GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES

LEGEND

CENOZOIC

QUATERNARY
RECENT

- 1975 — Debris flow; detritus derived from units P1 and P3x
- 1947 — Debris flow; detritus derived from unit P3f
- Ral — Alluvium; near Pebble Creek includes redeposited Bridge River Tephra

PLEISTOCENE AND RECENT

- Qal — Alluvium; few if any outcrops
- Qcl — Colluvium; few if any outcrops
- Qca — Glacial deposits, talus, alluvium; few if any outcrops

MEAGER VOLCANIC COMPLEX

Extrusive | Intrusive

QUATERNARY
RECENT
GARIBALDI GROUP (R4f to P1)
BRIDGE RIVER ASSEMBLAGE (R4f to R1):

- R4f — Light grey, porphyritic (plagioclase, quartz, hornblende) rhyodacite vitrophyre
- R3ls — Landslide or lahar debris derived from unit P9f
- R2x — Welded block and ash flow of porphyritic (plagioclase, quartz, hornblende) rhyodacite vitrophyre
- R1 — BRIDGE RIVER TEPHRA: blocks and ash of porphyritic (plagioclase, quartz, hornblende, pyroxene, biotite) rhyodacite pumice

PLEISTOCENE
MOSAIC ASSEMBLAGE (P10f, P10x):

- P10f — Porphyritic (olivine, pyroxene, plagioclase) basalt
- P10x — Vesicular to scoriaceous basalt breccia, tuff and bombs
- TILL — Till

PLINTH ASSEMBLAGE (P9f to P9x):

- P9f — Light to medium grey, porphyritic (plagioclase, biotite, quartz) rhyodacite flows
- P9x — Light to medium grey, porphyritic (plagioclase, biotite, quartz) rhyodacite breccia and ash
- P9i (intrusive) — Medium to dark grey, porphyritic (plagioclase, biotite, quartz) rhyodacite
- TILL — Till

CAPRICORN ASSEMBLAGE (P8f to P8x):

- P8f — Dark grey to purple, porphyritic (plagioclase, quartz ± biotite) rhyodacite flows
- P8x — Dark grey to purple, porphyritic (plagioclase, quartz ± biotite) rhyodacite breccia and ash
- P8i (intrusive) — Dark grey to purple, porphyritic (plagioclase, quartz ± biotite) rhyodacite intrusions with some flows and breccia

DEVASTATION GLACIER ASSEMBLAGE (P7f, P7x):

- P7f — Ochre weathering, porphyritic (plagioclase, quartz, hornblende, biotite) rhyodacite flows
- P7x — Ochre weathering, porphyritic (plagioclase, quartz, hornblende, biotite) rhyodacite breccia and ash
- P6f — Light grey, porphyritic (plagioclase, hornblende) andesite flows
- P6i (intrusive) — Light grey, porphyritic (plagioclase, hornblende) andesite
- P5x — Porphyritic (hornblende, plagioclase ± biotite) andesite breccia and tuff
- P4f — Porphyritic (hornblende, plagioclase) andesite flows
- P4x — Porphyritic (hornblende, plagioclase) andesite breccia

PYLON ASSEMBLAGE (P3f to P3x):

- P3f — Porphyritic (plagioclase ± pyroxene) andesite flows
- P3x — Porphyritic (plagioclase ± pyroxene) andesite breccia and ash
- P3i (intrusive) — Porphyritic (plagioclase ± pyroxene) andesite
- P2f — Dark grey, aphanitic andesite flows

THE DEVASTATOR ASSEMBLAGE (P1):

- P1 — White, altered rhyodacite tuff, breccia and flows
- P1 (intrusive) — White, altered rhyodacite intrusions (not distinguished on map)

TERTIARY
PLIOCENE

- P4f — Porphyritic (quartz, plagioclase, hornblende) dacite flows
- P4x — Porphyritic (quartz, plagioclase, hornblende) dacite breccia
- P3f — Dark grey, porphyritic (plagioclase) andesite flows
- P3x — Dark grey, porphyritic (plagioclase) andesite breccia
- P2x — Volcanic breccia with dominant plutonic and some aphanitic volcanic clasts
- P1 — Medium grey-green aphanitic flows and breccia

