PRELIMINARY GEOLOGY AND MINERAL POTENTIAL OF THE CASCADE RECREATION AREA (92H/2, 3, 6, 7)

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KEYWORDS: Regional geology, Cascade Recreation Area, mineral potential, Methow basin, Hozameen fault, Dewdney Creek Formation, geochemistry, veins, skarns.

INTRODUCTION

The Cascade Recreation Area was created in 1987 to preserve wilderness and heritage recreation opportunities in 167 square kilometres of the northern Cascade Mountains. The area encompasses the headwaters of the Tulameen, Snass and Skaist rivers in the Hozameen Ranges, 30 kilometres southeast of Hope and is bordered by Manning Provincial Park on the southeast and Skagit Valley Recreation Area on the south (Figure 1-5-1). The Recreation Area contains parts of several provincially significant heritage trails, including the 1858 Whatcom Trail and the 1860 Dewdney Trail. Present resource use of the area includes backcountry hiking, grazing and trail riding.

In 1990, a mineral potential study of the Cascade Recreation Area was begun, to provide government and industry with mineral resource information prior to further time-limited exploration and decisions regarding suitability for park status. The study is modelled after the methodologies developed by McLaren (1990) in the Chilko Lake area and is the first government-sponsored mineral potential study of a Section 19 Recreation Area.

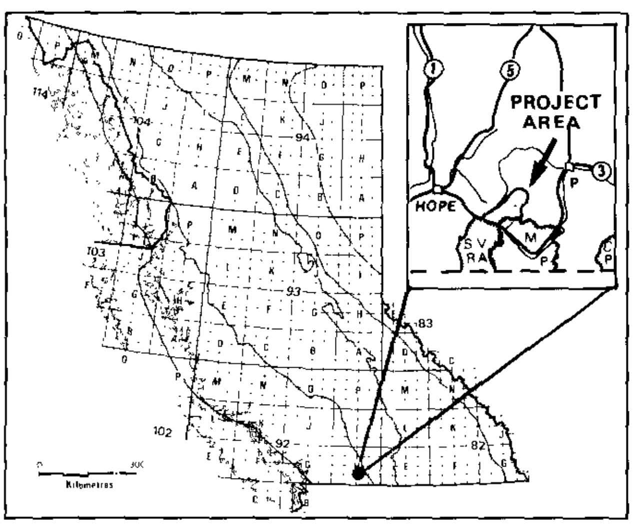

Figure 1-5-1. Location of Cascade Recreation Area, NTS 92H/2,3,6 and 7, in relation to Hope, Princeton (P), Skagit Valley Recreation Area (SVRA), Manning Provincial Park (MP), and Cathedral Provincial Park (CP).

The 1990 field project consisted of examining the regional geology, a geochemical drainage survey over the entire Recreation Area, and limited geological mapping at 1:20 000 scale in the Punchbowl Lake–Turnbull Creek area. Mineralized and unmineralized rocks, additional drainage-sediment samples, and macrofossils were collected for mineral potential and geological interpretation.

The Giant Copper (AM and Invermay) copper-gold-silver-molybdenum, Treasure Mountain silver-lead-zinc, and Ladner Creek gold properties are hosted by rocks known to extend into the Recreation Area. Despite considerable regional mineral exploration, the area received little exploration attention until the discovery of gold-silver-copper mineralization in the Punch Bowl Creek watershed in 1984 by Mr. R. Rabbit, while prospecting for the source of placer gold in the upper Tulameen River.

In 1986, the provincial Wilderness Advisory Committee (1986) studied the initial 410 square kilometre Cascade Wilderness proposal, and recommended creation of the 167 square kilometre Cascade Recreation Area. Subsequently, a mineral and placer no-staking reserve was established over the Recreation Area to prohibit further mineral exploration and mine development, including exploration on existing mineral claims. It is anticipated that the Recreation Area will be re-opened to mineral exploration, following completion of this government-sponsored mineral potential study as required under Section 19 of the *Mineral Tenure Act*.

