Industrial Mineral Studies

INDUSTRIAL MINERALS IN SOME TERTIARY BASINS SOUTHERN BRITISH COLUMBIA* (92H, 92I)

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INTRODUCTION

This report summarizes results from 72 days of fieldwork investigating the occurrence of industrial minerals, and those aspects of the Tertiary stratigraphy and structure which control the development of industrial minerals, in the Princeton, Tulameen, Merritt-Guichon Creek-Quilchena Creek, McAbee, and Hat Creek basins. The industrial minerals of major interest are bentonite, zeolites and diatomaceous earth, as well as clays for brick and ceramic uses, and materials suitable for concrete aggregates. Laboratory investigations of samples are in progress, but tests of materials relative to ASTM specifications have not yet been started.

STRATIGRAPHY AND STRUCTURE OF THE PRINCETON BASIN AND PLACER MOUNTAIN OUTLIER

The Princeton Basin is a northerly trending trough filled by Eocene volcanic rocks of mainly intermediate composition comprising the Lower Volcanic Formation, and an overlying Eocene sedimentary sequence of sandstone, shale, waterlain rhyolite tephra and coal, up to 2000 metres thick, comprising the Allenby Formation (Rice, 1947; McMechan, 1983). The trough is the site of a major northerly trending half graben bounded on the east by the northerly to north-northeasterly trending Boundary fault (Figure 4-1-1). South of Princeton, northwesterly to westerly trending folds and faults break the half graben into a northern sediment-dominated segment centred on Princeton, and a southern, volcanic-dominated portion centred on Friday Mountain. The Princeton segment contains up to 1370 metres of volcanic rocks overlain by 1600 to 2100 metres of sandstone, tuffaceous sandstone, shale, waterlain rhyolite tephra and coal (McMechan, 1983, page 13). In contrast, the Friday Mountain portion contains at least 1500 metres of volcanic rocks overlain by no more than 100 metres of volcanic conglomerate, sandstone and waterlain rhyolite breccia. A brief examination of the Placer Mountain outlier of Tertiary volcanic rocks shows some 500 metres of medium grey aphanitic flows and overlying porphyritic (plagioclase, hornblende) rhyodacite flows resting on a basement of volcanogenic sediments of the Upper Triassic Nicola Group. Apparently an insufficient thickness of volcanic rocks remains in this outlier to preserve the waterlain acid tephra present in the Friday Mountain segment only 10 kilometres to the northwest.

INDUSTRIAL MINERALS OF THE PRINCETON BASIN

ZEOLITES

The Princeton Basin contains the only bedded zeolite deposits known in southern British Columbia south of latitude 51°N prior to this investigation (Hora and Kwong, 1984), and also the only bentonite deposit with production records. With the exception of the Princeton Ash, all waterlain rhyolite tuff and volcanic breccia layers are zeolitized. They form five distinct tephra lenses which range in thickness from 7 metres, with upper and lower contacts exposed, to more than 22 metres with neither contact exposed, and in length from 400 metres at Bromley Vale to 3500 metres for the Tailings tephra (Figure 4-1-1). The zeolite is heulandite-clinoptilolite which replaces original glass shards in waterlain vitric-crystal (biotite, plagioclase, sanidine, quartz) tuff, and rhyolite glass in volcanic breccia lenses of the Allenby Formation.

The tephra horizons and surrounding sedimentary stratigraphy have been mapped at 1:25 000 scale throughout the basin. Four of the horizons have been sampled in detail at 0.9-metre intervals across their exposed thicknesses at selected localities. They are briefly described following.

The Sunday Creek tephra is the only zeolitized horizon in the Friday Mountain portion of the basin; it lies within 100 metres of the base of the Allenby Formation. The tephra is mainly a fine (1 to 4-centimetre) rhyolite breccia with a vitric-crystal (biotite, feldspar, quartz) matrix and a few per cent subangular andesite clasts up to 5 centimetres in diameter. Although unbedded to crudely bedded, it contains fragments of wood up to 50 centimetres long which indicate that it is waterlain. The breccia outcrops over a distance of up to 500 metres south of the fork of Sunday Creek, in a 5-metre-high roadcut on the west side of Highway 3. The only other exposures are in the south fork of Sunday Creek downstream from Highway 3; the creek twice intersects the tephra which outlines an open, gently northerly plunging syncline. In a section sampled in detail about 100 metres downstream from Highway 3, the creek exposes a volcanic pebble to cobble conglomerate underlying a section of tephra at least 30 metres thick which grades into an overlying brownish weathering sandstone (Figure 4-1-2a). The tephra has a strike length of 1300 metres with both ends passing beneath drift.

In the Princeton portion of the basin, Asp Creek tephra is the stratigraphically lowest zeolitized horizon that has been sampled in detail. It lies about 30 metres below the unzeolitized Princeton Ash and is exposed on the highway to Tulameen at the northwest end of the single-lane bridge across Tulameen River within Princeton town limits. The tephra contains scattered plant fragments and consists of bedded, white ash with intercalated layers of vitric-crystal (biotite, plagioclase, sanidine, quartz) tuff. Because neither the top nor bottom contacts are exposed at this locality, the tephra was sampled in detail from cliffs on the right bank of Asp Creek about 500 metres upstream from its junction with Tulameen River (Figure 4-1-2b). There the tephra is 7.3 metres thick, overlies a fine-grained biotite-bearing sandstone and underlies a carbonaceous shale. The strike length of the tephra is about 1000 metres with both ends covered by drift, but with an eastern extension likely.

