GEOLOGY OF THE KLAWLI LAKE, KWANIKA CREEK AND DISCOVERY CREEK MAP AREAS, NORTHERN QUESNEL TERRANE, BRITISH COLUMBIA
(93N/7W, 11E, 14E)

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KEYWORDS: Regional geology, Nina Creek, Lay Range, Takla, Slate Creek, Inzana Lake, Witch Lake, Plughat Mountain, Chuchi Lake, Twin Creek, Jurassic sediments, mineralization, structural geology, Manson fault, Discovery fault, dextral transfer.

INTRODUCTION

This report covers 1:50 000-scale geological mapping of 93N/7 West Half, 93N/11 East Half and 93N/14 East Half, completed in the summer of 1992, the third and final mapping season of the Nation Lakes project. The maps are available as Open Files 1993-3, 4, and 5 (Nelson *et al.*, 1993a, b; Bailey *et al.*, 1993). The area, shown on Figure 1-7-1, links previously published map coverage by the Nation Lakes project (Nelson *et al.*, 1991b, 1992a) with that of the Manson Creek and Northern Quesnel Trough projects (Ferri *et al.*, 1988, 1989, 1992c; Ferri and Melville, 1990b).

Mapping highlights include a major northwest-trending aeromagnetic high in the Valleau Creek valley, Takla Group

stratigraphy and structure around the Takla-Rainbow property, and a regional transcurrent fault system in the Discovery Creek map area. Exploration activity was quiet in the northern Quesnel belt following Placer Dome's decision to shelve the Mount Milligan project and the dissolution of B.P. Resources Canada Limited.

MAPPING GOALS

Mapping goals in 1992 were directed toward resolution of the following problems:

- Work in 1990 and 1991 led to a fourfold stratigraphic subdivision of the Takla Group in map areas 93K/16, 93N/1, 93N/2E and 93N/7E (Nelson *et al.*, 1991a, 1992b). Do these informal formations, the Rainbow Creek, Inzana Lake, Witch Lake and Chuchi Lake, persist northward, or do gross facies changes intervene? In particular, what is the relationship between this stratigraphy and that proposed by Ferri and others in the Germansen Lake area (Ferri and Melville, in preparation).
- On the basis of mapping for Eastfield Resources Limited and Golden Rule Resources Limited, David Bailey (personal communication, 1991) reported a Triassic-Jurassic unconformity in the Twin Creek area on the Takla Rainbow property. Farther south, the contact between Triassic and Jurassic volcanic rocks is apparently transitional (Nelson *et al.*, 1992b). How could these conflicting observations be reconciled?
- Regional aeromagnetic coverage shows a very strong northwest-trending linear magnetic anomaly in the Valleau Creek valley. It terminates abruptly near Klawli Lake. What is the geological source of this anomaly? Does it bear any relationship to alkalic porphyry copper-gold deposits?
- Do potassic-propylitic alteration haloes, common around the Nation Lakes, persist northward within the Takla Group?
- The Discovery Creek area is transected by the northern extension of the Manson fault zone, a regional dextral transcurrent fault which apparently dies to the north near Wasi Creek (Figure 1-7-2; Ferri *et al.*, 1992c). A second array of dextral faults occurs in the Discovery Creek valley but dies southward near Germansen Lake. A reasonable structural model involves the transfer of motion from the Manson fault zone to the Discovery Creek fault system. What is the nature of this transfer zone?
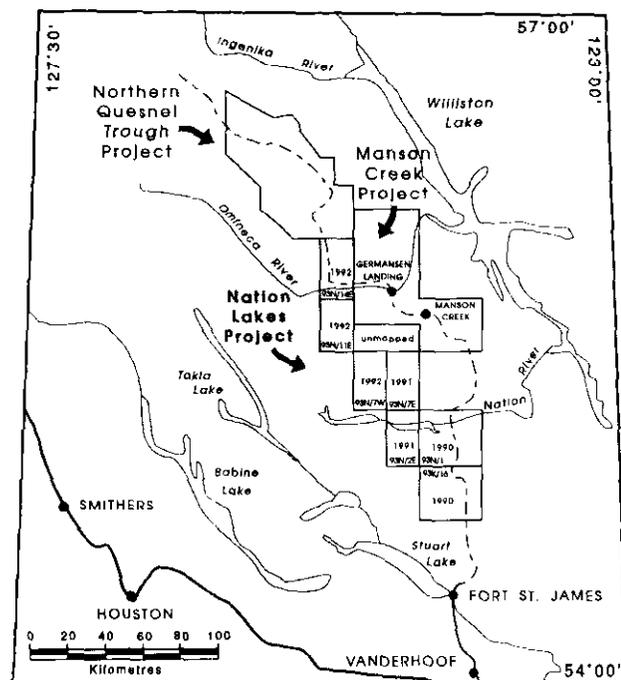