REGIONAL SETTING AND PREVIOUS WORK

The Cascade Recreation Area is situated in the northern Cascade belt between the Coast plutonic complex to the west and the Intermontane Belt to the east. It is underlain primarily by the Methow basin, a fault-bounded, northwest-trending sequence of Lower Jurassic to Upper Cretaceous sedimentary and volcanic rocks (Jeletzky and Tipper, 1968; Coates, 1974) that records the progressive evolution of a back-arc to nonmarine basin (Davis *et al.*, 1978; Anderson, 1976; Ray, 1990). Methow basin stratigraphy can be correlated with the Tyaughton trough in the Chilcotin Mountains (Jeletzky and Tipper, 1968; Kleinspehn, 1985) and with other Mesozoic sedimentary-volcanic successions along the Coast-Intermontane boundary.

The Methow basin is bounded on the west by the Hozameen fault, which separates the basin from the Paleozoic to Jurassic Hozameen complex of the Bridge River Terrane, and on the east by the Pasayten fault which separates it from the Cretaceous Eagle plutonic complex of Quesnellia Terrane (Monger *et al.*, 1982; Monger, 1989; Greig, 1988;

LEGEND

TERTIARY

GRANODIORITE (NPP - NEEDLE PEAK PLUTON, MOP - MOUNT OUTRAM PLUTON, CB - CHILLIWACK BATHOLITH)

LATE OLIGOCENE TO EARLY MIOCENE

OMCv — COQUIHALLA FORMATION INTERMEDIATE FELSIC PYROCLASTICS AND FLOWS

EOCENE

PRINCETON GROUP

INTERMEDIATE FLOWS, VOLCANICLASTICS, ES SANDSTONE, CONGLOMERATE, ARGILLITE

CRETACEOUS

LATE EARLY, EARLY LATE CRETACEOUS

KP — **PASAYTEN GROUP**

NONMARINE SANDSTONE, CONGLOMERATE, ARGILLITE, MINOR RED BEDS, TUFF

EARLY AND MIDDLE CRETACEOUS

KJ — **JACKASS MOUNTAIN GROUP**

SANDSTONE, ARGILLITE, POLYMICTIC CONGLOMERATE

JURASSIC

LATE JURASSIC AND EARLY CRETACEOUS

JKgd — **EAGLE PLUTONIC COMPLEX**

GRANODIORITE, GNEISS, AMPHIBOLITE, MUSCOVITE BIOTITE GRANITE, MONZONITE, DIORITE, PEGMATITE

LATE JURASSIC

lJs — THUNDER LAKE SEQUENCE, SANDSTONE, CONGLOMERATE, ARGILLITE

EARLY AND MIDDLE JURASSIC

JL — **LADNER GROUP**

ARGILLITE, SLATE, SILTSTONE, TUFF

JD — DEWDNEY CREEK FORMATION OF LADNER GROUP; VOLCANIC SANDSTONE AND ARGILLITE, TUFFACEOUS SILTSTONE, WACKE, MAFIC TO INTERMEDIATE VOLCANIC FLOW, BRECCIA, RARE LIMESTONE (ON FIGURE 1-XX-3, JDV - COARSE ANDESITE BRECCIA, AGGLOMERATE AND FLOWS; JDC - MASSIVE VOLCANIC-PEBBLE CONGLOMERATE AND TUFFACEOUS SANDSTONE)

TRIASSIC AND/OR JURASSIC

TJu — **TULAMEEN COMPLEX**

ULTRAMAFICS, GABBRO, SYENODIORITE

LATE TRIASSIC

TN — **NICOLA GROUP**

MAFIC TO FELSIC VOLCANIC FLOWS, PYROCLASTICS, AND RELATED SEDIMENTS

TRIASSIC

PMu — ULTRAMAFIC ROCK, SERPENTINITE, GABBRO

PERMIAN TO JURASSIC

PJH — **HOZAMEEN COMPLEX**

UNDIFFERENTIATED CHERT, PELITE, BASALT, MINOR LIMESTONE, GABBRO AND ULTRAMAFIC ROCK

SYMBOLS

Geological boundary (defined, approximate)

Fault (defined, approximate, minor)