COAST PLUTONIC COMPLEX (including pendants)

Stratified Rocks: Low grade | High grade metamorphic rocks | Intrusions

TERTIARY
MIOCENE

- Mqm — FALL CREEK and AFFLICTION CREEK STOCKS: biotite quartz monzonite, leucoquartz monzonite; alaskite

MESOZOIC

CRETACEOUS
UPPER CRETACEOUS

- ιKqd — SPIDERY PEAK PLUTON: biotite hornblende quartz diorite

LOWER CRETACEOUS(?)
GAMBIER GROUP(?)

- lKGv — Aphanitic grey-green flows, tuff, and breccia with granitic detritus

CRETACEOUS AND/OR JURASSIC

- Mqd — Biotite hornblende quartz diorite
- Mqm — Biotite quartz monzonite
- Md — Hornblende diorite

TRIASSIC(?)
UPPER TRIASSIC(?)
CADWALLADER GROUP(?)

- uTrcv — Greenstone, volcanic breccia
- uTrcp — Grey phyllite; minor greywacke
- uTrcm — Streaky amphibolite
- uTrcsb — Biotite muscovite schist and gneiss
- uTrcc — White marble

Geological boundary (defined, approximate, assumed)
Limit of geological mapping
Bedding, facing determined (inclined, vertical, overturned)
Bedding, facing undetermined (horizontal, inclined, vertical)
Flow layering (horizontal, inclined, vertical)
Flow lineation
Fold (symmetric, northerly vergence*)
Plane perpendicular to columnar jointing (horizontal, inclined, vertical)
Jointing (inclined, vertical)
Foliation (inclined, vertical)
Spring: fossil spring area FS; cold spring CS; warm spring WS; hot spring HS
Diamond drill hole ● DDH 78-H-2
Contour interval 100 feet
Potential slide area

Radiometric date: location and rock type — O igneous rock; material — b biotite, f flora, w whole-rock; method — C Radiocarbon, K Potassium-argon; 1.9 — Potassium-argon age in millions of years, Radiocarbon age in years before present; Laboratory — b University of British Columbia, g Geological Survey of Canada

* Vergence is the direction of the upper member of the rotational couple implied by the asymmetry of the fold.

Geology by P. B. Read, 1976, 1977, 1978

Geological cartography by P.B. Read, 1978. Base map compiled by Integrated Resources Photography Ltd., 1975 from B.C. Government photos taken in 1965.

DESCRIPTIVE NOTES

Meager Creek, site of a Pliocene to Recent volcanic complex, is in the Coast Mountains of British Columbia about 150 km north of Vancouver. It lies at the northern end of the northwesterly trending Garibaldi Volcanic Belt (Fig. 1) which is one of three Quaternary volcanic belts in the Canadian Cordillera. Underlying the volcanic complex is a basement complex composed of mainly Mesozoic quartz diorite and less common septa of Mesozoic metamorphic rocks. Garibaldi Volcanic Belt obliquely cuts the common northwesterly trend of basement structures in the southern Coast Mountains. Paralleling the northwesterly trend is a line of hot springs stretching 240 km from the International Boundary to its intersection with the Garibaldi Volcanic Belt at Meager and Pebble Creek hot springs. This publication succeeds an earlier study by Anderson (1975) and a preliminary account by Read (1977).