Figure 1-7-1. Location map showing Nation Lakes, Manson Creek and Northern Quesnel Trough projects. Shaded area depicts 1992 map area.
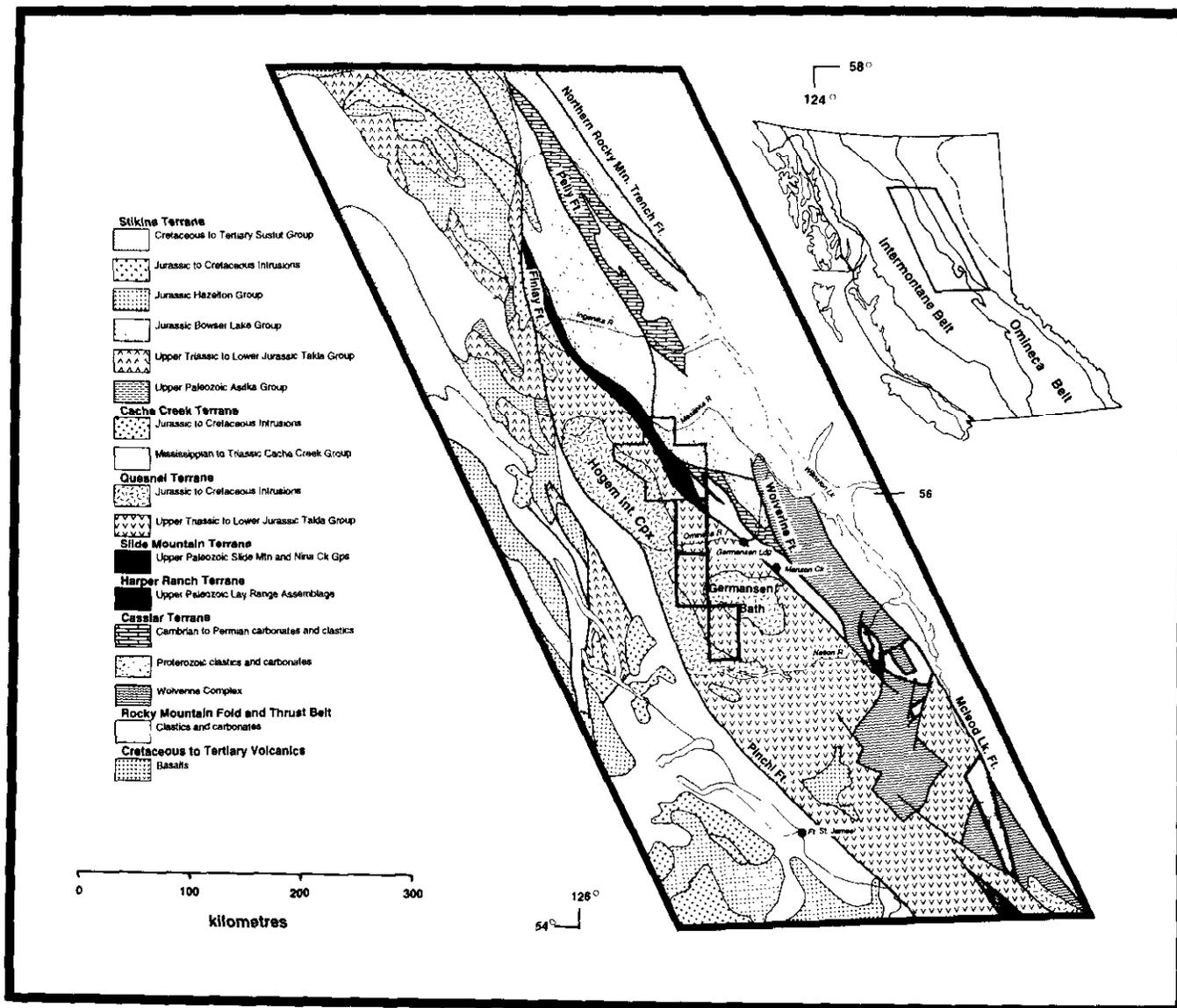
Figure 1-7-2. Regional geological setting of the Nation Lakes area. Small squares represent Nation Lakes 1992 mapping, The larger area depicts mapping of the Uslika Lake area (modified after Ferri *et al.*, 1992a).

GEOLOGIC OVERVIEW

Most of the mapped area is underlain by the Upper Triassic to Lower Jurassic Takla Group of the Quesnel Terrane (Figure 1-7-2). It is intruded to the west by the Hogem intrusive complex (Garnett, 1978; Nelson *et al.*, 1992b). Lower Jurassic sedimentary rocks, slightly younger than the volcanic Takla Group, form a single panel within the Discovery Creek fault zone 2 kilometres north of the Omineca River. They contain a rich ammonite fauna of latest Toarcian age (Table 1-7-1). Rocks of the upper Paleozoic Lay Range assemblage, part of the Harper Ranch Terrane, and Nina Creek group, belonging to the Slide Mountain Terrane, occur in fault-bounded panels east of the Discovery Creek fault system in 93N/14. Cretaceous to Early Tertiary units are restricted to the Discovery Creek fault zone.

STRATIFIED UNITS

NINA CREEK GROUP

Upper Paleozoic oceanic rocks of the Slide Mountain Terrane, termed the Nina Creek group, form a large klippe above the miogeoclinal Cassiar Terrane in the Nina Creek area (Ferri and Melville, in preparation). The Nina Creek group comprises a lower package of Pennsylvanian-Permian pelagic sedimentary strata with gabbro sills, termed the Mount Howell formation, and an upper, Pennsylvanian-Permian basaltic pile with minor chert and argillite called the Pillow Ridge formation. The age overlap between the two suggests that they are separated by a thrust fault rather than a stratigraphic contact. The two formations are probably facies packages that have been subsequently telescoped.

TABLE 1-7-1
FOSSIL IDENTIFICATION

REPORT J1-1992-GKJ

Report on Jurassic fossils from the Manson River map area (93N14) and submitted by J. Nelson (BCGS) in September 1992, for identification.

Field No.:	92-JN-24-1 G.S.C. Loc. No.: C-189742
Locality:	*Discovery Creek, Takla Group. UTM 368600E 6187000N.*
Identifications:	ammonites
	Pleydellia n.sp.
	Lytoceras sp.
	Phymatoceratidae n.gen. et n.sp.
	ammonite aptychi
	bivalves
Age & Comments:	late Late Toarcian

Field No.:	92-JN-21-4 G.S.C. Loc. No.: C-189663
Locality:	Discovery Creek, approximately 2.25 km from road crossing. UTM 367500E 6187975N. Takla Group.
Identifications:	pelecypods
	rhynchonellid brachiopods
	belemnite
Age & Comments:	The presence of a belemnite with an internal radiating structure suggests an age younger than Middle Toarcian.

