the Omineca Geanticline to the east and the upper Paleozoic Cache Creek Group in the Pinchi Geanticline to the west. Broad areas of the Trough between Kamloops and Williams Lake are covered by Eocene volcanics and sediments and by Miocene-Pliocene plateau lava.

Granitic intrusions were apparently mainly confined to two major episodes; one about 200 m.y. ago (coeval with the Guichon Batholith) and one about 100 m.y. ago. In addition, the region includes small granitic and syenitic intrusions, some porphyritic, that may be all or partly still younger.

Exposures in the region are generally small and scattered, obscured by widespread, not necessarily thick glacial deposits. This, together with the extensive Tertiary cover, makes prospecting difficult.

The part of the Quesnel Trough discussed here is the direct northwestward extension of the copper-rich Kamloops-Merritt-Princeton region. It contains the Boss Mountain molybdenum mine related to a breccia zone induced in a batholith of the oldest group by a younger intrusion, and the Cariboo Bell copper deposit in Lower Jurassic volcanic-clastic rocks and syenitic intrusions. The Gibraltar deposit in a 200 m.y. intrusion is within the Pinchi Geanticline close to the margin of the trough. Molybdenum prospects are mainly restricted within or near the 100 m.y. granitic rocks. Copper prospects, on the other hand, are most prominent in the volcanic-clastic rocks and in the 200 m.y. old granitic rocks though they can also be spatially related to younger intrusions. Copper thus has a wide potential distribution.

The writers believe that the region is deserving of careful and comprehensive exploration by directly applying the knowledge and techniques developed in the important producing areas to the south. All of the major

pre-Tertiary geological elements seem to have potential for mineral deposits; none should be ignored. A thorough knowledge of the thickness and distribution of the Tertiary rocks and the development of geophysical methods to "see through" them is of particular importance.

Geology and Mineral Exploration Potential of the Quesnel Trough, British Columbia

Introduction

For several years the writers have believed that the Quesnel Trough between Kamloops and Prince George warranted intense mineral exploration. This belief was discussed with various people from time to time and it now seems useful to present the substance of our ideas to a broader audience.

A vital aspect of the Quesnel Trough is that in comprises the direct northwestward geological extension of the Princeton-Merritt-Kamloops copper producing region. Essentially all of the major geological features of that area are repeated along the Quesnel Trough (Campbell, 1962, 1963; Campbell and Tipper, 1966; Tipper, 1959; 1960). This, coupled with the fact that such important deposits as Boss Mountain, Cariboo Bell, and Gibraltar are within or near the belt, provides a straightforward and compelling argument that the region is deserving of intensive exploration.

J.O. Wheeler kindly read the manuscript and made many helpful suggestions. The authors are grateful to the Director of the Geological Survey of Canada for permission to publish this paper.

Tectonic setting

The term Quesnel Trough (Roddick et al, 1967) applies to a long narrow strip of dominantly lower Mesozoic mainly volcanic rocks that lies between the Proterozoic and Paleozoic strata of the Omineca Geanticline to the east and the upper Paleozoic rocks of the Pinchi Geanticline to the west (Fig. 1). The trough extends from below the 49th parallel far into northern British Columbia. Around both the northern and southern ends of the Pinchi Geanticline it is connected with the Nechako Trough to which it is geologically similar.

The term may be misleading in that the Quesnel Trough is not a simple depositional feature. It is a partly fault-bounded structure and is a trough insofar as it contains younger rocks flanked by older in the adjoining geanticlines. Also it contains debris shed from the Pinchi Geanticline which was all or partly emergent, at least periodically, during the time of deposition in Quesnel Trough. The Omineca Geanticline, on the other hand, emerged as a continuous topographically high feature after cessation of deposition in the trough.

In contrast to the moderately to weakly deformed rocks of the Quesnel Trough, the older rocks of the geanticlines are commonly much deformed and generally metamorphosed.

