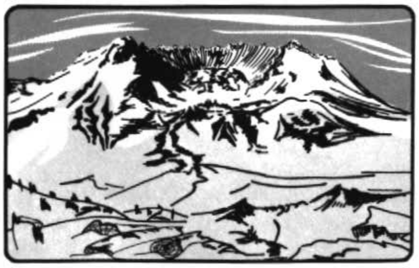

Mount Meager Complex, Garibaldi Belt, Southwestern British Columbia

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Summary

The Mount Meager Complex [recent publications have misnamed the complex Meager Mountain; Mount Meager is the accepted name of the mountain] of Pliocene to Recent age contains volcanic rocks ranging in composition from basalt to rhyolite. Products of three periods of volcanism dominate the complex; early and late periods of rhyodacite bound a middle episode of andesite. In the early episode rhyodacite tephra and flows, from <1.9±0.2 Ma to > 1.0±0.1 Ma, covered remnants of a basal breccia and overlying dacite flows on the southwestern edge of the complex. Products from the middle episode of andesite volcanism, from 1.0±0.1 Ma to 0.5±0.1 Ma, underlie the southern and central parts of the complex; The Devastator was their principal source. The late episode of rhyodacite volcanism, from 0.1±0.02 Ma to 2340±50 years B.P., produced rhyodacite flows, tephra and lava domes from vents in the northeastern part of the complex. The vent at the 1650 m (5400 foot) level on the northeast flank of Plinth Peak is the source of the Bridge River tephra. Meager and Pebble Creek hot springs issue from the Mesozoic basement near vents.

Introduction

The Pliocene to Recent Mount Meager Complex (Read, 1977) is in the Coast Mountains of British Columbia immediately west of the confluence of Meager Creek and Lillooet River and about 150 km north of Vancouver (Figure 1). The complex lies at the northern end of the north-northwesterly trending portion of the Garibaldi Volcanic Belt of Quaternary age. A basement complex composed mainly of Mesozoic quartz diorite and less common septa of Mesozoic metamorphic rocks underlies the volcanic complex. The Garibaldi Volcanic Belt acutely cuts the common northwesterly trend of basement structures in the southern Coast Mountains. A northwesterly trending line of hot springs stretches over 240 km from the International Boundary to its junction with the Garibaldi Volcanic Belt at Mount Meager Complex. Meager Creek hot springs, the largest in British Columbia, and Pebble Creek hot springs lie at the junction and provided the focus for extensive geophysical surveys, drilling programs, and hydrological and geological investigations which were funded by BC Hydro and the Geological Survey of Canada.

Meager Creek valley, between its confluence with Devastation Creek and Lillooet River, is probably the most active and dangerous valley in the Canadian Cordillera (Read, 1981). Debris flows, mainly from the complex, have filled the valley to a depth of 250 m. Radiocarbon dating of entrapped trees indicates that some debris flows at the surface of this deep valley fill are over 4000 years old. This hazard has sparked further studies by the University of British Columbia (Jordan, 1990) and the Geological Survey of Canada (Evans, 1990).

Mount Meager Complex

Rocks from three volcanic periods constitute the bulk of the complex. Remnants of the early rhyodacite episode crop out along the southern edge of the complex where they underlie the extensive andesite that forms all but the northern part. In the northern part, the late rhyodacite episode, of inter- and postglacial age, includes the Bridge River tephra and overlying flows. Nine volcanic assemblages comprise the complex; they are depicted in Figures 2 and 3 and discussed in order of decreasing age.

1. ***Basal breccia (PL1).*** On the south side of the complex, locally preserved remnants of a basal breccia up to 300 m in thickness overlie a Mesozoic basement surface with up to 400 m of relief. Clasts of granitic, grey, green or maroon aphanitic volcanic, and minor metamorphic rocks lie in a tuffaceous matrix. South of Pylon Peak, where the breccia is thickest, clasts increase in size downwards, from less than 0.5 m long to jumbled blocks of quartz diorite up to 20 m long lying in less than 10% matrix. This area, where the basement is lowest, may represent a partly exhumed vent of the initial eruptive phase of the complex. Bedding rarely develops in the unit distal to the jumbled blocks of the vent.

2. ***Porphyritic (quartz) dacite (PL2).*** In the southwestern corner of the complex, a green-grey dacite, with sparse phenocrysts of quartz, plagioclase and hornblende, forms a 200-m-thick remnant of subhorizontal flows. Gently dipping tephra of the early rhyodacite episode overlap the older dacite along a steeply dipping eastern contact. A whole-rock yields a K-Ar radiometric age of 1.9±0.2 Ma.