Field No.:	92-JN-21-5 G.S.C. Loc. No.: C-189664
Locality:	Discovery Creek, approximately 2.25 km from road crossing. UTM 367525E 6188050N. Takla Group.
Identifications:	ammonites
	Dumortieria n.sp.
	Phymatoceratidae n.gen. et n.sp.
Age & Comments:	late Late Toarcian

Field No.:	92-JN-22-1 G.S.C. Loc. No.: C-189665
Locality:	750 m northeast of Ron Repko's house. UTM 370000E 6186825N. Takla Group.
Identifications:	crinoid columnals
Age & Comments:	not diagnostic

Note: Data contributed by G.K. Jakobs, Visiting Scientist, Geological Survey of Canada, Vancouver

The northeastern corner of 93N/14 is underlain by the Nina Creek group (Figure 1-7-3). Although outcrop control on the contact is poor, it apparently rests structurally on the lower Mississippian Gilliland felsic tuff unit of the Cassiar Terrane (Ferri and Melville, in preparation).

MOUNT HOWELL FORMATION (PPmh)

The lower part of the Nina Creek group is a monotonous sequence of grey to black argillite/chert and green chert that dips moderately to the southwest. It is overlain by 50 to 75
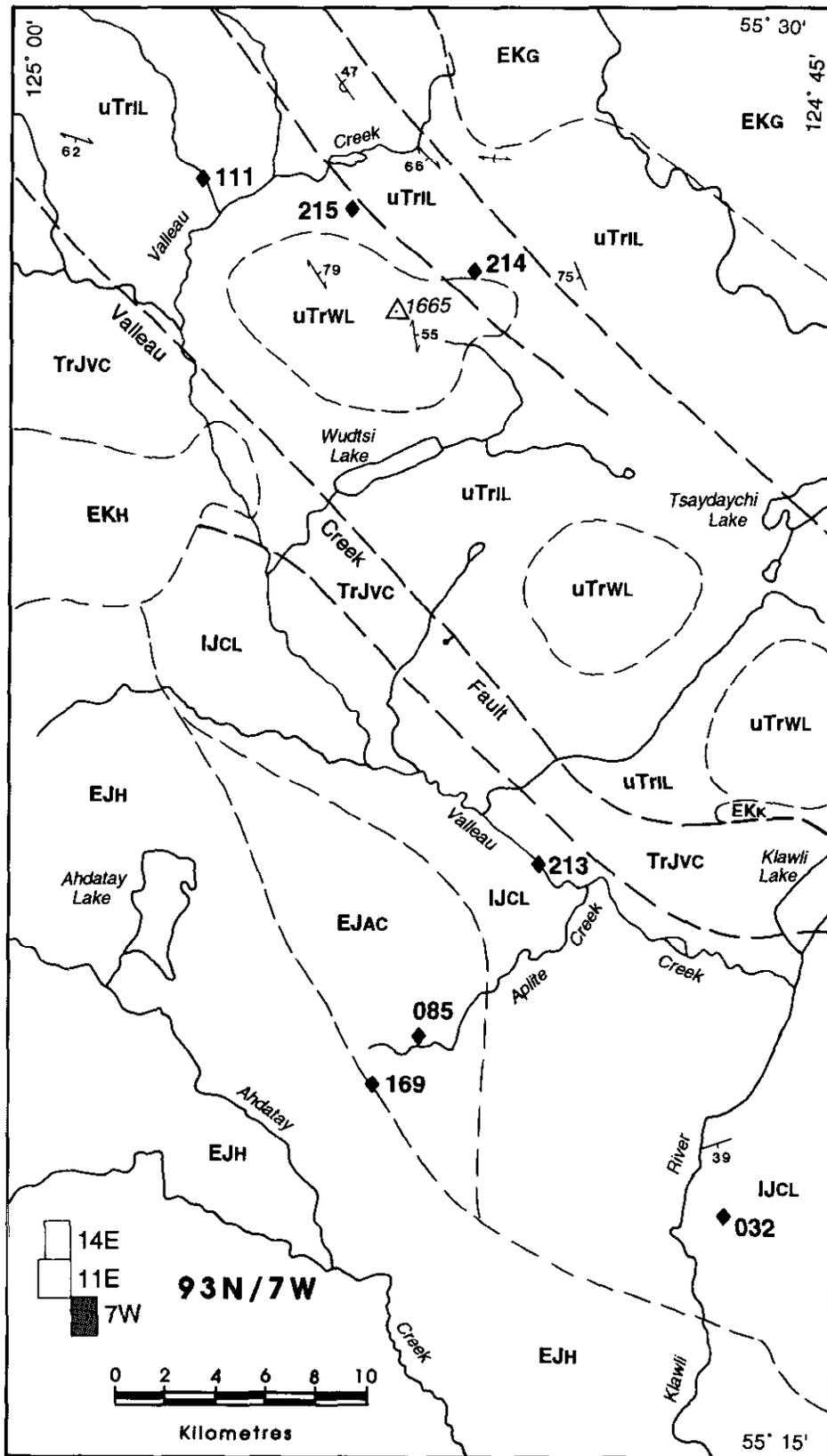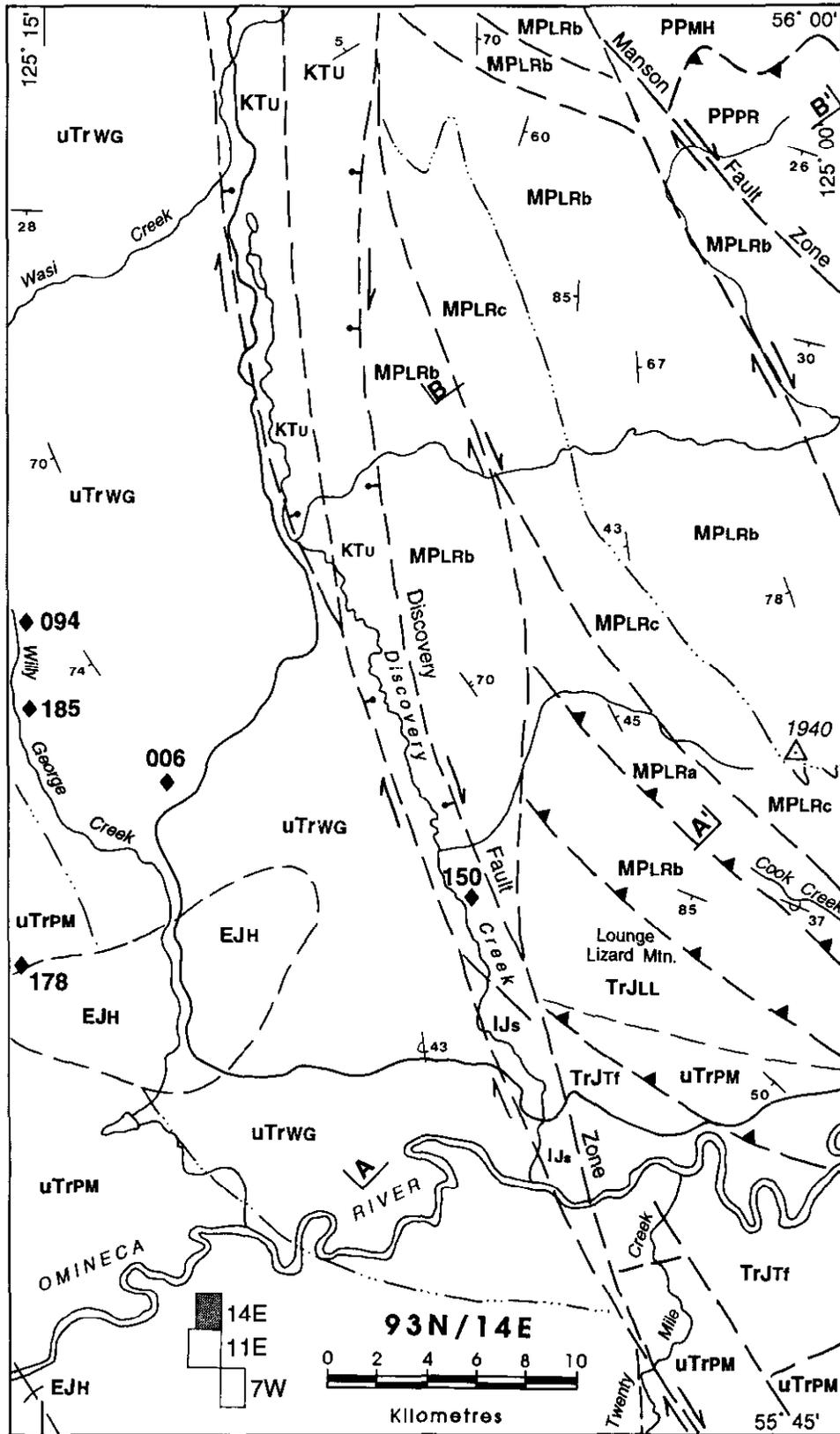
Figure 1-7-3. Geology of the Klawli River (93N/7W), Kwanika Creek (93N/11E) and Discovery Creek (93N/14E) map areas. *See* following pages for adjoining map sheets and legend.