Thrust fault, teeth on overthrust plate

Fold axis and form

Bedding, foliation

Glacial striae

Mine or significant deposit (LC; Ladner Creek Au: E; Emancipation Au: TM; Treasure Mountain Ag-Pb-Zn: GC; Giant Copper Cu-Au-Mo)

Mineral occurrence (Figure 1-5-3)

Macrofossil site

Park or Recreation Area boundary

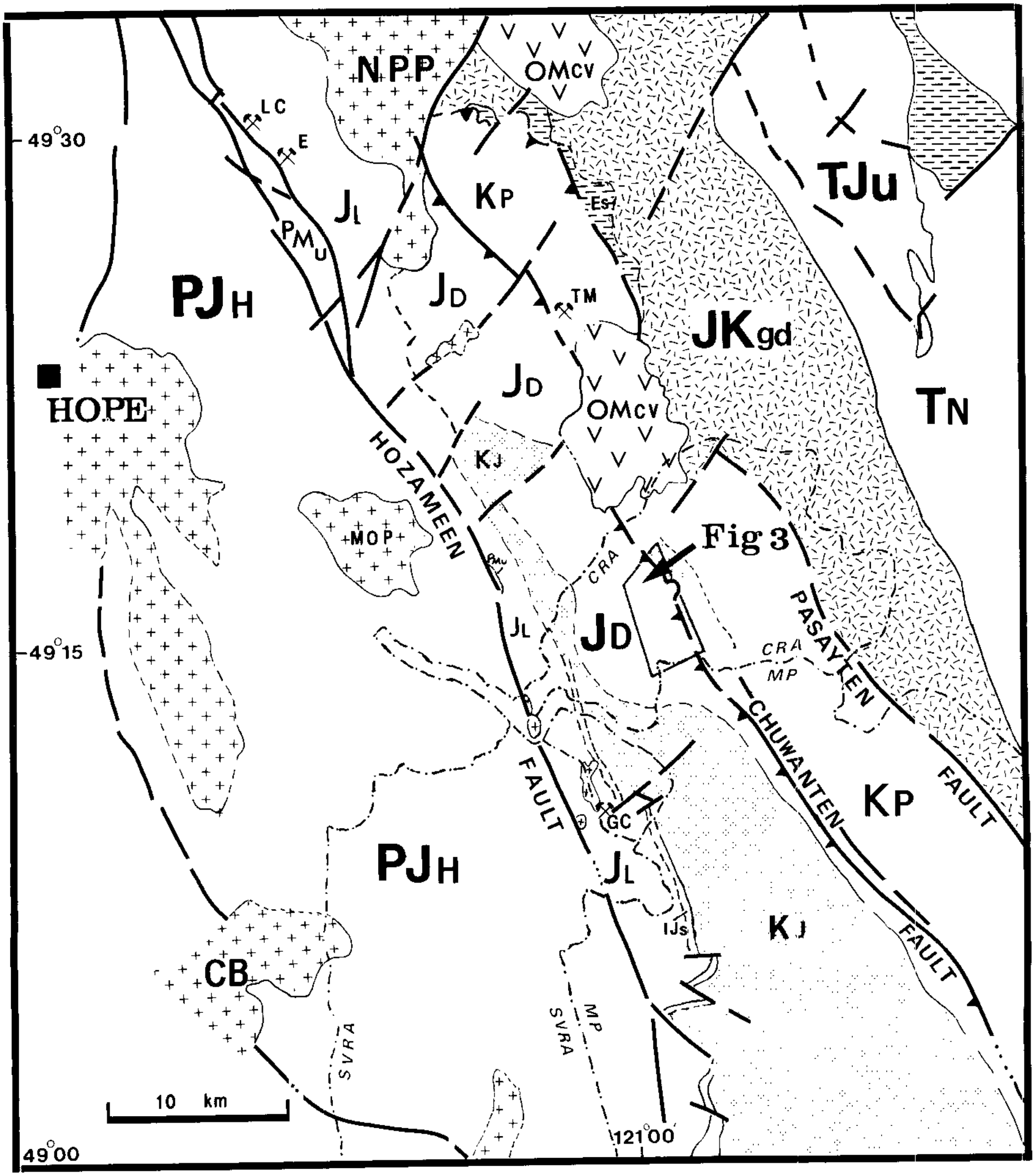

Figure 1-5-2. Regional geological setting of the Cascade Recreation Area, modified from Monger (1989) and O'Brien (1986). Methow