Basement Complex:

The basement complex consists of plutonic rocks which host northwesterly trending septa of gneiss, migmatite, and regionally metamorphosed stratified rocks of probable Mesozoic age. Stratified metamorphic rocks form a large septum which extends northwesterly for 75 km along the Lillooet River and passes through the map area. They are divided into two units based on the absence of granitic detritus in, and more intense deformation and metamorphism of the older unit which is tentatively correlated to the Cadwallader Group of late Triassic age, and a younger unit which is weakly metamorphosed and foliated, has abundant granitic detritus, and may be part of the Lower Cretaceous Gambier Group (lKGv). In the Cadwallader Group(?), abundant massive greenstone (uTrcv), less grey phyllite (uTrcp) and rare marble (uTrcc) lie along Lillooet River valley, but to the southwest an increase in metamorphic grade produces amphibolite (uTrcm) and biotite-muscovite schist (uTrcsb). On either side of Mosaic Glacier, volcanic breccia and tuff are intercalated with meta-andesite and meta-basalt of the Gambier Group (lKGv). The breccia consists of unsorted, angular clasts up to 50 cm in diameter, which are a mixture of plutonic, and porphyritic and aphanitic metavolcanic rocks in a tuffaceous matrix. On the east side of Mosaic Glacier, volcanic rocks of the Gambier Group(?) overlie amphibolite of the Cadwallader Group(?) along a subvertical unconformity. Plutonic rocks dominate the basement complex. They are massive and range in composition from quartz diorite to quartz monzonite. The older plutons (Mqd) are complexly jointed and altered compared to the younger stocks and locally on the east side of Mosaic Glacier they underlie volcanic rocks of the Gambier Group(?) along a subvertical nonconformity. Crossing the lower course of Meager Creek and straddling the Lillooet River is a fresh, sparsely jointed quartz diorite (ιKqd) which yields a biotite K-Ar age of 82 ± 3 Ma. Spanning Lillooet River north of Pebble Creek is an ochre-weathering, biotite leucoquartz monzonite (Mqm) which gives a radiometric K-Ar age of 10.1 ± 0.6 Ma on biotite. On the west side of the map area, quartz monzonite of Affliction Creek stock may be of similar age.

Volcanic Complex:

In the volcanic complex, widespread andesite constitutes most of the older part which is best exposed in the south. In the northern half of the complex, young rhyodacite flows and lava domes overlie and intrude remnants of the formerly more extensive andesite flows. Rhyodacite forms one-third of the complex and is of interglacial age. Fifteen volcanic assemblages comprising the complex are described in order of decreasing age.

(a) Pliocene:

Traces of four Pliocene volcanic assemblages outcrop along the southwest margin of the complex. Whether grey-green aphanitic flows, breccia and intrusions(?) of P1 are older than the basal breccia (P2x) is uncertain. On the south side of the complex, locally preserved remnants of breccia (P2x) up to 300 m thick overlie a basement surface with up to 400 m of relief. Clasts of granitic, grey or green aphanitic volcanic and minor metamorphic rocks lie in a tuffaceous matrix. South of Pylon Peak where the breccia is thickest, clasts less than 0.5 m long increase in size downwards to jumbled blocks of quartz diorite up to 20 m long with less than 5 per cent matrix. This area where basement is lowest, may represent a partly exhumed vent. Locally, bedding develops in the unit distal to the jumbled blocks of the vent. High on the western edge of the complex, at the heads of Affliction and Devastation creeks, lies a gently dipping sequence of andesite flows (P3f) and breccia (P3x) which yields a radiometric age of 1.9 ± 0.2 Ma. Nearly 3000 vertical feet lower on the east side of Devastation Creek are grey-green dacite flows (P4f) with sparse phenocrysts of quartz, plagioclase and hornblende. They form a 200 m thick sequence of subhorizontal flows capped by similar breccia (P4x). A whole-rock yields a K-Ar radiometric age of 1.9 ± 0.2 Ma. Gently dipping rhyodacite tuff and breccia (P1) overlap the older dacite along a steeply dipping eastern contact.