General geology

A schematic version of the geology of the Quesnel Trough is presented in Figure 2. The rocks of the trough, divided into two volcanic and two sedimentary units cut by intrusives of two ages, are flanked on either side by the Paleozoic and older rocks of the Pinchi and Omineca Geanticlines. Extensive Tertiary and Quaternary deposits have been omitted hence the map is highly interpretive.

The Pinchi Geanticline on the west flank of the trough is composed primarily of Pennsylvanian to Permian Cache Creek Group, a unit of folded and mildy metamorphosed limestone, chert, argillite, greenstone, and greywacke. Substantial areas are underlain by ultramafic rocks and Mesozoic granitic intrusive bodies. East of the trough in the Omineca Geanticline the sedimentary and metasedimentary rocks of the Proterozoic Kaza Group and lower Paleozoic Cariboo Group together with the unconformably overlying sedimentary and volcanic rocks of the Slide Mountain Group are generally highly deformed. Where intensely metamorphosed these rocks comprise a major part of the Shuswap Metamorphic Complex.

The oldest rocks of the Quesnel Trough are the Upper Triassic black phyllite unit and the Nicola Group. The former consists dominantly of dark grey to black phyllite with local thin limestone beds; with differing grades of metamorphism the pelitic rocks vary from shale to kyanite schist. This unit lies generally along the eastern margin of the trough where it appears to be the basal unit resting unconformably on the strata of the Omineca Geanticline. Scant paleontological evidence coupled with structural information suggests a Late Triassic age.

The Nicoal Group consists dominantly of volcanic-clastic rocks of basic to intermediate composition. Minor intercalations of limestone and argillite are present and locally prominent. The rocks are unmetamorphosed or are but mildly altered. The group may overlie or be all or partly equivalent to the black phyllite so that these two units together effectively form the basal member of the Quesnel Trough. Widespread but scarce fossil occurrences point to a Late Triassic age of the group thus indicating the the trough did not form until Late Triassic time.

Emplacement of granitic masses accompanied by uplift and erosion at the close of Triassic time ended the marine deposition of the Nicola Group. These plutons are grouped as 200 m.y. intrusions (Fig. 2) typified by the Guichon Batholith (White et al, 1967) within which Highland Valley is situated. The age of any pluton in the group may vary considerably from 200 m.y. The rocks vary in composition from hornblende-biotite granodiorite to quartz diorite; prominent porphyritic textures are exceptional. These plutons lie in a broad zone that trends northwesterly slightly oblique to the trend of the Quesnel Trough. The zone leaves the trough between Williams Lake and Prince George, crosses the Pinchi Geanticline, and extends northwesterly into the Nechako Trough (Fig. 1), where it appears to continue in the Endako-Babine Lake region as the belt of Topley Intrusions, some of which at least may belong to the 200 m.y. group.

Jurassic volcanic and sedimentary rocks are mapped as two units (Fig. 2), a volcanic-clastic unit similar to the Nicola Group and a sedimentary unit. The relation between the two is not known precisely but they are in part correlative. The Jurassic volcanic-clastic assemblage is characterized by coarse augite porphyry breccia and fine-grained, well-bedded rocks of similar or identical composition. True sedimentary rocks may be totally absent in some sections, locally prominent in others, but commonly form insignificant interbeds a few inches thick. Early and Middle Jurassic fossils have been found sparingly. Locally the base of the unit is marked by coarse conglomerate containing clasts of Nicola and Cache Creek Group rocks and of the 200 m.y. intrusions. Except where this conglomerate is recognized or where fossils permit an age assignment the unit is apparently indistinguishable from parts of the Nicola Group. Although the interval between marine Triassic deposition and marine Jurassic deposition was marked by intrusion, uplift, and erosion, volcanism was probably more or less continuous, hence locally the depositional record may be unbroken. In a few places red beds mark this interval. In the trough northwest of Prince George Jurassic and Triassic rocks of similar lithology comprise the Takla Group and apparently present a similar problem of separation.