55° 45'

125° 20'

125° 00'

△1818
Eaglenest Mtn.

uTrPMa

5

EJH

uTrPM

C'

uTrPM

D

067

uTrPM

EJH
+
uTrPM

077

Goat
Ridge

IJTC

uTrPM

h Tvs

EJH

26

△169?

uTrPM

IJTC

uTrPMb

5

Twin

15

IJTC

West Dog Creek

082

095

IJTC

IJTC

58

Twin

Creek

uTrPMb

IJTC

uTrPM

uTrPM

Creek

25

IJTC

Twin Creek

IJTC

uTrPM

EKH

Fault

IJTC

28

Groundhog Creek

uTrPMb

Caribou
Mtn.

50

C

IJTC

27

212

uTrPM

EJH

IJTC

uTrPM

Creek

IJTC

muTrsc

uTrPMb

D'

Moly
Lakes

EKG

Kwanika

75

muTrsc

EJH

14E
11E
7W

IJTC

93N/11E

hTriL

0 2 4 6 8 10

TrJVC

EJH

EJH

30

Kilometres

107

102

55° 30'

uTrWG

KTu

KTU

MPLRb
MPLRb

PPMH

Manson

56° 00'

B'

PPPR

Fault

26

125° 00'

MPLRb

MPLRb

Wasi

Creek

28

KTu

MPLRc

85

67

30

70

uTrWG

KTu

43

MPLRb

78

094

Willy

74

MPLRb

185

George

Discovery

Discovery

MPLRc

006

70

45

1940

MPLRa

MPLRc

Creek

uTrWG

Cook Creek

uTrPM

EJH

150

Fault

MPLRb

85

37

178

Creek

Lounge
Lizard Mtn.

EJH

IJs

TrJLL

43

TrJTf

uTrPM

50

IJs

uTrWG

Zone

A

RIVER

Creek

Twenty Mile

TrJTf

uTrPM

OMINECA

14E
11E
7W

93N/14E

0 2 4 6 8 10

uTrPM

uTrPM

EJH

Kilometres

55° 45'

LAYERED ROCKS

Cretaceous to Tertiary?

KTv — maroon, orthoclase and quartz-bearing tuff with plagioclase-porphyritic volcanic fragments

KTvs — plagioclase+hornblende±biotite, quartz-eye rhyolite tuff and flow, minor mafic lapilli tuff, siltstone, sandstone, quartzofeldspathic conglomerate

KTu — USLIKA FM: conglomerate, sandstone, siltstone, mudstone, minor coal

Toarcian

lJs — arkose, greywacke, sandstone, siltstone, minor conglomerate

Lower Jurassic
Takla Group

lJTC — TWIN CREEK fm: heterolithic lapilli tuff, plagioclase±quartz porphyritic flows and agglomerate/tuff breccia

lJcL — CHUCHI LAKE fm: plagioclase ± augite porphyry flows and fragmental volcanics