Tailings tephra is the most extensive zeolitized horizon in the Princeton Basin. It is exposed in a roadcut on the northwest side of Highway 3, 600 metres east of a side-road up Bromley Creek and 100 metres northeast of an operating gravel pit (Figure 4-1-2c). A few exposures lie up to 900 metres west of the highway and several lie up to 2200 metres to the east. These outcrops all lie on the north limb of a westerly trending and gently plunging syncline. About 500 metres to the south, Tailings tephra outcrops on the south limb of the syncline from the left bank of Similkameen River to the former

* This project is a contribution to the Canada/British Columbia Mineral Development Agreement.

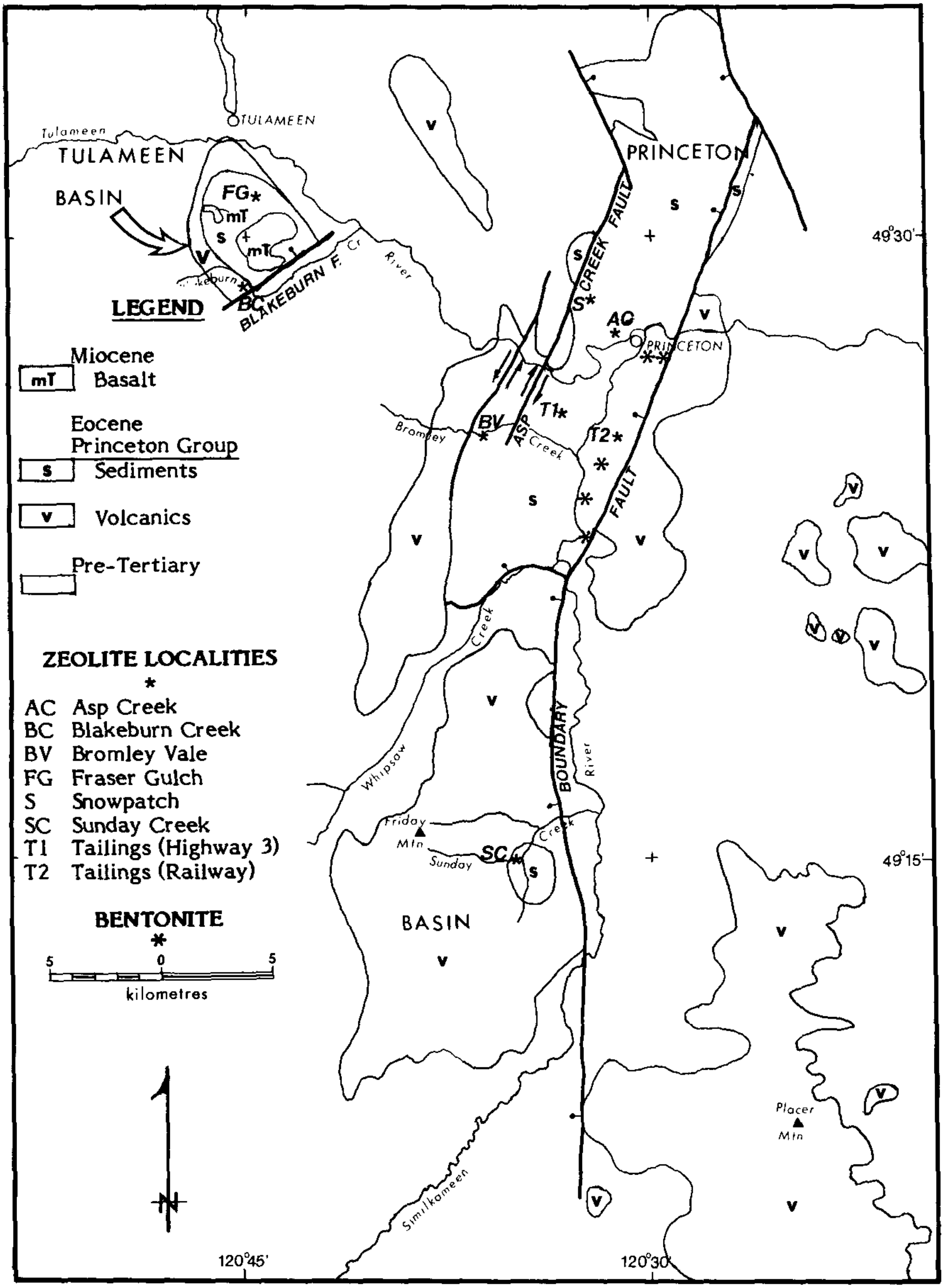

Figure 4-1-1. Simplified geological map of the Princeton and Tulameen basins showing industrial mineral localities. [Geology modified from Church and Brasnet (1983), McMechan (1983) and Monger (unpublished data)].

Copper Mountain railway grade. Along the grade, a section sampled in detail consists of a 4-metre thickness of vitric-crystal (biotite, feldspar, quartz) tuff overlain by 4.2 metres of mainly vitric rhyolite tuff. Neither the top nor bottom contacts of the zeolitized horizon are exposed. The thick montmorillonite-bearing vitric-crystal tuff layers with less than 40 per cent zeolite, surrounding a 1-metre-thick, fine rhyolite breccia with 40 to 60 per cent zeolite, as exposed in the highway section (Z.D. Hora, personal communication, 1986), are absent in the railway section. The presence of differing rock types in the two sections indicates that horizontal facies changes are present and these may have an affect on the extent of zeolitization.