Along the western side of the Quesnel Trough Lower and Middle Jurassic shale, greywacke, and conglomerate rest unconformably on the Cache Creek Group of the Pinchi Geanticline and possibly on the Nicola Group. The base is commonly boulder to pebble conglomerate. This assemblage is believed to be the western shoreline facies of the Quesnel Trough and is correlative in whole or in part with the Jurassic volcanic-clastic unit.

The 100 m.y. intrusions are primarily biotite quartz monzonite and granodiorite commonly displaying distinct potash feldspar phenocrysts. Thus they are distinct from the hornblendic, less potassic, and less prominently porphyritic 200 m.y. group. The age of the plutons is determined primarily by potassium-argon determinations and, although grouped as 100 m.y. intrusions for simplicity, they include rocks that may range from 40 to 160 m.y. The bulk of them are probably between 80 and 120 m.y. old, i.e. mid-Early Cretaceous to mid-Late Cretaceous. The intrusions post-date all but obvious Tertiary structural features including an episode of folding and metamorphism in Omineca Geanticline. The 100 m.y. intrusions generally seem to be confined to a zone along the northeastern side of the belt of 200 m.y. plutons.

The Mesozoic rocks described above are the essential components of the Quesnel Trough. They attest to a history of volcanism and sedimentation from Late Triassic to Middle Jurassic, interrupted at the close of Triassic time by an episode of intrusion, uplift, and erosion, and followed by a second period of intrusion and uplift. The volcanic and sedimentary rocks were not deposited in a restricted trough-like zone but most probably accumulated in the western part of a broad sea that stretched far to the east toward the craton. Thus these rocks represent a western remnant of those that once covered large areas now the site of the Cariboo and Rocky Mountains. The sea was probably continuously interconnected with a similar one in the site now occupied by Nechako Trough (see Fig. 1). During the period of deposition the Pinchi Geanticline became progressively more positive, perhaps evolving from a few small islands in Late Triassic to a single large island in late Early and early Middle Jurassic.

In Middle or early Late Jurassic a general uplift, centred primarily along the axis of the Omineca Geanticline, brought marine deposition in Quesnel Trough to a close. Consequent erosion stripped Mesozoic deposits from the geanticlinal axis and the Trough assumed essentially the outlines it has to-day. The boundaries of the Quesnel Trough are thus partly depositional and partly structural; fault boundaries are important at least locally.

The distribution of the Tertiary rocks, omitted from Figure 2, is superimposed on the pre-Tertiary geology in Figure 3. Tertiary deposits fall into two distinct units, lower Tertiary sedimentary and fragmental volcanic rocks varying from basalt to rhyolite with abundant andesite, and upper Tertiary dominantly basaltic plateau lava. The lower Tertiary rocks are faulted and gently tilted whereas the upper Tertiary lavas are flat-lying and undeformed.

The lower Tertiary rocks may, in their own right, have some economic importance, but generally Tertiary deposits have been regarded as cover rock, hence their thickness and distribution is a matter of importance. The lower Tertiary deposits are commonly several thousand feet thick but locally must be very much thinner. On the other hand the plateau lava is relatively thin over broad areas; where flows flooded old valleys they may be as much as 2,000 feet thick but over much of the plateau the thickness may be less than 500 feet. Holes or "windows" through the lavas are known and many more are to be expected. Effective exploration of the region requires a thorough knowledge of the Tertiary rocks.

Structural geology

Faults and fractures seem to be the dominate structural features in the Quesnel Trough. No widespread regional fold pattern has been discerned though locally dips are steep, possibly from tilting and local folding within individual blocks. If regional folding did exist it presumably produced only broad open flexures. The rocks of the trough in a zone of variable width adjacent to the Omineca Geanticline, particularly the black phyllite, are highly folded.

Some major faults probably were active as early as mid-Triassic time and were loci of continued intermittent movement into early Tertiary. In the north faults that bound the trough and some that lie within it are strands of the Pinchi Fault system, a major structural feature of central British Columbia. Faults farther to the south have an unknown relationship to the Pinchi Fault system.