Upper Triassic
Takla Group

TrJTf — TAKLA FELSIC unit: heterolithic lapilli tuff, agglomerate, conglomerate, amygdaloidal augite porphyry flow, crystal ash tuffs (plagioclase>augite); clasts of plagioclase-rich volcanics, monzonite intrusives, maroon augite porphyry and cherty tuffaceous sediments

uTrPM — PLUGHAT MOUNTAIN fm: predominantly green augite±plagioclase-porphyritic basalt flows and fragmentals, maroon basalt, pillow basalt, amygdaloidal olivine porphyritic basalt, heterolithic lapilli tuff, volcanic sandstone and siltstone, limestone; uTrPMa: limestone; uTrPMb: maroon augite±olivine basalt flow, flow breccia, minor red sandstone

uTrWL — WITCH LAKE fm: green and maroon, augite±plagioclase and hornblende±plagioclase porphyritic flows and volcaniclastics

uTrWG — WILLY GEORGE sequence: augite-plagioclase lapilli tuff, crystal tuff, sedimentary breccia, arkose/wacke, argillite, siltstone

uTrlL — INZANA LAKE fm: green tuff, lapilli tuff, grey siltstone and slate

muTrSC — SLATE CREEK fm: grey slate and siltstone

Pennsylvanian to Permian
Nina Creek Group

PPMH — MOUNT HOWELL fm: grey to black argillite, green and red ribbon chert, diabase sills

PPPR — PILLOW RIDGE fm: pillow basalt±variolites, diabase-gabbro sills

Mississippian to Permian
Lay Range Assemblage

MPLRc — MAIN sequence: green and maroon augite±plagioclase and augite±olivine porphyritic basalt

MPLRb — MAIN sequence: crystal and lapilli tuff, volcanic sandstone, siltstone, siliceous argillite, chert and quartzite-bearing grit

MPLRa — COOK CREEK panel: thin-bedded siliceous siltstone and argillite, sandstone, siliceous tuff and bedded chert

INTRUSIVE ROCKS

Early Cretaceous

EKG — GERMANSEN batholith: coarse-grained hornblende-biotite granite, equigranular to orthoclase megacrystic

EKK — KLAWLI stock: orthoclase-megacrystic, hornblende-biotite granite

EKH — HOGEM intrusive complex: orthoclase-megacrystic granite, minor syenite

Early Jurassic

EJH — HOGEM intrusive complex: monzonite, quartz monzonite, granodiorite, and diorite

EJac — APLITE CREEK intrusive complex: equigranular to porphyritic, fine to medium-grained diorite and gabbro, intrusive breccia, porphyritic monzonite

Late Triassic - Early Jurassic

TrJLL — LOUNGE LIZARD intrusive complex: vary-textured diorite and gabbro, minor large plagioclase porphyritic diorite dykes

TrJvc — VALLEAU CREEK intrusive complex: fine to coarse-grained diorite, gabbro, pyroxenite and hornblendite

SYMBOLS

Geologic contact (approximate)

Lithologic contact (approximate)

Facies relationship (inferred)

Fault (approximate)

Bedding (tops known, unknown, overturned)

Foliation

Strike-slip fault (motion indicated)

Normal fault (motion indicated)

Mineral occurrence & MINFILE number .... ◆ 215

Elevation in metres .... △ 1818

metres of distinctive bright blood-red and bright green ribbon chert with argillite partings. This upper red chert unit is of regional extent and can be traced over 3 kilometres of strike length in the present map area. Identical cherts occur at the top of the Mount Howell formation from northwest of Nina Lake to south of Wasi Lake (F. Ferri, personal communication, 1992). Diabase-gabbro sills intrude both it and the underlying argillites and cherts.

PILLOW RIDGE FORMATION (PPₚR)

To the west, near the Manson fault zone, red and green cherts of the Mount Howell formation are overlain by a 200-metre-thick sequence of gabbro and diabase sills with minor chert remnants (Figure 1-7-3). This unit thins to the northeast; at the eastern edge of the map area pillow basalts of the Pillow Ridge formation directly overlie the pelagic sequence.

The contact between the diabase-gabbro sill unit and the pillow basalts is well exposed and apparently transitional. The average grain size in the diabase decreases upwards. Chert disappears only tens of metres below the lowest occurrence of variolites that marks the first basalt flow. The sill unit is probably a feeder zone to the overlying flows and is included within the Pillow Ridge formation. A thrust fault between the sills and the underlying cherts and argillites cannot be demonstrated locally, but is inferred based on regional evidence.

The highest part of the Nina Creek Group is a 200-metre sequence of commonly pillowed basalt. These basalts are generally fine grained and equigranular, aphanitic or diabasic. Variolites are common in the finer grained and glassy flows. Pillow morphologies show upright tops that dip gently southwest. In one area pillow imbrications indicate a southerly paleoslope.

LAY RANGE ASSEMBLAGE

The Lay Range assemblage is named for extensive exposures in the Lay Range, 100 kilometres northwest of the present map area. There, it consists of a lower division of Mississippian to middle Pennsylvanian mixed siliciclastic, epiclastic, carbonate and pelagic-hemipelagic strata overlain by several kilometres of volcanic sandstone, fine lapilli tuff and ash tuff of Permian age (Ferri et al., 1993a, b; and authors' 1992 observations). Ferri et al., (1992a, c) recognized Lay Range sequences in the southern part of 94C/3, which adjoins the Discovery Creek map area. In 1992 we redefined contiguous parts of the Discovery Creek area as Lay Range assemblage that were previously included in the Takla Group by Armstrong (1949).

MAIN SEQUENCE (MPₗRb, c)

The Lay Range assemblage outcrops on the high ridges east of Discovery Creek (93N/14E; Figure 1-7-3). The regular bedding in the steeply dipping, generally west-facing panel results in the formation of ribby, ridge-top exposures. The assemblage consists of two conformable stratigraphic divisions; a lower siliceous fine-grained epiclastic division (MPLRb) and an upper volcanic division of lapilli tuffs, agglomerates and flows (MPLRc). The contact between the

two is transitional and is marked by an upward increase in coarse volcanic units over several hundred metres.

The lower division is dominated by olive green volcanic sandstone and siltstone, siliceous argillite and crystal, fine lapilli and ash tuff. Rare but diagnostic grit beds contain clasts of a variety of volcanic lithologies as well as chert, vein quartz, quartzite and/or metachert, minor limestone and plutonic lithologies. A few turquoise green and red beds of radiolarian chert form part of this sequence.