3. ***The Devastator assemblage (P1).*** On the south and west flanks of Pylon Peak and The Devastator is a cream to yellow-ochre weathering assemblage up to 500 m in thickness of felsic volcanic rocks and hypabyssal intrusions (Figure 4). They are so intensely hydrothermally altered that phenocrysts of quartz, plagioclase and biotite are preserved only locally. Quartz, sericite, pyrite, ubiquitous clay minerals and locally carbonates characterize this unit. Crudely layered tephra, dipping gently northeast, compose all but the eastern end of the unit. Here the unit is massive, steeply truncates the older basal breccia, and represents the flows and hypabyssal intrusions of a partly preserved vent. A chemical analysis of one of the least altered rocks yielded a rhyodacite composition. Although the assemblage is unsuited for dating, its formation must fall in the inter-

Figure 1 *Location map and regional geological setting of Meager Creek geothermal area.*

val 1.9±0.2 Ma to 1.0±0.1 Ma and it represents remnants of the early episode of rhyodacite volcanism. The assemblage forms the subcrop of most of the potential slide areas and source areas of past slide masses.

4. ***Pylon assemblage (P2** and **P3).*** Medium to dark grey aphanitic flows (P2) form small lenses on the south side of Pylon Peak and locally overlie the basal breccia and The Devastator assemblage (Figure 4). Although volumetrically insignificant at less than 1% of the complex, the base of the unit marks the end of a period of volcanic quiescence and deep dissection, and heralds an episode of widespread andesite volcanism. A chemical analysis indicates that the aphanitic flows are andesitic. A whole rock K-Ar radiometric determination yields an age of 1.0±0.1 Ma.

Porphyritic plagioclase andesite (P3), the most extensive unit of the complex, underlies most of its southern and western parts. Gently dipping flows are more extensive than basal and intercalated tephra, and plugs and dykes are restricted to The Devastator and possibly on the divide between Job and Devastation glaciers. The maximum thickness of flows exceeds 1200 m south of Capricorn Creek. The flows are commonly flow-layered, separated by thin reddened breccia and lapilli tuff lenses, and dip up to 15° away from The Devastator. Monomictic breccias of porphyritic plagioclase andesite clasts lie at or within a few hundred metres of the base of the unit. The monomictic composition and differential weathering of the clasts distinguish this breccia from the Pliocene basal breccia. A concentration of hypabyssal intrusions and coarse volcanic breccia clasts up to several metres in length suggest that The Devastator is a major vent (Figure 4). Whole-rock K-Ar ages of 0.9±0.2 Ma and 0.5 ± 0.1 Ma from this unit indicate that a long period of andesite volcanism is spanned by the two units of the Pylon assemblage.

5. ***Job assemblage (P4).*** Around Mount Job, in the centre of the complex, are ochre-yellow weathering flows of porphyritic hornblende, biotite and quartz rhyodacite. They are prominently flow-layered and locally columnar jointed. On the east side of Affliction Glacier, the assemblage overlies porphyritic andesite of the Pylon assemblage, and at the head of Affliction and Capricorn glaciers, it underlies biotite rhyodacite of the Capricorn assemblage. The assemblage represents the partly preserved basal remnants of the late rhyodacite episode which includes the Job, Capricorn, and Plinth assemblages and the Bridge River tephra.

6. ***Capricorn assemblage (P5).*** The final 600 m of Mounts Capricorn and Job are maroon weathering rhyodacite. Coarse phenocrysts (5 mm) of plagioclase, quartz, and biotite characterize this rhyodacite. Angular clasts up to 2 m long form a basal breccia up to 100 m in thickness and similar breccia is interspersed throughout the assemblage. On the south side of Plinth Peak, it underlies rhyodacite flows of Plinth assemblage. A K-Ar whole-rock age determination yields an age of 0.09 Ma or less.