Locally, as in the region 40 to 60 miles north of Kamloops near the eastern boundary of the trough, an impressive array of surface lineaments testifies to the intensity of faulting and fracturing. These trend north northeast, and northwest. Similar lineaments are less prominent elsewhere though fracturing on a macroscale is thought to be universal. This fracturing, apparently resulting from an episode of block faulting, is a characteristic deformational feature of the rocks of the Quesnel Trough.

Mineral occurrences

The location of most of the mineral occurrences for which information has been published are plotted in Figure 3; this information was derived mainly from reports of the British Columbia Department of Mines and Petroleum Resources. The presence of copper, molybdenum, lead, zinc, silver, and gold is indicated. Only the geographic location and important constituent metals are considered; no suggestion of size or grade is intended hence a producing mine such as Boss Mountain is given no more prominence than a minor showing. The maps serve only to give a rough qualitative distribution of certain metals throughout the region.

If the plotted occurrences are roughly representative of the metal distribution in the Quesnel Trough then certain relationships are apparent. A concentration of mineral occurrences within the trough is obvious. Although our data may be incomplete, few recorded showings appear in the adjacent geanticlines other than gold and a few lead-zinc properties in the Omineca Geanticline and little or nothing in the Pinchi Geanticline except the copper occurrences north of and near Williams Lake (e.g. Gibraltar, located on Fig. 3).

The plot suggests that copper has an affinity for 200 m.y. granitic rocks and Triassic-Jurassic volcanic rocks, thus copper has a wide potential distribution over most of the trough. The scarcity of showings in the northern part of the trough (Fig. 3) may reflect the near absence of 200 m.y. plutons or it may mean that this region of poor exposures has an unrealized potential.

Molybdenum shows a pronounced relationship to the 100 m.y. intrusions. Though situated within a 200 m.y. batholith, the Boss Mountain molybdenum deposit is apparently related to a 100 m.y. intrusion.

Lead-zinc deposits, though few in number, are concentrated along the eastern side of the trough and in the Omineca Geanticline. They seem to have a close relationship to the Proterozoic and lower Paleozoic rocks of the geanticline.

Gold and silver have an erratic distribution although they too seem to have an affinity for rocks of the Omineca Geanticline.

Conclusions

The preferential concentration of copper and molybdenum occurrences within the Quesnel Trough in the study area is obvious from the map shown in Figure 3. Copper mineralization is widespread and seems to occur in association with almost any pre-Tertiary rocks in the trough whereas molybdenum seems restricted to the environment of 100 m.y. intrusives. Details of control of localization cannot be generalized at present. Figure 1 shows the extension of the main geological features of the study area to the north and south and gives the locations of some important mineral deposits.

For a full exploitation of the mineral potential of the Quesnel Trough several approaches are indicated. First, continued exploration of the area in which the Mesozoic volcanic and granitic rocks are the underlying bedrock and in which mineral showings are recorded. Because of widespread glacial drift and forest cover, we doubt that the potential of these areas is completely tested.

Secondly, a long range investigation into the mineral potential beneath the Tertiary is warranted. Mineral occurrences are lacking in a large area between Highland Valley and the Gibraltar property (Fig. 3), obviously because of the blanket of Tertiary volcanics over the mineralized Mesozoic rocks. The distribution of mineral occurrences beyond the margins of the Tertiary cover strongly suggests that mineral occurrences are to be expected beneath it. It seems reasonable that one facet of mineral exploration of the Quesnel Trough should aim at a detailed knowledge of the distribution and thickness of the Tertiary deposits and at the development of methods, to "see through" the Tertiary cover.

Thirdly, the potential of the trough north of the Gibraltar showing should be assessed. The Quesnel Trough extends far to the north into the Omineca district where many significant copper showings are known. The gap between those deposits and others south of Prince George may be because of the lack of granitic rocks, particularly the 200 m.y. intrusions, or because of heavy drift cover and few outcrops. Careful application of geological, geophysical, and geochemical techniques are required to determine the worth of this region.