The upper division is dominated by heterolithic lapilli tuff containing variable volcanic clasts including plagioclase porphyry with an aphanitic green or, less commonly, maroon matrix; clinopyroxene porphyry with an aphanitic green or, less commonly, maroon matrix; clinopyroxene ± plagioclase crowded porphyry with clinopyroxenes larger and less abundant than plagioclase; and clinopyroxene and fresh olivine porphyry with an aphanitic groundmass. Other less abundant lapilli include brick-red aphanitic to glassy fragments and black cumulate clinopyroxenites. Green to maroon augite-olivine-porphyritic flows and flow breccias, and brown-weathering andesites with small, sparse plagioclase phenocrysts form an important part of the upper division in some areas. Epiclastic units such as sandstones and apple green ash tuffs are also present.

The smaller ridges northeast and north of Lounge Lizard Mountain are included within the Lay Range main sequence, based on lithologic similarities. Grits with rounded chert and quartz pebbles and clasts of green and red lapilli tuffs are found within these sequences.

In contrast with the type locality in the Lay Range, the lower heterogeneous sedimentary sequence of the Lay Range assemblage is missing in the Discovery Creek area. Instead, the tuff sequence, which is lithologically similar to the upper part of the type stratigraphy, passes upward into a volcanic section 2 kilometres thick and is not observed farther north. The presence of abundant coarse volcanic material in Discovery Creek could be a function of a higher structural level or the preservation of strata closer to a volcanic edifice, perhaps near the axis of the Paleozoic arc.

COOK CREEK PANEL (MPₗRa)

The valley at the head of Cook Creek is underlain by a distinctive lithologic assemblage that is bounded and also transected by faults (Figure 1-7-3). It contains more chert and less epiclastic detritus than the main Lay Range sequence. Lithologies include thin-bedded siliceous sandstone and siltstone, siliceous tuff, bedded chert and siliceous argillite. One sample of volcanic siltstone from the headwaters of Cook Creek contains approximately 1 per cent detrital muscovite. There is no source for muscovite in the Lay Range assemblage, thus it, together with quartzite and rare plutonic fragments in the main sequence, may provide a link to a pericratonic or continental terrane with a Paleozoic plutonic component. The Lay Range arc may have formed adjacent to a suspect pericratonic terrane similar to the Yukon-Tanana Terrane, or to the Kootenay Terrane on the margin of ancestral North America.

DISTINGUISHING LAY RANGE ASSEMBLAGE FROM TAKLA GROUP

The Lay Range assemblage and Takla Group are two very similar lithotectonic assemblages. They both represent primitive volcanic arcs consisting of basalt and andesite and related marine sediments. Individual rock textures can be strikingly similar, such as green and red heterolithic lapilli tuff, or olivine-augite-phyric basalt. Distinction at an outcrop scale is difficult, particularly in the upper, volcanic division of the Lay Range assemblage (MP$_{LRc}$). Whole stratigraphic sequences must be examined. In this broader context, the differences between the Lay Range and Takla arcs are clear.

The Lay Range assemblage contains a number of lithologies that do not occur in the Takla Group. Most notable are the brightly coloured radiolarian cherts and the chert-quartz-quartzite grits. The very regular bedding and ribby outcrop aspect of the lower division distinguish it from most Takla exposures. Lay Range tuffs and sandstones are harder, more indurated and much more siliceous than those of the Takla Group.

Overall, the Triassic Takla and Lay Range arcs show parallel evolution. Both have progressed from deep marine deposition of epiclastic and fine pyroclastic material through a phase of basaltic volcanism and on to shallow marine conditions in which maroon volcanics are prominent. However, the abundance of maroon, plagioclase-phyric fragments in the lower Lay Range tuffaceous submarine sequence is not paralleled in the Takla arc. This suggests a shallow marine volcanic edifice that was shedding maroon volcanic material into the epiclastic submarine fans.

Chemically, the arcs show different trends. The Takla volcanics in this part of Quesnellia have characteristic island-arc signatures and chemistries that range from alkaline to transitional calcalkaline (Bellefontaine and Nelson, 1992). Preliminary data from the Lay Range assemblage suggest a transitional arc to ocean-floor setting with subalkaline volcanism (Ferri et al., 1992b).

TAKLA GROUP

OVERVIEW AND STRATIGRAPHIC NOMENCLATURE

Previous mapping defined an informal fourfold stratigraphic subdivision of the Takla Group near the Nation Lakes (Nelson et al., 1991a, 1992b). The Rainbow Creek formation comprises dark grey to black basinal shales and siltstones with subordinate epiclastic and pyroclastic strata and is assumed to be the oldest part of the Takla Group. The younger Inzana Lake formation is a mixed pyroclastic-epiclastic sequence in which lithologies range from augite-phyric lapilli tuff to fine-grained black siltstone and argillite. It has yielded three conodont collections, two of late Carnian age and one of middle Norian age. The Inzana Lake formation is overlain by and interfingers with the Witch Lake formation, a thick sequence of mostly augite-phyric, coarse pyroclastic basalt debris with lesser flows and minor plagioclase-dominant units and epiclastic sedimentary beds. It is overlain by plagioclase and augite-phyric fragmental rocks and flows of the Chuchi Lake formation.

Sedimentary units within the Chuchi Lake formation have yielded ammonites of early and late Plien bachian age (Nelson et al., 1992b).

Ferri and Melville (1988, 1989, 1990a, ir preparation) developed a parallel but internally distinct Takla Group stratigraphy in the Manson Creek and Germa isen Landing areas. The basal Slate Creek formation has yielded conodonts with ages ranging from late Anisian to Carnian. It is lithologically similar to the Rainbow Creek formation in the Nation Lakes area. The Slate Creek formation passes upward into an epiclastic-pyroclastic facies comparable to the Inzana Lake formation, which in turn is overlain by augite-phyric agglomerate and lapilli tuff. Both volcanic units are included within the Plughat Mount in formation. Jurassic intermediate to felsic volcanic rocks equivalent to the Chuchi Lake formation are not recognized.