A 22-metre thickness of Bromley Vale rhyolite tephra is exposed in Bromley Creek upstream from the portal to Bromley Vale No. 1 mine. It contains fragments of carbonized wood and plants (Figure 4-1-2d). Downstream, the easterly flowing creek crosses 9 metres of fine, white to cream-coloured rhyolite breccia overlain by 13 metres of white to light grey vitric-crystal (biotite, feldspar, quartz) bedded tuff and a thin, dark grey silicified (?) tuff. Neither the top nor bottom contacts are exposed and to the south very thick overburden mantles any possible extension. The tephra does not reappear to the north perhaps because of truncation by Asp Creek fault. If Asp Creek fault has a right-lateral strike-slip displacement of about 1200 metres, then Bromley Vale tephra should correlate with Tailings tephra.

Snowpatch tephra is exposed at 2825 feet (861 metres) elevation 2300 metres up the road to Snowpatch ski area from the Princeton-Tulameen Highway (Figure 4-1-1). A rockcut on the south side of the road exposes about 5 metres of yellow-ochre-weathering, coarse tuffaceous sandstone composed mainly of quartz, feldspar and biotite grains. Although neither the top nor bottom contacts are exposed, the zeolitized horizon is probably not much thicker than 5 metres. About 800 metres to the south-southwest, at 3100 feet (945 metres) elevation and east of a powerline, a dip slope exposes a 30-metre width of white-weathering vitric-crystal tuff. The strike length of the tephra horizon is 2400 metres with both ends passing under drift.

BENTONITE

Bentonite is widespread throughout the Princeton portion of the Princeton Basin, usually occurring in the shale and coal-rich sections of the stratigraphy in layers up to 2 metres thick (McMechan, 1983, page 19). Because bentonite outcrops slump shortly after exposure, only a few localities were sampled. A 4.3-metre-thick bentonite seam was exposed on the old Copper Mountain railway grade just south of the switchback about 2.4 kilometres south of Princeton, and a 1.9-metre-thick seam was exposed about 1500 metres to the east of the railway exposure (Spence, 1924, pages 9-10; Cummings and McCammon, 1952, pages 33-34). On the same railway grade, about 6 kilometres south of Princeton, a seam,

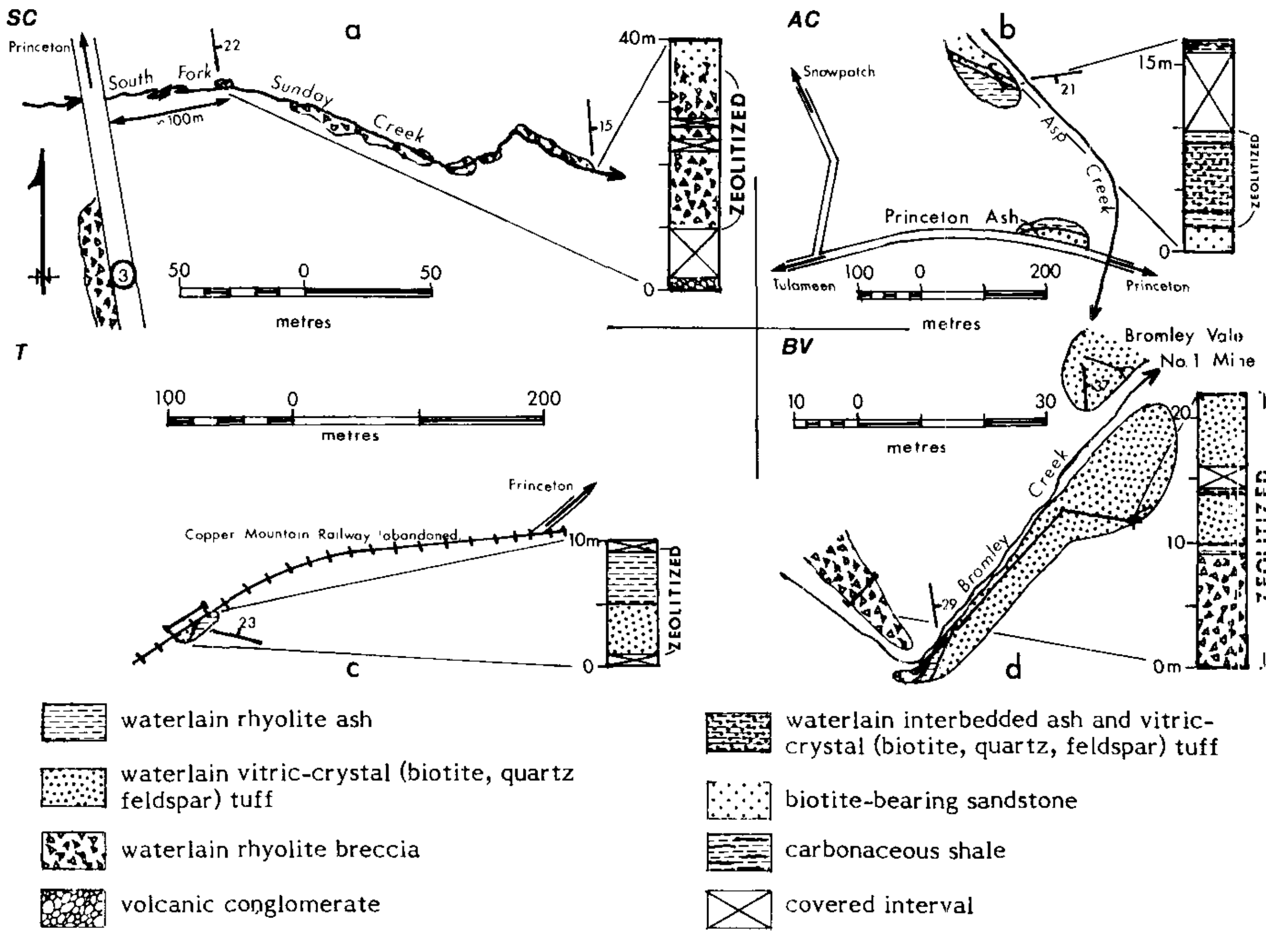

Figure 4-1-2. Geological sketch maps of sampled localities of zeolitized tephra in the Princeton Basin.