Fourthly, the granitic rocks of the Pinchi Geanticline between the Gibraltar property and the Endako Mine also merit some attention. Although few mineral occurrences are known in the Pinchi Geanticline, it must be remembered that the Gibraltar property and Endako Mine are within the geanticline, although on the margins. In this region the difficulties of poor exposure are compounded by patches of Tertiary cover.

The potential of the area between the Highland Valley in the south and the Cariboo Bell and Gibraltar properties in the north seems obvious. In this region, too, exposure is not abundant and Tertiary deposits present a major problem. The northward extension of apparently all the major geological features of the Princeton-Merritt-Kamloops copper producing region coupled with the many known occurrences in the study area suggest that the Quesnel Trough warrants extensive exploration activity.

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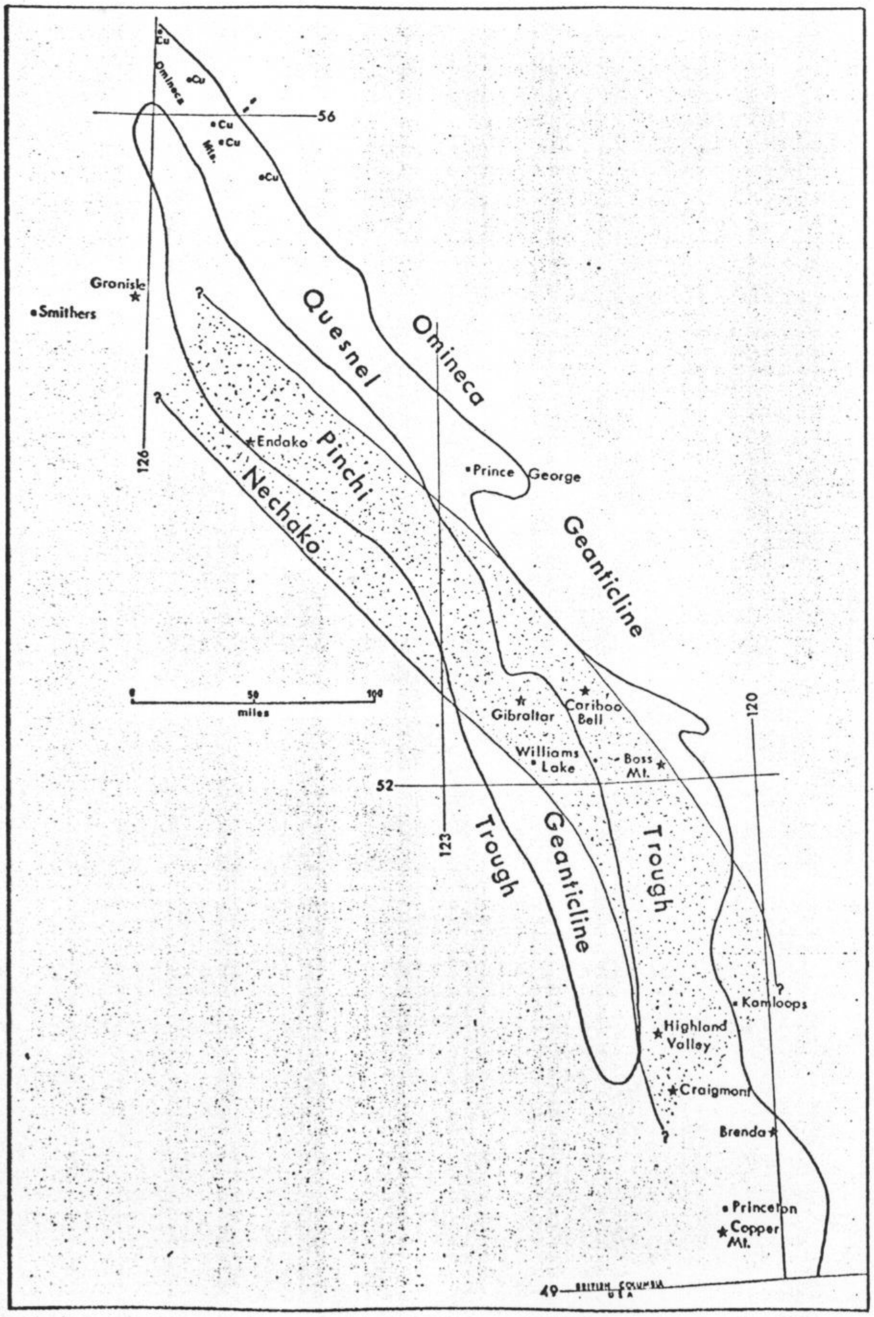
Captions for figures