basin lies between Hozameen and Pasayten faults and includes units JL, JD, KJ, and KP. Bridge River Terrane lies west of the Hozameen fault, Quesnellia Terrane lies east of the Pasayten fault. LC – Ladner Creek (Au); E – Emancipation (Au); TM – Treasure Mountain (Ag,Pb,Zn); GC – Giant Copper (Cu,Au,Mo). *See* text for description of units.

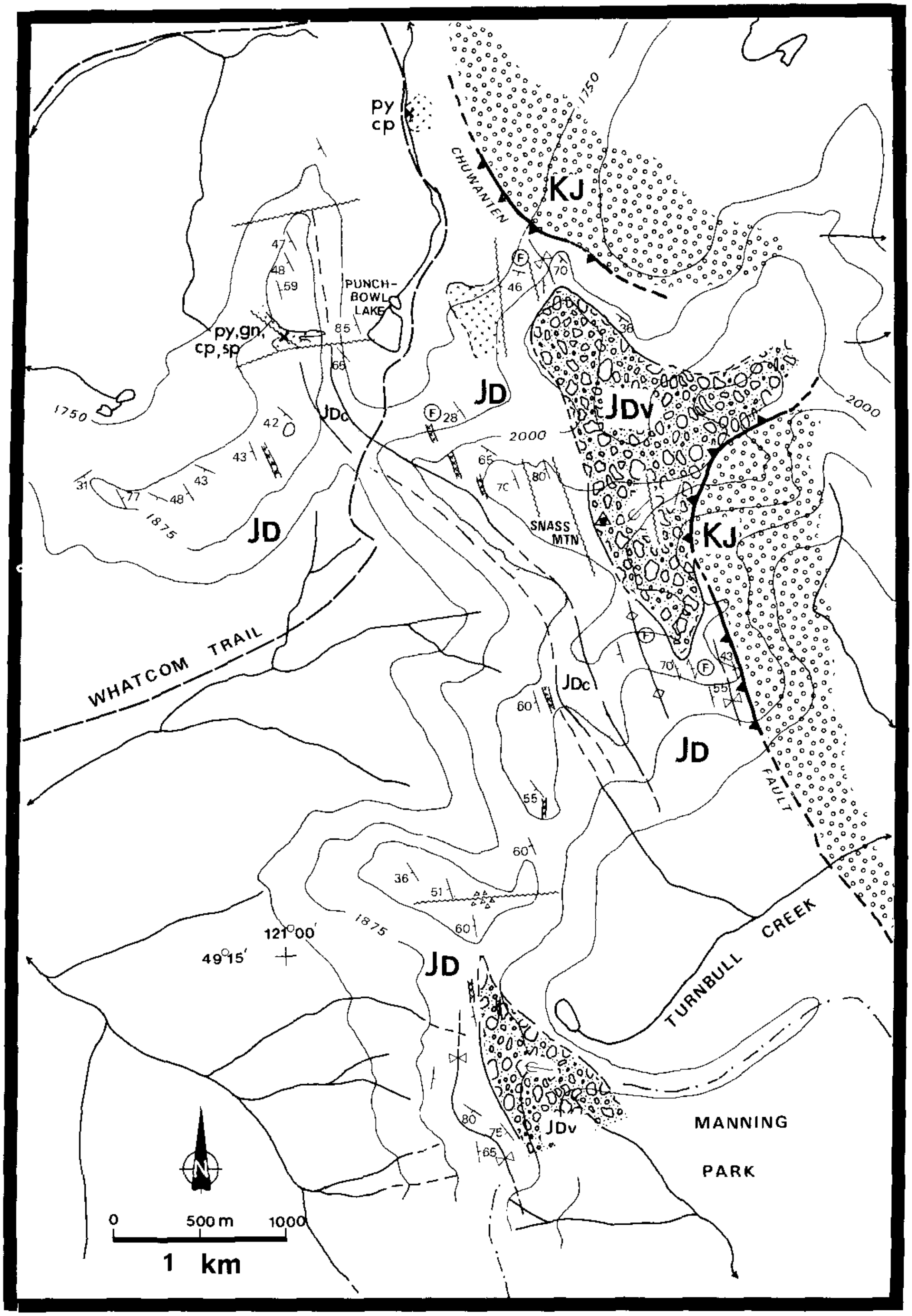

Figure 1-5-3. Detailed geology of the Snass Mountain area. *See* text for description of units.