The Plughat Mountain formation is similar to the Witch Lake formation in age and parental magma; toth are dominated by augite-phyric porphyritic basalt. However, a number of striking differences between the two support the idea that they represent two separate volcanic piles. The volcanic sequence on Plughat Mountain includes at least 1500 metres of aphyric to weakly augite-phyric porphyritic basalt flows, in contrast with the almost wholly fragmental Witch Lake formation. Bright red, highly amygdaloidal augite±olivine-phyric flows are common in the Plughat Mountain formation but absent in the Witch Lake formation. Plagioclase phenocrysts are subordinate in the Witch Lake formation, but small crowded plagioclase porphyry fragments make up a significant proportion of clasts in many pyroclastic rocks of the Plughat Mountain formation. There are also contrasts in the chemistry of the volcanics. The Witch Lake basalts are alkaline while the Plughat Mountain basalts range from alkaline to calkalkaline (Ferri and Melville, in preparation; Bellefontaine and Nelson, 1992). Overall, the Plughat Mountain formation is a more heterogeneous package than the Witch Lake formation.

Both of these stratigraphies project into the 1992 map area (Figure 1-7-3). The Witch Lake formation caps the hills east of Valleau Creek in 93N/7, but does not continue into 93N/11. The Plughat Mountain formation outcrops almost continuously from its type area near Germar sen Landing to Germansen Lake and into 93N/11. The Lower Jurassic Chuchi Lake formation extends into the lowlands east of Ahdatay Lake in southern 93N/7. A separate intermediate volcanic package, of presumed Early Jurassic age, overlies the Plughat Mountain formation near Twin Creek in 93N/11. Because of its distinct internal stratigraphy and lack of continuity with Chuchi Lake exposures, we have separately designated this volcanic sequence the Twin Creek formation.

SLATE CREEK FORMATION (muTrsc)

Grey slates, siltstones and minor tuffaceous sediments of the Slate Creek formation outcrop around the northern contact of the Germansen batholith in the Germansen Landing map area (Ferri et al., 1989). They continue into the southeastern corner of 93N/11, around the western edge of the batholith (Figure 1-7-3). The slates are often strongly foliated and foliations appear to wrap around the margin of the

batholith. Exposure of the oldest unit of the Takla Group encircling most of the Germansen batholith might suggest that diapiric emplacement entrained and uplifted the base of the Mesozoic section. We have designated the basal strata in this area the Slate Creek formation instead of the Rainbow Creek formation because of continuity with the type locality (Ferri and Melville, in preparation).

INZANA LAKE FORMATION (uTriL)

Well-foliated green tuff, lapilli tuff and grey siltstone and slate of the Inzana Lake formation extend from previously mapped exposures near Tsaydaychi Lake in 93N/7 East Half (Nelson *et al.*, 1992a) into the headwaters of Valleau Creek (Figure 1-7-3). Foliation and bedding strike northwest and dip steeply. In contrast, the contact with the overlying Witch Lake formation, defined in outcrops on the hills east of Valleau Creek, is nearly horizontal. This structural discordance between gross attitudes and attitudes within incompetent units is common in the Takla Group. It probably reflects strong disharmonic folding due to competency contrasts and the presence of décollements between massive and thin-bedded units.

WITCH LAKE FORMATION (uTrwL)

The Witch Lake formation east of Valleau Creek (Figure 1-7-3) consists of predominantly green and minor maroon augite porphyry flows, with lesser aphanitic flows, augite-plagioclase porphyry agglomerates, hornblende-porphyritic flows and plagioclase-phyric subvolcanic bodies. Subordinate volcaniclastics include tuffaceous sandstone, crystal tuff and lapilli tuff. The prominence of flows within these exposures is more akin to the Plughat Mountain formation than the Witch Lake formation to the south. However, the rocks lack olivine phenocrysts and large amygdules which are often present in the Plughat Mountain formation. This area may represent a mixing of volcanic styles between two different volcanic centres, or perhaps be the product of a centre with transitional characteristics.

PLUGHAT MOUNTAIN FORMATION (uTrPM)

The Plughat Mountain formation outcrops in most of eastern 93N/11 and on both sides of the Omineca River in 93N/14 (Figure 1-7-3). It is a lithologically and spatially highly variable, basalt-dominated volcanic pile. The most southerly exposures on Caribou Mountain, in eastern 93N/11, consist of interbedded green augite-porphyritic vesicular basalt flows and fragmentals with lesser maroon heterolithic agglomerate and flows. Minor quantities of plagioclase-phyric crystal tuff and a monzonite intrusive clast were noted on the north side of the mountain. The ridge north of West Dog Creek consists entirely of green augite±plagioclase-porphyritic agglomerate and lapilli tuff with one maroon augite-olivine porphyry flow at the base of the sequence near the road. Eaglenest Mountain is dominated by green augite±olivine±plagioclase-bearing flows and agglomerates. There are similar porphyritic flows and agglomerate on the mountain southeast of Eaglenest, as well as large outcrops of well-formed pillow basalt. The presence of pillow basalt in the heart of the Plughat Mountain formation may strengthen the case for the structural panel

hosting the Lounge Lizard intrusive complex as being part of the Plughat Mountain formation.

In the Omineca River valley lithologies include large-augite, small-plagioclase porphyry flows and agglomerates, large-amygdule flows, maroon and green amygdaloidal large-olivine porphyry flows and heterolithic lapilli tuffs that contain clasts in which plagioclase and augite are the primary phenocrysts. Limestone clasts occur within such lapilli tuffs near Twentymile Creek. Also along Twentymile Creek, aphanitic basalt flows, small-hornblende porphyry flows, augite and hornblende porphyry heterolithic lapilli tuffs and minor interbeds of tuffaceous sandstone form part of the sequence. In general, maroon colours are more common in the south while plagioclase contents of the volcanics increase to the north.