Figure 1 Map showing the location of the Quensel Trough and adjacent geanticlines with the locations of some important mineral deposits in the interior of British Columbia. The stippled area is the zone of 200 m.y. intrusions that lies at a small angle to the trend of the tectonic elements. The locations of towns and cities are marked by solid squares and of mineral deposits by stars or dots.

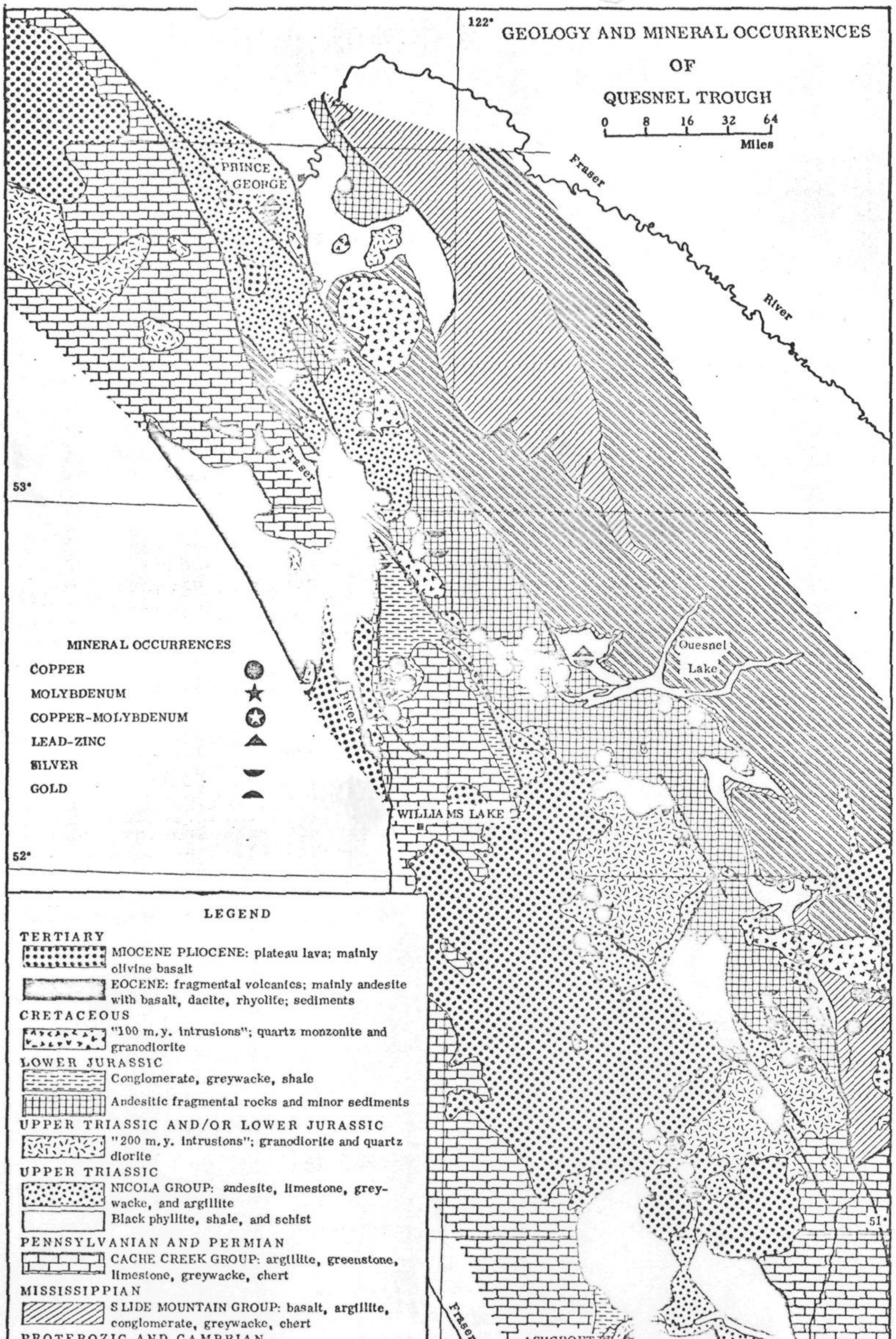
Figure 2 Schematic map of pre-Tertiary geology of Quesnel Trough and surroundings. The trough is defined by the occurrence of Upper Triassic and Lower Jurassic volcanic and sedimentary rocks and is bounded by Paleozoic or older rocks on either side.