7. ***Plinth assemblage (P6).*** The top 600 m of Mount Meager and the bulk of Plinth Peak consist of light grey porphyritic rhyodacite with phenocrysts of plagioclase, quartz, minor biotite and rare hornblende. It is commonly vesicular, has an aphanitic matrix, and is distinguished from other rhyodacite in the complex by the presence of rounded cognate 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 (Figure 5). In contrast, Plinth Peak consists of prominent columnar- or platy-jointed flows and widespread tephra on its northern flank. Three areas on the north ridge and flat-topped summit show steep flow layering and subhorizontally oriented columnar jointing of possible plugs or lava domes. The attitudes of the flows commonly are subparallel to topography and dips range from 30° to 60°

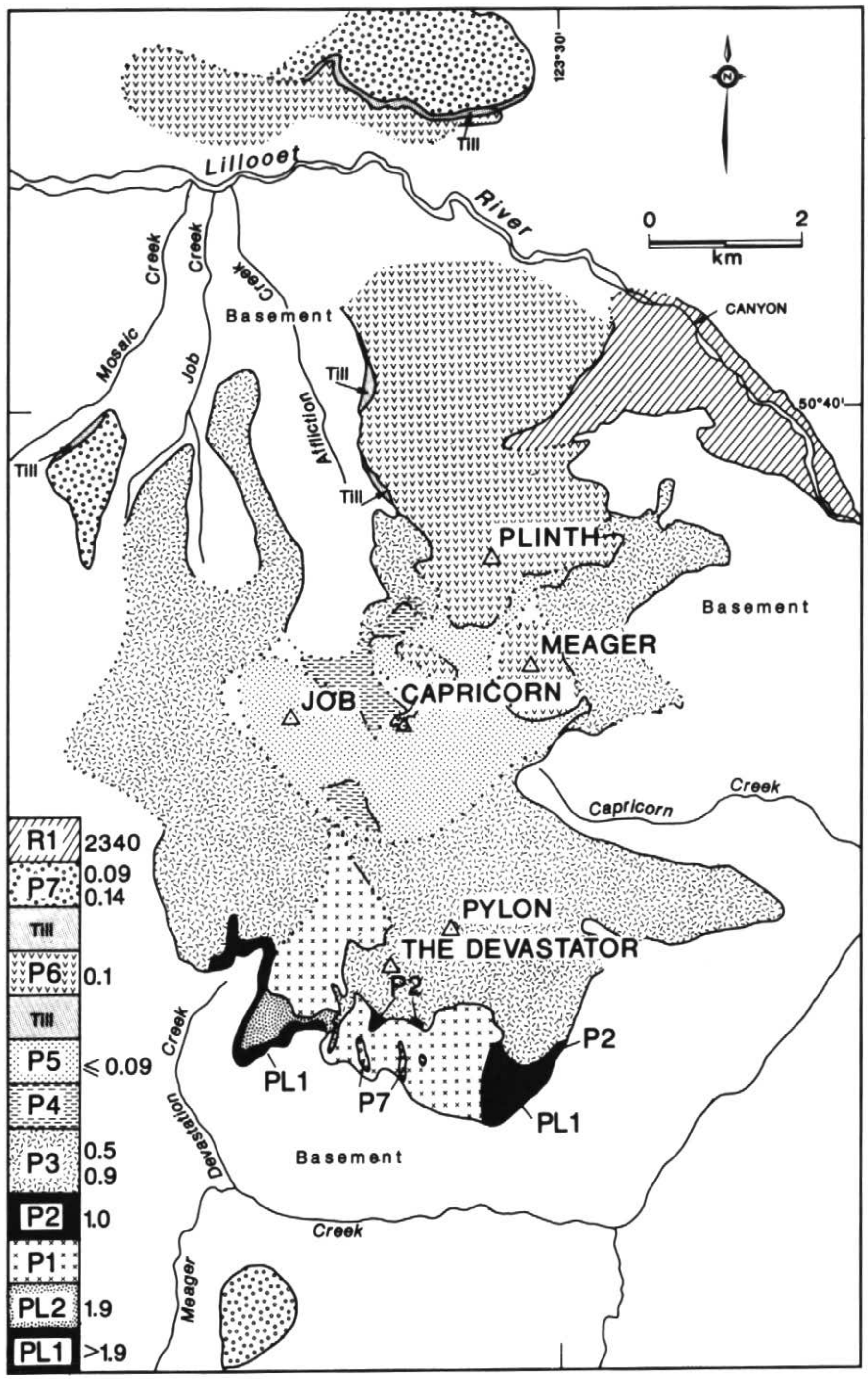

Figure 2 *Simplified geological map of Mount Meager volcanic complex. Absolute ages of the units are given beside the legend.*