reported by Cummings and McCammon to lie 8 kilometres south of Princeton (1952, page 34), has been freshly exposed and consists of a metre of carbonaceous shale underlying a 4.9-metre-thick sequence of bentonitic siltstone, shale and bentonite, capped by 1 metre of fine sandstone. About 400 metres east of Similkameen River and 7.2 kilometres south-southwest of Princeton, McMechan (1983, pages 19-21) reported a sandy bentonite 9 metres thick which was encountered at shallow depths in boreholes. Two kilometres downstream from the mouth of Whipsaw Creek, the slumped right bank of Similkameen River exposes a 20-metre-thick sequence of siltstone, bentonitic siltstone and bentonite which is part of the highest stratigraphy exposed in the basin. Shaw (1952, page 8) mentioned that bentonite occurs in two unspecified localities in seams about 4.6 metres thick. These are probably two of the seams observed by earlier workers.

With the exception of Sunday Creek tephra, all of the industrial mineral localities briefly described lie within 8 kilometres of the Canadian Pacific Railway which passes through Princeton.

STRATIGRAPHY AND STRUCTURE OF THE TULAMEEN BASIN

The Tulameen Basin preserves 1400 metres of Eocene volcanic and sedimentary rocks which overlie the Upper Triassic Nicola Group and underlie two remnants of Miocene Plateau Basalt (Church and Brasnet, 1983). Up to 500 metres of grey sparsely porphyritic (hornblende) dacite flows and locally rhyodacite to rhyolite flows and waterlain tuffs of the Lower Volcanic Formation underlie sedimentary rocks of the Allenby Formation. Along Blakeburn Creek, the passage from volcanic to the overlying sedimentary rocks is transitional as breccias pass upwards into crudely bedded breccia and tuffaceous wacke (Figure 4-1-1). The lower part of the sedimentary sequence grades laterally from breccia and tuffaceous sandstone in the southwest to arkose in the east. A medial section of shale and coal, and an upper section of mainly sandstone and granule conglomerate with minor acid tephra, complete a 790-metre thickness of sedimentary rocks. The 90-metre-thick shale and coal section is sparsely exposed in roadcuts; the 590-metre-thick upper sandstone-conglomerate section is poorly exposed. Church and Brasnet (1983, page 49) noted that the frequency of felsic volcanic rocks increases stratigraphically upwards to where rhyolite airfall tephra forms 12 thin layers in the upper part of the coal measures. The basin is a remnant of a southeasterly plunging syncline which has been truncated on its southeast side by Blakeburn fault.

INDUSTRIAL MINERALS IN THE TULAMEEN BASIN

Waterlain acid tephras of the Lower Volcanic Formation and the lower and middle sections of the Allenby Formation are suitable host rocks for the development of zeolites. Pevear *et al.* (1980) noted that most of the tephra layers consist of angular quartz, biotite and sanidine in a finer matrix of quartz, clay and other minerals. In the northern part of the basin, relict glass shards are altered to quartz, regularly interstratified illite-smectite and minor heulandite-clinoptilolite. Preliminary X-ray diffraction results from samples of waterlain acid tephra, collected during the present investigation, show that acid tephra of the Lower Volcanic Formation is locally replaced by laumontite on the southwestern edge of the basin at locality BC (UTM coordinates FK0663200mE, FK5483100mN) (Figure 4-1-1). Although the lower part of the sedimentary section is volcaniclastic in the southwest corner of the basin, the rocks apparently do not contain zeolites. In contrast to the thin acid tephra layers in the middle shale-coal section, which contain only minor heulandite-clinoptilolite, the upper sandstone section contains a heulandite-clinoptilolite-rich vitric-crystal (biotite, quartz, feldspar) tuff that is at least 3 metres thick and can be followed for about 100 metres southeastwards from an exposure on a four-wheel-drive track at locality FG (FK0663300mE, FK5486700mN). The southwesterly dipping waterlain tuff lies within a sandstone-granule conglomerate section and passes under drift along strike. A concentration of angular acid tephra float, containing heulandite-clinoptilolite, lies beside a barbed-wire fence at FK0662100mE, FK5486100mN.

Bentonite layers up to a metre thick are part of the middle shale and coal section. Cation exchange analyses of the bentonites indicate that calcium and magnesium are the major exchangeable cations (Peaver *et al.*, 1980). No bentonite layers outcrop and the sparse exposures do not allow a proper assessment of the zeolite potential. All industrial mineral localities lie within 6 kilometres of the Canadian Pacific Railway at Tulameen or Coalmont.