McGroder and Miller, 1989: Figure 1-5-2). Oligocene to Miocene volcanic rocks of the Coquihalla Formation unconformably overlie the Methow basin and Eagle plutonic complex along the northern margin of the Recreation Area (Berman and Armstrong, 1980). A thin wedge of Eocene clastic rocks overlies the Eagle plutonic complex in places along the Pasayten fault. Tertiary plutons, dikes and sills intrude most rock types in the region.

The central part of the Methow basin is occupied by the northwest-trending Chuwanten fault, along which Middle to Lower Jurassic Dewdney Creek Formation is thrust eastwards onto Early to early Late Cretaceous Jackass Mountain and Pasayten groups (Coates, 1974; O'Brien, 1986). Late Cretaceous to Early Tertiary transcurrent movement along the Fraser River–Straight Creek fault system resulted in the development of a complex system of northeast-trending horsts, grabens and normal faults (Monger, 1985).

The earliest geological investigations were conducted by Lt. Palmer in 1861 and G. M. Dawson in 1877 along the Dewdney Trail (Cairnes, 1924). Geological mapping in the Recreation Area is limited to 1:50 000-scale studies of Cairnes (1924, 1944) along the north and west boundary, and Coates (1974) and O'Brien (1986) along the south and southeast boundary. Monger (1989) provides the most recent regional compilation at 1:250 000 scale. Recent metallogenic studies by Ray (1990) on geology and gold deposits of the Coquihalla gold belt and Hozameen fault system, by Meyers and Hubner (1990) at the Treasure Mountain silver-lead-zinc deposit, and by Wilton and Pfeutzenreuter (1990) at the Giant Copper deposit, provide important mineral-potential analogues.

Regional geochemical drainage-sediment data (Geological Survey of Canada Open File 865; B.C. Regional Geochemical Survey 07), and Geological Survey of Canada regional aeromagnetic survey data (Maps 8529G, 8530G, 8533G and 8534G) cover the study area at reconnaissance scales.

STRATIGRAPHY

Permian to Miocene rocks in the Cascade Recreation Area strike northwest, parallel to the axis of the Methow basin, and are divisible into five major units. Mapping in 1990 (Figure 1-5-3) concentrated on a 15 square kilometre area west of the Chuwanten fault, primarily in Jurassic strata.

HOZAMEEN COMPLEX – UNIT PJH

The Hozameen complex is exposed adjacent to the southwesternmost part of the area, north of the Sumallo River and west of the Hozameen fault. The Hozameen complex is a tectonically deformed, oceanic assemblage consisting of chert, argillite, greenstone and minor limestone (McTaggart and Thompson, 1967; Monger, 1970) of Permian to mid-Jurassic age (Haugerud, 1985). It represents a southern, faulted extension of the Bridge River complex (Schiarizza *et al.*, 1989), which together comprise the Bridge River Terrane (Potter, 1986).

LADNER GROUP – UNITS JL, JD

The Ladner Group rocks (Cairnes, 1944) of Early to Middle Jurassic age are the oldest marine clastic sediments of the Methow basin. Ray (1986) suggests a total thickness of 1500 metres for the group. Ladner sediments are exposed in two parallel, northwest-striking belts between the Hozameen fault on the west and Chuwanten fault on the east. The belts are separated by the Early to late Early Cretaceous Jackass Mountain Group (Monger, 1989).