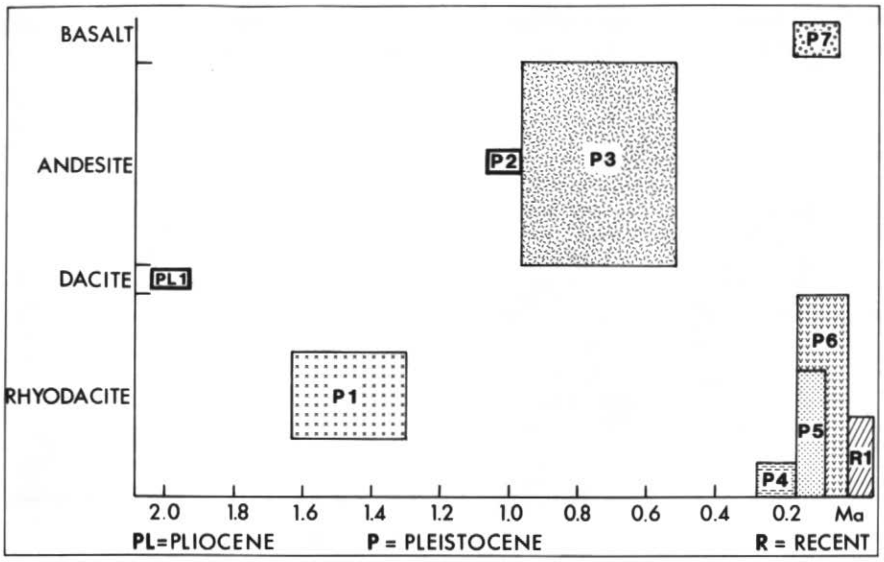

Figure 3 *Distribution of volcanic assemblages with respect to time and composition.*

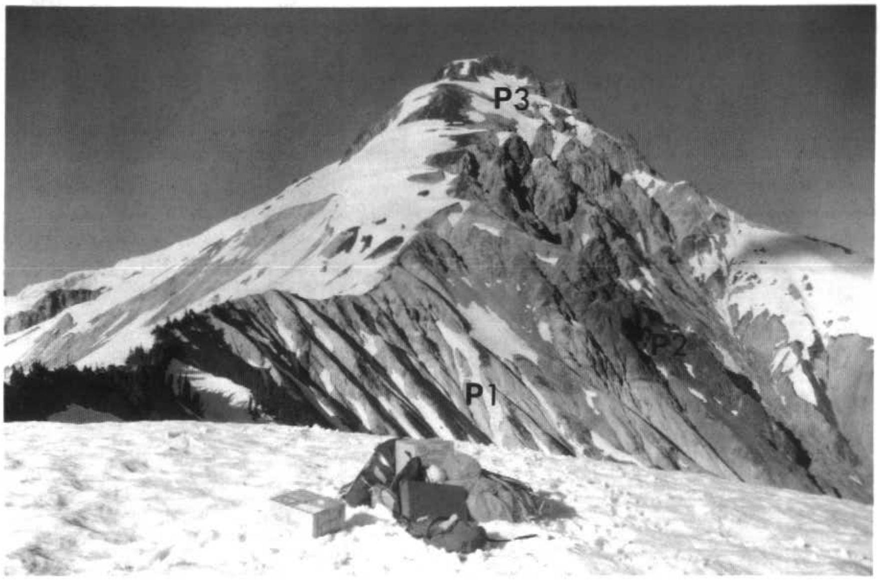

Figure 4 *On the west ridge of The Devastator, a dark lens of initial andesite flows (**P2**) separates underlying light weathering tephra of the Devastator assemblage (**P1**) from the overlying flows and hypabyssal intrusions of the Pylon assemblage (**P3**).*

Figure 5 *Massive rhyodacite lava dome of Mount Meager, the southern source of flows and breccias of the Plinth assemblage (**P6**).*

away from Plinth Peak. East of Affliction Creek, basal flows overlie till. The assemblage extends north across Lillooet valley. A whole-rock K-Ar age of 0.1±0.02 Ma indicates contemporaneity with the Capricorn assemblage. Because most of the phenocrysts of the late rhyodacite episode are xenocrysts, they are not considered representative of the rock as a whole and have not been used to name the rock. Instead, published (Stasiuk and Russell, 1989) and unpublished whole-rock analyses, which include the glassy matrix, indicate that the rocks of the last episode are mainly rhyodacite rather than dacite, which Stasiuk and Russell based on the xenocryst assemblage.