STRATIGRAPHY AND STRUCTURE OF THE MERRITT-QUILCHENA CREEK-GUICHON CREEK BASIN

Tertiary rocks in the Merritt-Quilchena Creek-Guichon Creek areas are dominantly clastic sediments of the Coldwater Formation. Eocene volcanic rocks of the Kamloops Group underlie a small area southwest of Merritt and west of Lower Nicola (Figure 4-1-3). Outcrops of the Coldwater Formation are so sparse that only local stratigraphic sections up to a few hundred metres in thickness have been measured in the coal-mining area southwest of Merritt. Even Cockfield's (1948, page 33) suggested stratigraphic order of sediments of the Coldwater Formation underlying volcanic rocks of the Kamloops Group seems unlikely. As Ells (1905), White (1947) and Cockfield (1948) observed, sandstone-rich sediments of the Coldwater Formation form southeasterly plunging, open to tight upright folds southwest of Merritt. The southwesternmost sediments occupy the core of a northeasterly overturned syncline and the volcanics of the Kamloops Group, bordering the sediments on the southwest, are a lower rather than a higher stratigraphic unit. In Quilchena Valley, mainly pebble conglomerate and sandstone, with minor shale and rare coal and bentonite, comprise a gently northeasterly dipping sequence unconformably overlying the Nicola Group, and dipping into a northerly trending fault on the east (Monger, 1982). In Guichon Valley, a single area of outcrop, 6 kilometres north of Lower Nicola, exposes about 500 metres of shale, claystone, bentonite and sandstone which dips gently northeastward into the Guichon Creek fault. Northwest of Lower Nicola, Tertiary volcanics probably pass northwards and upwards into sediments of the Coldwater Formation which lie beneath the drift-covered valley floor. This succession lies between the Guichon Creek fault on the east and an unnamed fault splay on the west (Figure 4-1-3).

INDUSTRIAL MINERALS IN MERRITT-QUILCHENA CREEK-GUICHON CREEK BASIN

The Guichon and Quilchena Valleys each have bentonite localities. In the Guichon Valley (GC, Figure 4-1-3) roadcuts on the road to Logan Lake, between 5.3 and 6.7 kilometres north of Highway 8, partly expose a section of claystone, shale, and friable sandstone which outcrops more completely east of the road in the beds of the first two intermittent streams south of Morgan Creek. West of the road, bulldozer trenches and roads expose shale and slumped bentonite. In the Quilchena Valley (QC, Figure 4-1-3) bentonite and slumped bentonite, possibly 8 metres thick, outcrop in a gully at 2400 feet (732 metres) elevation east of a caved adit, just above the Quilchena Creek road. The adit and shallow trenches, which expose shale, coal and bentonite, lie 3.5 kilometres up Quilchena Creek road from Highway 5. In the Guichon Valley the bentonite locality lies less than 7 kilometres from the Canadian