(b) Pleistocene:

Ten Pleistocene volcanic assemblages compose the bulk of the volcanic complex. The oldest of the assemblages outcrops in the southwest and the youngest in the north. Extensive andesite overlies hydrothermally altered rhyodacite and underlies fresh rhyodacite of largely interglacial age. On the south and west flanks of Pylon Peak and The Devastator is a cream to yellow-ochre weathering assemblage up to 500 m thick of acid volcanic rocks (P1). They are hydrothermally altered with locally preserved quartz, plagioclase and biotite phenocrysts. Quartz, pyrite, sericite, ubiquitous clay minerals and sporadic carbonates characterize this unit. Crudely layered tuff and breccia, dipping gently northeast, compose all but the eastern end of the unit. Here the unit is massive, sharply truncates the older basal breccia (P2x), and represents flows and hypabyssal intrusions of a partly preserved vent. A chemical analysis of one of the least altered rocks gives a rhyodacite composition. The unit is unsuited for dating but its formation falls in the interval 1.9 ± 0.2 to 1.0 ± 0.1 Ma.

Although volumetrically insignificant in the complex, the base of unit (P2f) marks the end of a period of volcanic quiesence and deep dissection and heralds a stage of widespread andesite volcanism. South of Pylon Peak and The Devastator, medium to dark grey aphanitic flows (P2f) here and there overlie the basal breccia (P2x) and acid volcanic rocks (P1), and a few dykes less than 50 m wide cut all units. A chemcial analysis indicates that the flows are andesite. Two whole-rock K-Ar ages yield 0.7 ± 0.35 and 1.0 ± 0.1 Ma of which the latter is preferred. Porphyritic plagioclase andesite, the most extensive unit of the complex, forms most of its southern and western parts. Gently dipping flows (P3f) are more extensive than basal and intercalated breccia and tuff (P3x), and plugs and dykes (P3i) are restricted to The Devastator and possibly on the divide between Affliction and Devastation glaciers. The maximum thickness exceeds 1200 m of flows south of Capricorn Creek. The flows are commonly flow-layered, separated by thin reddened breccia and tuff lenses, and dip up to 15 degrees away from The Devastator. Monomictic breccia of porphyritic plagioclase andesite lies at or within a few hundred metres of the base of the unit. The monomictic composition and differential weathering of the clasts compared to the matrix distinguish this breccia from unit P2x. A concentration of hypabyssal intrusions and coarse breccia clasts up to several metres in length, favour The Devastator as a major vent. Whole-rock K-Ar ages of 0.9 ± 0.2 Ma and 0.5 ± 0.1 Ma from the unit indicate a long period of andesite volcanism spanned by units P2f and P3. Crudely layered and locally cross-bedded volcanic breccia of unit P5x caps or fills paleovalleys carved in unit P3f. The polymictic volcanic breccia contains mostly porphyritic plagioclase andesite (P3), some hornblende ± biotite andesite and rare plutonic detritus. East of The Marionettes, a steep-walled paleovalley has preserved up to a 400 m thickness of breccia which was derived from the west. Light grey, porphyritic (plagioclase, hornblende) andesite (P6i) intrudes the older andesites of units P3 and P5x. In the valley east of The Marionettes, intrusion of a sill of P6i produced a reddened contact in units P3f and P5x. West of Devastation Glacier, small areas of P6f shown as flows might be sills instead.

An extensive sequence of young rhyodacite flows, breccia and intrusions forms the northern half of the complex. It ranges in age from interglacial to postglacial. Around Mount Job in the centre of the complex, are ochre-yellow weathering flows of porphyritic biotite hornblende and quartz rhyodacite (P7f). They are prominently flow-layered and locally columnar-jointed. On the east side of Job Glacier, they unconformably overlie porphyritic andesite (P3x) and at the head of Job and Capricorn glaciers, they underlie biotite rhyodacite of Mount Capricorn (P8). P7f represents the partly preserved basal remnants of a thick rhyodacite sequence which includes units P7, P8, P9, and R1 to R4f. The final 600 m of mounts Capricorn and Job are maroon weathering rhyodacite (unit P8).