8. ***Mosaic assemblage (P7).*** A sparsely porphyritic plagioclase — augite — olivine basalt and trachybasalt form remnants of scoriaceous flows, breccias, bombs and pillow lavas. North of Lillooet River, between Job and Mosaic creeks, and south of and in upper Meager Creek, the remnants cap ridges, and veneer valley walls and floor valleys. Each of the four areas probably has a subjacent vent. Stasiuk and Russell (1989) noted the alkaline character of the basalt from thin section and from whole-rock analyses. The assemblage overlies till and rhyodacite of the Plinth assemblage and has returned whole-rock K-Ar ages of 0.09±0.06 Ma and 0.14±0.1 Ma (Anderson, 1975; Woodsworth, 1977).

9. ***Bridge River tephra and flows (R1).*** Bridge River tephra incompletely blankets the area between the north and east ridges of Plinth Peak. Within this area, crudely stratified airfall tephra deposits are up to 20 m deep on some ridge crests. Over 90% of the clasts are cream-weathering, porphyritic (plagioclase, hornblende, augite) vitric rhyolite pumice. The clasts range in 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 percent are subrounded clasts of porphyritic leucocratic quartz monzonite derived from the basement underlying the vent at the 1650 m level in Fall Creek on the northeast flank of Plinth Peak. At a locality on the Lillooet River, Stasiuk and Russell (1990) identified at least five eruptive pulses in the airfall tephra phase. Welded rhyolite and rhyodacite ash and block flows up to 7 km long and at least 145 m thick floor Lillooet River valley northeast of Plinth Peak. The welded flows temporarily dammed the river, forming a lake as indicated by an elevated strandline upstream from the flows. The oversteepened walls surrounding the Bridge River vent, carved in the Plinth assemblage, catastrophically failed, forming a debris flow which crossed Lillooet River and climbed the opposite valley wall. Nasmith *et al.* (1967) mis-identified this debris flow as the Bridge River ash. A younger rhyodacite flow up to 20 m thick erupted from the same vent near the headwall of Fall Creek. Headward cutting of about 30 cm per year and downward cutting by the river have carved the 150-m-deep Lillooet canyon. The Bridge River airfall tephra and welded block and ash flow engulfed a mature coniferous forest on the floor of Lillooet valley. Remnants of this forest, complete with forest floor, lie burnt and buried beneath the tephra with moulds of tree trunks preserved in the tephra and overlying welded flow (Figure 6). Radiocarbon dating of charred wood from the centre of a stump yielded 2490±50 years B.P. Correction for the approximate 150-year age of the tree gives 2340±50 years B.P. for the Bridge River eruption.

Springs and Vents

In the complex, springs and vents trend northerly and are spatially associated. Geological investigations do not support northwesterly trending faulting along Lillooet valley as a cause of basement porosity and permeability. Instead, fracturing in the vent areas during rhyodacite volcanism probably produced the necessary permeability to depth in the basement in this area of abnormally high heat flow. However, the northward decrease in the ages of the vents does not coincide with the area of best geothermal potential which lies on the north side of Meager valley near the oldest vent.

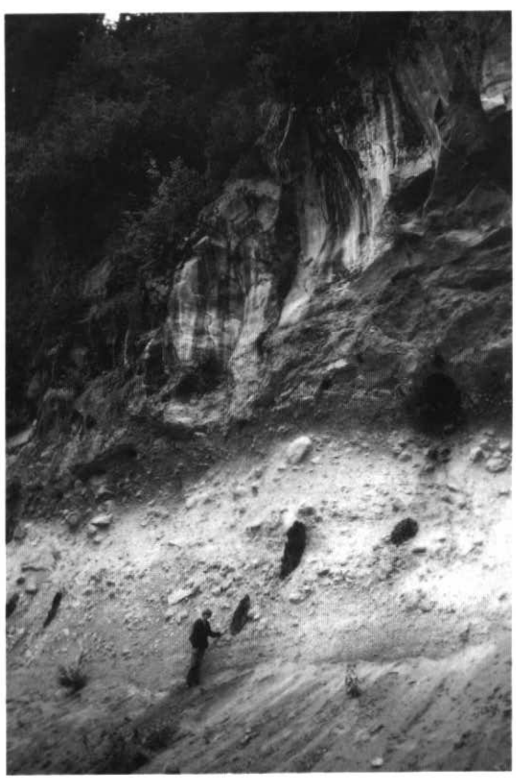

Figure 6 *Charred trees of a coniferous forest entombed by light coloured Bridge River tephra and an overlying welded block and ash flow exposed on the east bank of Lillooet River downstream from the canyon.*

Acknowledgements

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