The Ladner Group consists of a lower, marine clastic sequence (Unit JL) recording a period of tectonic quiescence, and an upper, generally conformable sequence of coarser, volcanic-rich sediments, breccia and minor flows represented by the Dewdney Creek Formation (Unit JD) which record the onset of regional volcanic activity. The lower, undivided sequence comprises lower Pleinsbachian to Bajocian argillite, siltstone and subordinate tuffaceous siltstone, wacke and conglomerate (O'Brien, 1986; Ray, 1986). It is exposed along the east side of the Hozameen fault where it underlies the west boundary of the Cascade Recreation Area near Mount Dewdney (Monger, 1989) outside the area mapped in 1990.

DEWDNEY CREEK FORMATION – UNIT JD

The upper part of the Ladner Group is represented by the Toarcian to Bajocian Dewdney Creek Formation (O'Brien, 1986, Coates, 1974). In the Recreation Area, Dewdney Creek Formation dominates the east and west belts of the Ladner Group (O'Brien, 1986; Monger, 1989).

During 1990 fieldwork, over 2000 metres of Dewdney strata west of the Chuwanten fault, from Punchbowl Lake southeast to Turnbull Creek (Figure 1-5-3), were examined. These rocks are lithologically diverse and include tuffaceous siltstones, sandstones and pebble conglomerates, crystal and crystal-lithic tuff, argillite, coarse volcanic conglomerate, agglomerate and breccia, intermediate volcanic flows, rare limestone, and calcareous siltstone. Rocks are thinly laminated to thickly bedded and are commonly well indurated and massive. Dark green to dark brown coloration dominates although there are local pale buff to grey-black colour variants. Argillites and pyritic tuffaceous units display prominent rusty weathering. Graded bedding, cross-bedding, ball-and-pillow, flame, and rip-up clast features were widely observed in finer grained strata. These features mostly indicated stratigraphic tops to the southwest. Deformation is manifest at the outcrop scale as kink banding, chevron and open undulating folds, as well as larger southeast-plunging isoclinal folds.

Much of the section is dominated by alternating thinly laminated tuffaceous siltstone and argillite interbedded with volcanic sandstone and pebble conglomerate. Plate 1-5-1 shows a typical turbiditic D-E Bouma sequence (Walker, 1984) 1.5 kilometres southwest of Punchbowl Lake.

A massive volcanic-pebble conglomerate (Unit JDc), and a massive andesitic breccia and agglomerate with subordinate intermediate volcanic flows (Unit JDv) comprise two distinct mappable units. The pebble conglomerate is characterized by resistant cliff-forming beds, 50 to 100 metres

Plate 1-5-1. Dewdney Creek Formation (Unit JD): interbedded tuffaceous siltstone, sandstone and argillite showing D-E Bouma sequence and undulating folds. Minor fold below hammer plunges into hill. Located 1.5 kilometres southwest of Punchbowl Lake.

Plate 1-5-2. Jackass Mountain Group (Unit KJ): imbricated polymictic conglomerate adjacent to the Chuwanten fault north of Snass Mountain. Cobbles are mostly derived from Eagle plutonic complex (Unit JKgd).

thick, extending over a strike length of more than 4 kilometres. The andesitic volcanics crop out west of the Chuwanten fault, generally north of Snass Mountain, and comprise primarily breccia and agglomerate with angular to subangular fragments up to 0.8 metre across, and lesser andesitic flows and volcanic conglomerate with subrounded clasts less than 10 centimetres in diameter, and rare limestone. Locally, the underlying tuffaceous sediments coarsen upwards into the coarse volcanic sequence; elsewhere the coarse breccia unconformably overlies the finer grained strata.

The Dewdney Creek Formation is intruded by a variety of aplite, diorite and gabbro dikes and sills, typically less than 2 metres thick and rarely exposed for more than 20 metres along strike.

Although the Dewdney Creek Formation contains thick sections of unfossiliferous strata, several intervals contain an abundant ammonite and bivalve fauna.

Jackass Mountain Group – Unit KJ

The Jackass Mountain Group comprises Hauterivian to Albian marine sandstone, polymictic conglomerate, volcanic lithic wacke and pelite. It is exposed in a narrow belt separating the two Ladner Group belts (Monger, 1989). Jackass Mountain strata were mapped in this study east of the Chuwanten fault, east of Punchbowl Creek and east and south of Snass Mountain, where they are overthrust by the Dewdney Creek Formation. Along the Chuwanten fault, the Jackass Mountain strata consist of massive polymictic conglomerate with imbricated and well-rounded granitic cobbles (Plate 1-5-2), and minor interbedded light grey sandstone.