Coarse phenocrysts (5 mm) of plagioclase, quartz and biotite characterize the vesicular rhyodacite. Angular clasts up to 2 m long form a basal breccia (P8x) up to 100 m thick, and similar breccia is interspersed throughout the unit. The absence of flow-layering on Mount Capricorn favours this as a source of the unit. On the south side of Plinth Peak, P8 underlies P9. A K-Ar whole-rock age is ≥ 0.09 Ma. The top 600 m of Mount Meager and the bulk of Plinth Peak consists of light grey porphyritic rhyodacite with phenocrysts of plagioclase, quartz, minor biotite and rare hornblende. It is commonly vesicular, has a glassy matrix, and is distinguished from other rhyodacites by scattered, rounded inclusions of fine grained hornblende andesite. On Mount Meager, steeply inclined-flow layering and the absence of flows or breccia imply that it is a plug or lava dome. In contrast, Plinth Peak consists of prominent columnar- or platy-jointed flows and widespread breccia and ash on its northern flank. Three areas on the north ridge and the flat-topped summit show steep flow-layering and subhorizontal columnar jointing of possible plugs or lava domes. Attitudes of flows commonly subparallel topography and dips range from 30 to 60 degrees away from Plinth Peak. East of Job Creek, basal flows overlie till and extend northward across Lillooet valley. A whole-rock K-Ar age of 0.1 ± 0.02 Ma indicates contemporaneity with unit P8.

Interrupting the rhyodacite volcanism is a sparsely porphyritic plagioclase, augite, olivine basalt and andesitic basalt (P10) which forms remnants composed of scoriaceous flows, breccia and bombs. North of Lillooet River, between Affliction and Mosaic creeks, south of and in upper Meager Creek the remnants cap ridges, veneer valley walls and floor valleys. The unit overlies till and rhyodacite of unit P9 and has whole-rock K-Ar ages of 0.09 ± 0.06 Ma and 0.14 ± 0.1 Ma.

Bridge River Tephra (R1), which incompletely blankets the area between the north and east ridges of Plinth Peak marks the latest return to rhyodacite volcanism. Within this area, crudely stratified breccia and ash deposits of R1 are up to 20 m deep on some ridges. Over 90 per cent of the clasts are cream-weathering, porphyritic (plagioclase, augite, hornblende) rhyodacite pumice. They range in maximum size from 10 cm on the summit of Plinth Peak (Nasmith et al., 1967) to 5 m blocks on the north side of Fall Creek. Two per cent of the clasts are subrounded cobbles of a porphyritic leucoquartz monzonite (Mqm) exposed in the basement near the bottom of the creek and in the nearby Lillooet River. These data strongly indicate that the lower part of Fall Creek or nearby Lillooet valley contains a vent area for the tephra. Scoriaceous rhyodacite forms a welded block and ash flow (R2x) up to 6 km long and at least 145 m thick in the Lillooet valley northeast of Plinth Peak. The welded flow probably came from the same vent as the tephra. A younger rhyodacite vitrophyre (R4f) emerged from a vent near the headwall of Fall Creek (Fig. 2) and flowed a few kilometres down Fall Creek valley which it filled to a depth of at least 20 metres. A landslide or lahar composed of detritus from unit P9 separates the two flows and briefly filled Lillooet valley near Fall Creek to a depth of 300 metres. In the Bridge River Assemblage, the tephra of R1 has been dated by ^{14}C at 2490 ± 50 years B. P. from a charred tree in living position which was covered by the tephra. The welded flow of unit R2x has drastically changed the gradient of Lillooet River resulting in development of an elevated terrace extending from above Lillooet Falls to Manatee Creek (Ral) and formation of a terrace composed of redeposited Bridge River tephra near Pebble Creek (Ral).

Geologic Hazards:

In 1931, 1947 and 1975, debris flows originated on the western flanks of The Devastator and flowed down Devastation Creek. The map shows a clear relationship between the hydrothermally altered volcanics of units P1 and P3x and the source of the 1975 slide (Read, 1977). Unit P1 underlies most potential slide areas, of which the largest potential slide masses lie on the western flanks of The Devastator overlooking Devastation Glacier which is receding and removing its support from the base of the slopes.