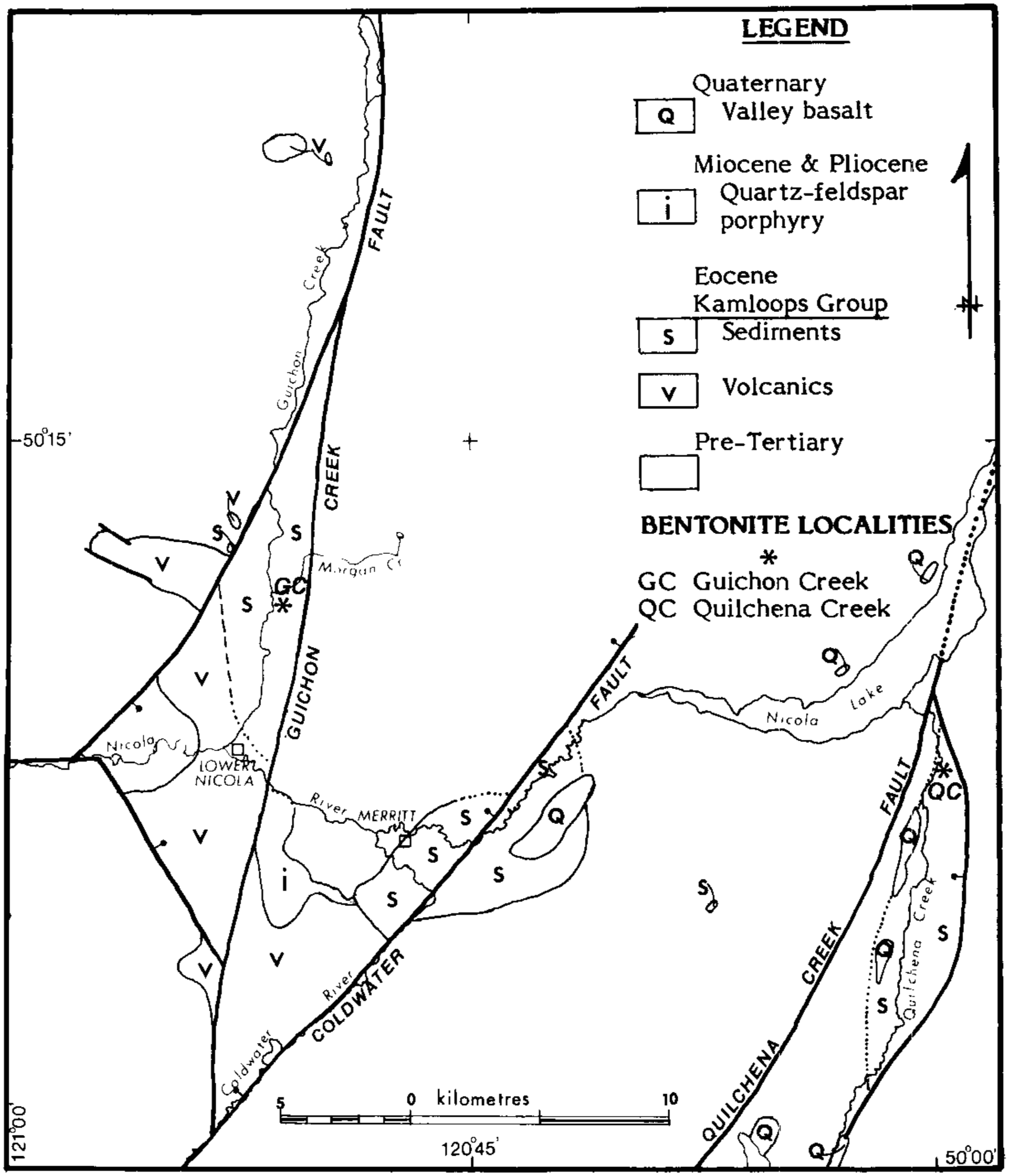

Figure 4-1-3. Simplified geological map of the Merritt-Guichon Creek-Quilchena Creek area showing industrial mineral localities [geology modified from White (1947), Preto (1979) and Monger (1982)].

Pacific Railway at Coutlee or Coyle. Bentonite occurrences in Quilchena Valley are about 27 kilometres from the railway at Merritt. Although the Coldwater Formation occupies the same stratigraphic position as the zeolitized tuffs of the Allenby Formation in the Princeton and Tulameen Basins, waterlain acid tephra, the most suitable host rock for zeolites, is unreported in the Merritt-Quilchena Creek-Guichon Creek basin. The lack of outcrop hinders an assessment of the industrial mineral potential and further investigation depends upon a planned examination of drill cores from the region.

STRATIGRAPHY AND STRUCTURE OF THE CACHE CREEK-McABEE AREA

North of the Trans-Canada Highway between McAbee and Cache Creek, Tertiary volcanic and minor sedimentary rocks overlie either volcanic rocks of the Nicola Group or dark grey slate of the Ashcroft Formation on an unconformity that has up to 250 metres of relief at the west end of the Cache Creek Hills (Figure 4-1-4). Medium grey aphanitic flows and flow breccias, and grey porphyritic (plagio-

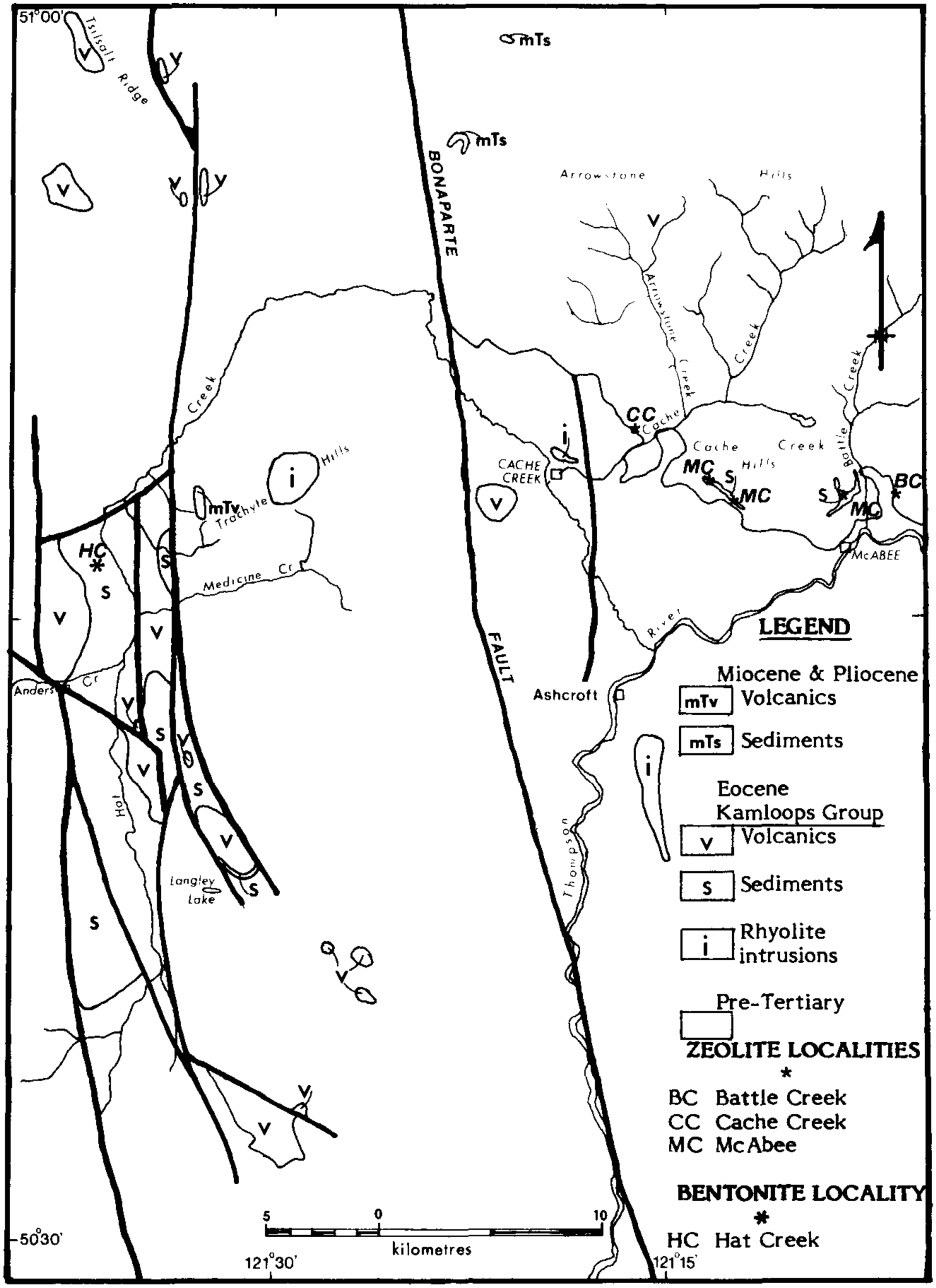

Figure 4-1-4. Simplified geological map of the McAbee-Cache Creek-Hat Creek area showing industrial mineral localities [geology modified from Church (1977), Ewing (1981) and Monger (1982)].