Pasayten Group – Unit KP

The upper Albian to Cenomanian Pasayten Group (Rice, 1947; Coates, 1974) represents a nonmarine succession of predominantly sandstone, siltstone, minor conglomerate and shale which underlies the eastern part of the Methow basin. These rocks were not mapped during the 1990 field area.

Coquihalla Formation – OMCv

Oligocene to Miocene calcalkaline intermediate to acid pyroclastics, flows and intrusions unconformably overlie and crosscut the Dewdney Creek Formation and the Pasayten Group along the northern boundary of the Recreation Area. These rocks belong to the Coquihalla Formation (Monger, 1989) and were recently studied near Coquihalla Mountain by Berman and Armstrong (1980), who concluded that the volcanics are coeval with the Pemberton volcanic belt.

INTRUSIVE ROCKS

Unit PMu

Ultramafic rocks consisting of gabbro and serpentinite, related to the Coquihalla serpentine belt (Ray, 1986; 1990) are exposed as a narrow fault-bounded sliver along the Hozameen fault north of the Sumallo River. Gabbro dikes and sills up to 3 metres wide and several metres long intrude the Dewdney Creek Formation in several locations.

Eagle Plutonic Complex – Unit JKgd

The Cretaceous Eagle plutonic complex underlies the northeastern part of the Recreation Area east of the Pasayten fault. Greig (1988) mapped the complex to the north and recognized three major units: a western muscovite granite and an eastern foliated to gneissic granodiorite, separated by a heterogeneous gneiss. Although these rocks were not examined, numerous glacial erratics derived from the complex were encountered at elevations over 2000 metres, indicating a minimum of 10 kilometres southwest-directed ice transport.

Tertiary Intrusions – Units Mgd, Mb

Tertiary stocks, plugs, dikes and sills are widespread through the region. A Miocene granodiorite plug dated at 87 Ma (Coates *in* Wanless *et al.*, 1967) intrudes the Hozameen fault, Hozameen complex, Ladner Group and ultramafic rocks where the fault crosses Highway 3 in the southwestern corner of the Recreation Area.

Near Punchbowl Lake, several aplite and diorite dikes invade Tertiary(?) brittle faults, and occur as sills and dikes in Dewdney Creek strata. A granodiorite intrusion of unknown dimensions is exposed in lower Punchbowl Creek where it is associated with disseminated pyrite and chalcopyrite mineralization.

South of Punchbowl Lake, and in the headwall above upper Turnbull Creek, several gabbro and diorite dikes and sills intrude the Dewdney Creek Formation. Narrow zones of hornfelsing and pyritization occur locally at the contacts with argillaceous sediments.

GEOCHEMISTRY

A drainage-sediment (moss-mat) and water geochemical survey was conducted over the entire Recreation Area, under contract to MPH Consulting Ltd. A total of 74 sites were sampled, for a site density of 1 per 2.3 square kilometres. Standard RGS collection and quality-control methods were used. Sediment analyses for a wide range of elements, currently in progress, will be used to guide further mineral-potential mapping and interpretation.

MINERAL OCCURRENCES

Five mineral occurrences are known in the Recreation Area and are briefly described below. Information on two previously undocumented occurrences will be added to MINFILE.

Ultramafic-hosted Gold and Nickel-bearing Veins:

Forks (092HSW040): Nickeliferous pyrrhotite occurs in serpentinite along the Hozameen fault north of Highway 3 in the southwest corner of the Recreation Area.

Skarns

BB (Rainbow) (092HSW042): Skarn and related vein mineralization occur along the contact of a Miocene quartz diorite and Hozameen greenstone and limestone. Mineralization consists of pyrite, arsenopyrite, sphalerite and minor chalcopyrite and galena, with variable concentrations of gold, silver, copper, zinc, lead and antimony.