Springs:

Included within springs are hot and warm springs which issue from basement, cold springs flowing from the basement or volcanic complex, and fossil spring areas found only within the volcanic pile (Fig. 2). Meager Creek hot spring precipitates calcite, aragonite and opaline silica at surface and calcite, kaolinite, clay minerals, laumontite, heulandite and gypsum at depth (Read, 1975). A geochemical study of the hot spring water (Hammerstrom and Brown, 1978) showed that the mineral assemblages at depth are in equilibrium with the water which no longer retains any evidence of a previous thermal history. Of several odorless, cold springs found, most deposit carbonate or hydrated iron oxides. Fossil spring areas are characterized by opaline silica encrusting joint surfaces over areas less than 100 metres square adjacent to vents.

Springs and vents trend northerly (Fig. 2) and are spatially associated, particularly if the estimated position of the subcrop of Meager Creek hot spring is considered. Geologic investigation to date does not support northwest trending regional faulting along Lillooet valley as a cause of basement porosity and permeability. The undeflected trend of the contact between metamorphic and plutonic rocks in the basement (Fig. 2) shows a lack of significant faulting of other orientations. Geochemistry of the spring waters indicates that Meager and Pebble Creek hot springs are geochemically distinct (Hammerstrom and Brown, 1978) and developed in separate environments. The two springs lie close to known or inferred vents ranging in age from 1.9 ± 0.2 Ma to 1.0 ± 0.1 Ma for Meager Creek hot springs and 2490 ± 50 years B. P. for Pebble Creek hot spring. Fracturing during rhyodacite volcanism in these vent areas probably produced the necessary permeability to depth in the basement which permits deep circulation of water in this area of abnormally high heat flow.