clase, hornblende) andesite flows of the Kamloops Group, up to a few hundred metres in thickness, underlie two lenses of sedimentary rocks. The western lens, called the McAbee sediments by Hills (1965, page 23), is 2 kilometres long, up to 30 metres thick, and outcrops in the cliffs 5 or more kilometres west of the Trans-Canada Highway culvert across Battle Creek. The lower 24 metres of section is a pebble to cobble conglomerate which underlies 6 metres of shale, carbonaceous shale, bentonite, and minor white tuffaceous siltstone. A medium grey aphanitic volcanic breccia overlies the McAbee sediments.

The second sedimentary lens, about 2 kilometres long and up to 150 metres thick, outcrops in the cliffs less than a kilometre northwest of the culvert across Battle Creek. It also contains a basal polymictic pebble to cobble conglomerate up to 30 metres thick that passes upwards into white-weathering siltstone and shale. Locally the uppermost 6 to 10 metres is a white-weathering rhyolite tuff that interfingers with the andesite lahar overlying the sediments.

White-weathering, aphanitic rhyolite dykes intrude slates of the Ashcroft Formation at the west end of Cache Creek Hills. The dykes do not intrude the Tertiary succession. Just north of the Cache Creek village limits, a body of white aphanitic rhyolite and rhyolite breccia may intrude greenstone of the Cache Creek Group. In the Trachyte Hills, 12 kilometres west of Cache Creek, a massive aphanitic rhyolite underlies a roughly circular area, 2 kilometres in diameter, and either lies on or intrudes unnamed Lower to Middle Cretaceous sediments (Church, 1977, page G109; Monger, 1982). A 6-kilometre-long body of porphyritic (biotite, hornblende, quartz, feldspar) rhyolite, which Drysdale called the Ashcroft rhyolite porphyry, outcrops south-southeast of Ashcroft and 13 kilometres from Cache Creek. Although long believed to be part of the Kamloops Group volcanic suite and to rest on deformed shales of the Ashcroft Formation (Drysdale, 1914, page 141; Duffell and McTaggart, 1952, page 67; Monger, 1982), the rhyolite locally has vertical or outward dipping contacts and shales within a metre of its margin are contact metamorphosed. All of these occurrences of rhyolite are probably intrusive into pre-Eocene but not Eocene rocks, suggesting that the earliest phase of vulcanism in the Kamloops Group was acidic.

White, waterlain, crystal-rich (biotite, hornblende, quartz, feldspar) vitric tuff locally forms thin basal lenses of Eocene sediments, up to 15 metres thick, immediately overlying grey slate of the Ashcroft Formation at and near the west end of Cache Creek Hills at FM0624400mE, FM5630400mN, and at FM0621700mE, FM5632000mN. The tuff nonconformably overlies the Guichon Creek batholith 1.5 kilometres east-northeast of the Trans-Canada Highway culvert across Battle Creek at FM0633700mE, FM5629400mN.

As the names Arrowstone Creek and Arrowstone Hills imply, the area has long been known to the Indians as a source of glassy rocks suitable for the making of stone implements. In addition, a volcanic remnant of the Kamloops Group on Tsilsalt Ridge contains obsidian (J.W.H. Monger, personal communication, 1986).

Dips are gentle in the Cache Creek-McAbee area, usually less than 20 degrees, and the irregularity of the Tertiary unconformity results from a high paleorelief and not from subsequent deformation.

INDUSTRIAL MINERALS OF THE CACHE CREEK-McABEE AREA

The basal tuffaceous lenses of the Eocene succession are commonly zeolitized with heulandite-clinoptilolite replacing original vitric fragments. North of Cache Creek and near the west end of the Cache Creek Hills (FM0621700mE, FM5632000mN), all nine samples taken from a 6-metre-thick section of bedded vitric-crystal (biotite, hornblende, quartz, feldspar) rhyolite tuff contain heulandite-clinoptilolite (CC, Figure 4-1-4). Neither the top nor bottom of this section of basal Tertiary tuff outcrops and within a hundred metres along strike it passes beneath drift. At 1900 feet (579 metres) elevation and 1.5 kilometres east-northeast of the Trans-Canada Highway culvert over Battle Creek (FM0633700mE, FM5629400mN), a minimum thickness of 6 metres of bedded vitric-crystal (biotite, hornblende, quartz, feldspar) tuff with heulandite-clinoptilolite overlies a sedimentary breccia composed of angular fragments derived from the underlying Guichon intrusion (BC, Figure 4-1-4). At FM0624400mE, FM5630400mN, a single sample from a lens of the same basal tuffaceous sandstone is not zeolitized, but poor exposures prevented proper sampling.