Granite and Pegmatite-hosted Molybdenum and Tungsten:

Granite Scheelite (092HSE101): Quartz veins in Eagle granodiorite and pegmatite reportedly contain molybdenite and scheelite.

Mesothermal Veins:

Punchbowl Claims: Southwest of Punchbowl Lake, quartz veins exposed along the contact between several diorite dikes and fine-grained clastics of the Dewdney Creek Formation, contain variable amounts of pyrite, galena, chalcopyrite and sphalerite. Several trenches are located near the ridgetop southwest of Punchbowl Lake, in the area of most intense mineralization and ankeritic alteration. In this mineralized area, a 3-metre-wide diorite dike shows minor right-lateral displacement along a splay of an east-trending fault. Cardinal

(1986a, b) and Kallock (1987) report concentrations of 770 ppm zinc, 720 ppm lead, 1100 ppm arsenic and 215 ppb gold in quartz veins from the occurrence. The occurrence was mapped and sampled in detail during 1990, and geochemical analyses are in progress.

Punchbowl Creek: Approximately 1 kilometre north of Punchbowl Lake, a poorly exposed hornblende diorite plug intrudes Dewdney Creek Formation argillite and tuffaceous siltstone in a deeply incised part of Punchbowl Creek. Pyrite and chalcopyrite occur in quartz veins and as disseminations and streaks along cleavage and fracture planes. Mineralization is exposed intermittently over a length of 100 metres along the creek. Several mineralized samples were collected to determine the trace element content. The areal extent of the intrusive rocks and their possible relationship to the nearby Chuwanten fault will be further examined during the 1991 field season.

SUMMARY: MINERAL POTENTIAL

The Cascade Recreation Area encompasses a thick succession of marine and nonmarine sedimentary and volcaniclastic rocks. These rocks record Early Jurassic to Late Cretaceous progressive restriction and infill of the Methow basin. The margins of the basin are delineated by the Hozameen fault on the west, which separates the basin from the Bridge River Terrane, and by the Pasayten fault on the east, against which Eagle plutonic complex rocks are juxtaposed. Accretionary tectonics have produced a system of major northwest-trending faults and Tertiary transtensional faults and associated intrusions. The varied depositional settings and complex structural history have created a variety of metallogenic environments.

The Chuwanten fault trends northwest through the area to Treasure Mountain and the Summit Camp, where it has provided the locus for intrusive and hydrothermal activity giving rise to numerous silver-lead-zinc vein deposits. Preliminary investigation of the Punchbowl Creek occurrences provides evidence that similar metallogenic environments may exist in the Cascade Recreation Area. Additional fieldwork will be carried out in this area in 1991.

In the southwest corner of the Recreation Area, a variety of base and precious metal skarn and vein deposits occur in a complex geological setting. A Miocene granodiorite has intruded the Hozameen fault zone, Hozameen greenstone and limestone, Ladner sediments, and ultramafic rocks. Mineralization in this area contains copper, zinc, gold, silver, tungsten, nickel, arsenic and antimony. The occurrences will be examined in the 1991 field season and the potential for discovering similar additional mineralization will be assessed.

The Eagle plutonic complex is exposed in a belt 1 to 4 kilometres wide along the eastern side of the Recreation Area. Recent mapping of the complex to the north indicates that the dominant rock types along its western margin are muscovite granite, monzonite and pegmatite. Molybdenum and tungsten prospects are recognized to the north in these rocks, and therefore potential also exists for discovery of these commodities in the Recreation Area. There is largely untested potential for tin, flourine and rare-earth elements in these rocks. Heavy-mineral drainage-sediment samples will be collected during the 1991 field program to further test these possibilities.

ACKNOWLEDGMENTS

The following individuals are thanked for their varied contributions to this project: G. Ralph and staff of the Ministry of Parks, Manning Park Zone, for their cooperation and hospitality during our fieldwork; H.P. Wilton, V.A. Preto, and J.W.H. Monger for discussions on regional geology; W. Jackaman and T. O'Niell, for directing the geochemical survey; and Valley Helicopters Ltd. in Hope for exemplary helicopter service.

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NOTES