Figure 3 Geologic map of Quesnel Trough similar to Figure 2 but including Tertiary deposits and showing locations of mineral occurrences.

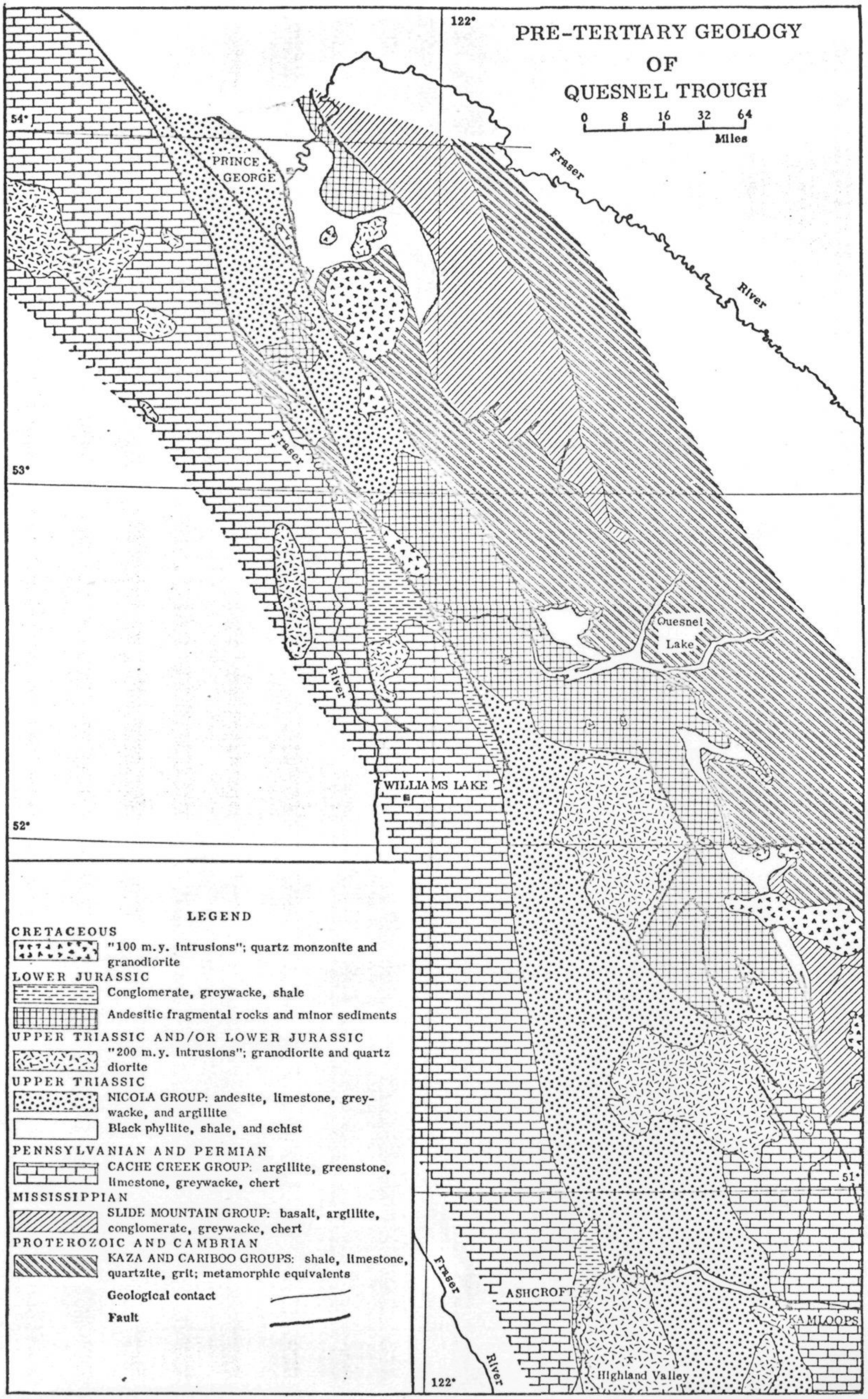


Cu
Omineca
Cu
56
Cu
Mts.
Cu
Cu
Gronisle
Smithers
Quesnel
Omineca
Endako
Pinchi
Nechako
126
Prince George
Geanticline
0 50 100
miles
Gibraltar
Cariboo Bell
Williams Lake
Boss Mt.
52
123
120
Trough
Geanticline
Trough
Kamloops
Highland Valley
Craigmont
Brenda
Princeton
Copper Mt.
49
BRITISH COLUMBIA
U.S.A.

Fig. 3



GEOLOGY AND MINERAL OCCURRENCES
OF
QUESNEL TROUGH
0 8 16 32 64
Miles
122°
53°
52°
51°
122°
Fraser River
Fraser
River
Fraser
River
PRINCE GEORGE
Quesnel Lake
WILLIAMS LAKE
ASHCROFT
KAMLOOPS
Highland Valley
MINERAL OCCURRENCES
COPPER
MOLYBDENUM
COPPER-MOLYBDENUM
LEAD-ZINC
SILVER
GOLD
LEGEND
TERTIARY
MIOCENE PLIOCENE: plateau lava; mainly olivine basalt
EOCENE: fragmental volcanics; mainly andesite with basalt, dacite, rhyolite; sediments
CRETACEOUS
"100 m.y. intrusions"; quartz monzonite and granodiorite
LOWER JURASSIC
Conglomerate, greywacke, shale
Andesitic fragmental rocks and minor sediments
UPPER TRIASSIC AND/OR LOWER JURASSIC
"200 m.y. intrusions"; granodiorite and quartz diorite
UPPER TRIASSIC
NICOLA GROUP: andesite, limestone, greywacke, and argillite
Black phyllite, shale, and schist
PENNSYLVANIAN AND PERMIAN
CACHE CREEK GROUP: argillite, greenstone, limestone, greywacke, chert
MISSISSIPPIAN
SLIDE MOUNTAIN GROUP: basalt, argillite, conglomerate, greywacke, chert
PROTEROZIC AND CAMBRIAN
KAZA AND CARIBOO GROUPS: shale, limestone, quartzite, grit; metamorphic equivalents
Geological contact
Fault



PRE-TERTIARY GEOLOGY
OF
QUESNEL TROUGH
0 8 16 32 64
Miles
122°
54°
53°
52°
51°
PRINCE GEORGE
Fraser River
Fraser
River
Quesnel Lake
WILLIAMS LAKE
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