Within a few hundred metres above the base of the volcanic-rich Eocene section, tuffaceous sediments of the two lenses north of McAbee are commonly zeolitized (MC, Figure 4-1-4). Shale, claystone and siltstone, containing zeolitized vitric-crystal tuffs, comprise the upper 10 to 70 metres of the lenses. The bedded tuffs range in thickness from less than a metre to more than 5 metres and in rock type from heulandite-clinoptilolite-bearing vitric-crystal (biotite, hornblende, quartz, feldspar) to finely laminated vitric tuffs. In the latter, mineral assemblages range from dominantly tridymite-cristobalite through mixtures containing some of heulandite-clinoptilolite, kaolinite, montmorillonite, feldspar and quartz, to essentially pure heulandite-clinoptilolite. The lenses have not been mapped or sampled in detail.

Bentonite-bearing rocks are rare in the area. North of McAbee, the upper 10 metres of the western end of the western sedimentary lens contains friable bentonite-bearing sandstone and siltstone.

All zeolite and bentonite localities lie within 11 kilometres of the Canadian National Railway at McAbee or Ashcroft and are within 3 kilometres of the Trans-Canada Highway.

Sources of glassy volcanic rocks, potentially suitable for pozzolan, occur within the watershed of Arrowstone Creek and on Tsilsalt Ridge.

STRATIGRAPHY AND STRUCTURE OF HAT CREEK BASIN

The Hat Creek basin consists of two northerly plunging synclines and an intervening faulted anticline, preserved within a northerly trending system of easterly dipping, reverse and strike-slip faults (Figure 4-1-4). The 1500 or more metres of Late Eocene (Rouse, 1977) basin-fill consists of over 1000 metres of sediments capped by 400 to 600 metres of acid and intermediate volcanic rocks. According to Church (1977), the lowest unit consists of coal with intercalations of siltstone, conglomeratic sandstone and thin bentonite layers. Overlying the uppermost coal is a monotonous siltstone-claystone sequence that is up to 600 metres thick. For surface mapping of the very sparse outcrops in the Hat Creek Valley, the author presently prefers Monger's (1982) nomenclature and has combined both sedimentary units into the "Hat Creek Beds". Although the "Hat Creek Beds" are over 1000 metres thick in the central part of the basin, they thin dramatically to the southeast near Langley Lake where less than 100 metres lies between the basement of Cache Creek limestone and the overlying Eocene volcanic rocks. The lowest of the overlying volcanic units is rhyolitic in composition, and ranges from flows, through volcanic breccia and unbedded tuff to waterlain tuffaceous sediments. The complete range in rock types outcrops in an unnamed gully 5 kilometres north of Medicine Creek where the unit is 500 metres thick. From there the unit outcrops discontinuously for 14 kilometres southward along the east side of the Hat Creek Valley and in widely scattered locations on the west side. Aphanitic grey to maroon volcanic breccia and lahar of intermediate composition interfingers with and overlies the rhyolite flows and tephra on both sides of the valley. The highest volcanic unit consists of grey aphanitic flows of latite and dacite which outcrop on both sides of the valley. All but the lowest unit of the succession outcrop on the western limb of a faulted anticline exposed in an unnamed creek about 3 kilometres north of Medicine Creek.

Although the Hat Creek basin has been described as a graben, structural data collected during surface mapping appear to conflict with this interpretation. These data are: (1) in map pattern, the faults within and bounding the Eocene rocks at Hat Creek are convex to the west; (2) Tertiary strata in the easternmost fault panel in Hat Creek Valley dip from steeply westward through the vertical to overturned to the northeast; (3) a few small faults at 3450 feet (1052 metres) elevation in an unnamed creek 3 kilometres north of Medicine Creek are easterly dipping reverse faults and; (4) roadcuts along Highway 12, exposing the easternmost fault zone bounding the basin, show oblique-slip faults with strike-slip as the dominant component of movement. These observations seem more compatible with a northerly trending system of easterly dipping reverse faults developed either synchronously with, or followed by, strike-slip movement on the northerly trending faults and a northwesterly trending fault cutting the Eocene rocks east of Anderson River. A northeasterly striking fault of unknown displacement forms the northern limit of Eocene rocks in the Hat Creek Valley.

INDUSTRIAL MINERALS OF HAT CREEK

Bentonite is widespread and the main industrial mineral contained in the "Hat Creek Beds" and overlying acid volcanic unit. Montmorillonite, the major clay mineral component of bentonite, is widely distributed within the coal layers and in the overlying siltstone-claystone sequence (Campbell *et al.*, 1977). Bentonitic siltstone and claystone outcrop in a trench 9 metres deep at EM0597600mE, EM5625200mN (HC, Figure 4-1-4), but the hummocky topography, disturbed drainage pattern, and lack of outcrop on many of the lower slopes on the west side of Hat Creek Valley attest to the presence of bentonite in the subcrop. A detailed investigation of the bentonite potential in the Hat Creek Valley awaits a planned examination of B.C. Hydro's drill logs and core.

An X-ray diffraction examination of 31 samples of acid tephra from Hat Creek Valley shows only a trace of possible heulandite-clinoptilolite in four samples. The zeolite potential is low because the most suitable host rock is mainly altered to montmorillonite.

At the north end of the valley, a trench 200 metres long, oriented along the dip direction of the moderate east-northeasterly dipping beds, exposes a zone of burnt coal and baked sediments which is estimated to affect a zone measuring 200 by 700 metres (Church *et al.*, 1979). The baked sediments have been tested for use as a pozzolan, but they do not meet the ASTM criteria (Z.D. Hora, personal communication, 1986). Another burnt zone outcrops in a few roadcuts at EM0598600mE, EM5611700mN, but has not been tested.

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