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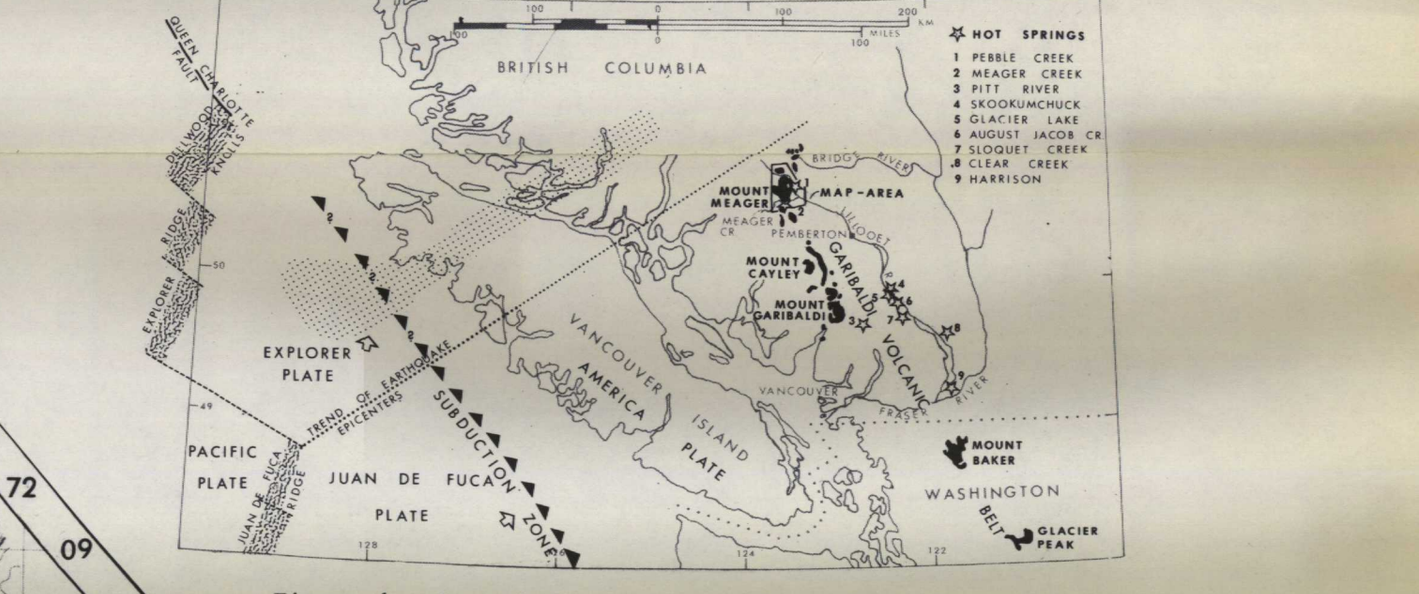
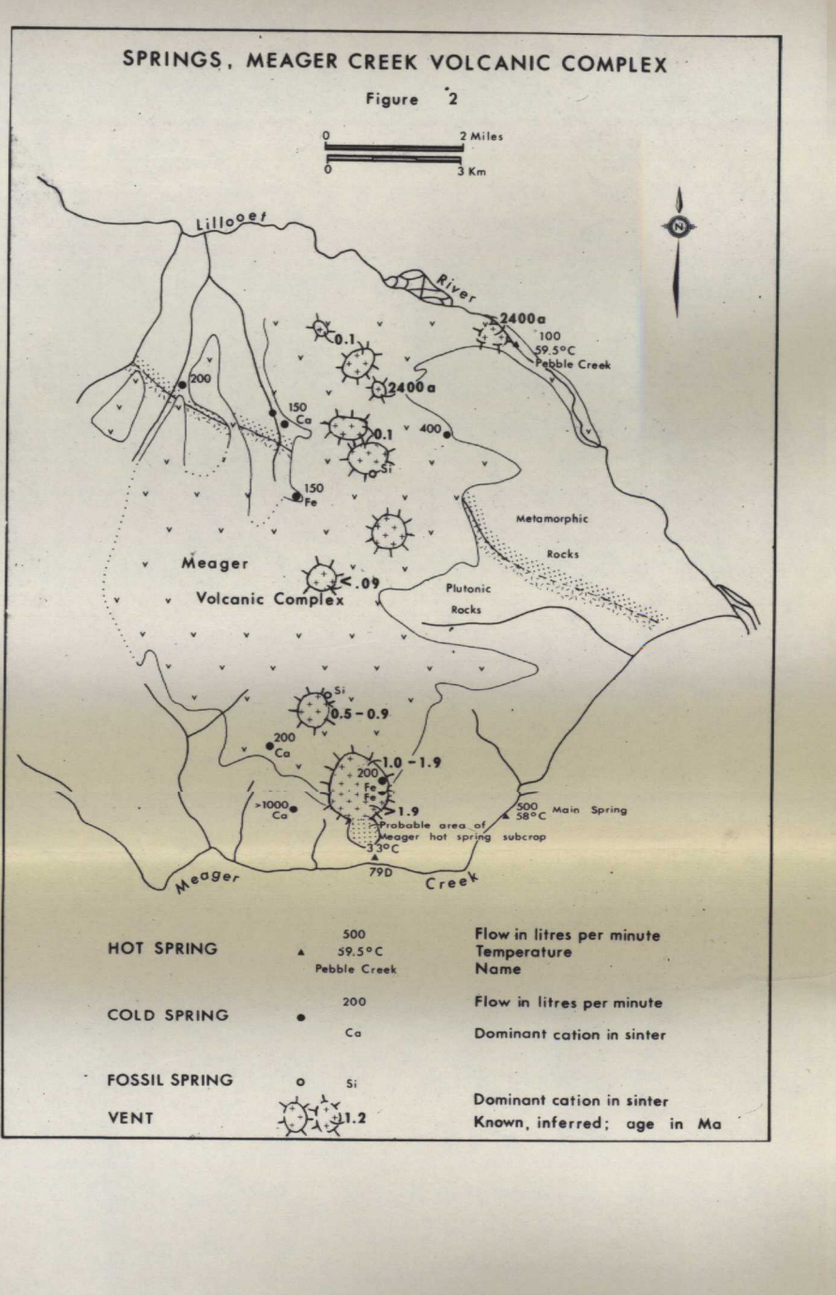


Figure 1: Location map showing Garibaldi Volcanic Belt, hot springs and plate boundaries.



GEOLOGY

MEAGER CREEK GEOTHERMAL AREA

BRITISH COLUMBIA

Scale 1:20,000