One thrust panel north of the Omineca River contains aphyric to small-olivine porphyry pillow basalts that are intruded by the Lounge Lizard intrusive complex. The southeastern continuation of this panel into 93N/15 is a narrow, fault-bounded sliver of pillow basalt and green and red basalt lapilli tuff. Although continuity cannot be establish, this panel is assigned to the Plughat Mountain formation on the basis of lithologic similarities.

An Upper Triassic limestone reef (uTrPMa), viewed from a distance, resembles a kilometre-wide cliff nest, giving rise to the local name of Eaglenest Mountain (Plate 1-7-1). A well-used golden eagle nest is located on one of the limestone buttresses. The reef itself contains a rich and varied coralline fauna in discrete packstone beds that are interbedded with crinoid wackestones and calcirudites. Its intimate relationship with Plughat Mountain basalts is shown by abundant volcanic debris in the wackestones, and conversely by limestone clasts in nearby lapilli tuffs. Its perched position in the western cliffs of Eaglenest Mountain suggests that the mountain itself is part of an exhumed Late Triassic volcanic edifice. Identification of coral species is pending.

One continuous, mappable subunit was defined at the top of the Plughat Mountain formation west of Kwanika Creek. It is a bright red to maroon augite±olivine-phyric basalt flow (uTrPMb) that is often highly vesicular to scoriaceous. Flow breccia is common near its top. The presence of scattered bright red sandstone lenses overlying the breccia suggests reworking in shallow water. This maroon basalt marker unit overlies green augite±olivine porphyry agglomerates and flows of the main Plughat Mountain formation.

CHUCHI LAKE FORMATION (lJcL)

In the eastern half of 93N/7, the Chuchi Lake formation overlies the Witch Lake formation in a gently south-dipping homocline (Nelson *et al.*, 1992a). This continues into the lowlands west of Valleau Creek, east of Ahdatay Lake and in bank exposures along Valleau Creek where plagioclase-augite-porphyritic amygdaloidal flows, heterolithic plagioclase-dominant laharic agglomerates, plagioclase-porphyritic lapilli tuffs and a body of large plagioclase-phyric hypabyssal monzonite are exposed (Figure 1-7-3). The Chuchi Lake formation does not outcrop north of this area.
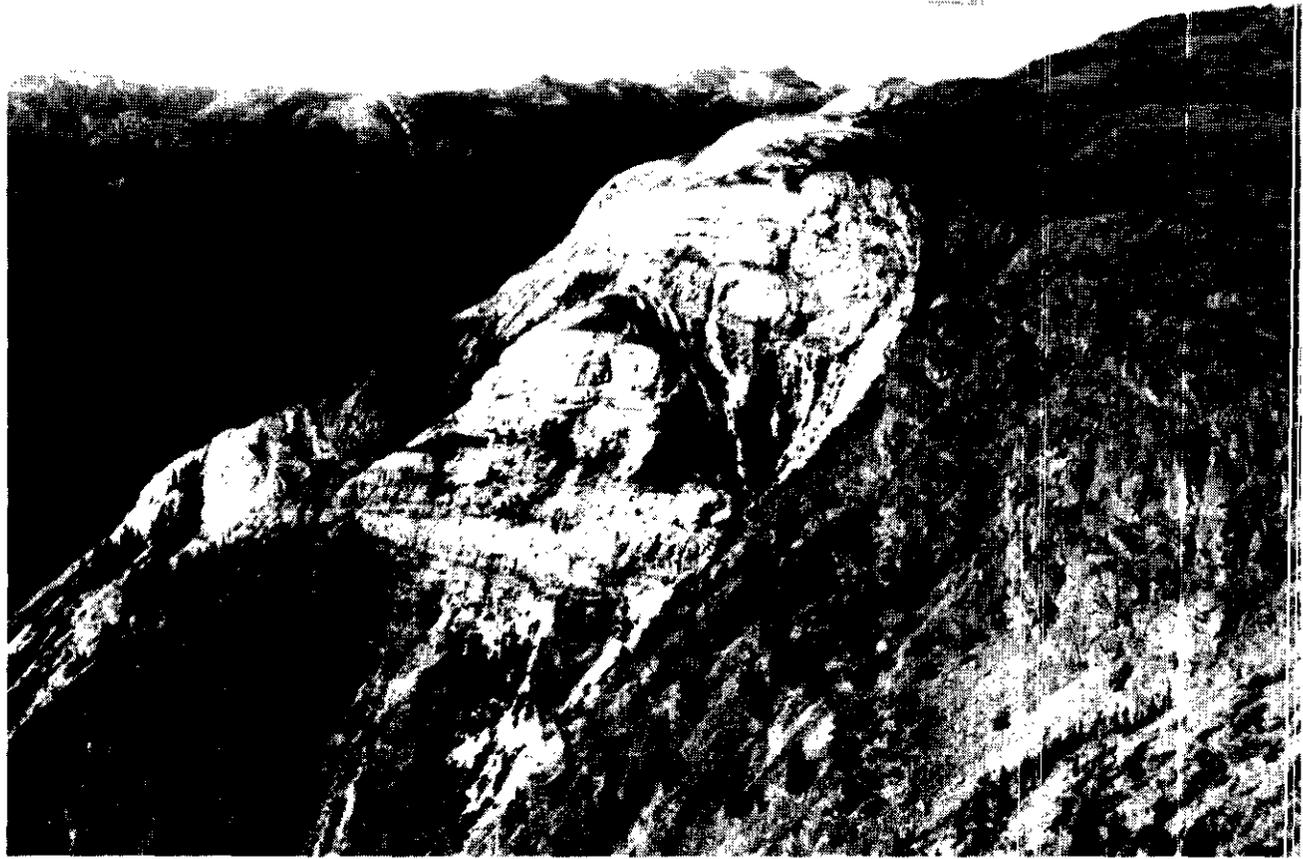
Plate 1-7-1. Eaglenest limestone of probable Late Triassic age has reefoid appearance as it outcrops along the edge of a cliff exposing volcanic rocks of the Plughat Mountain formation (uTrPM).

TWIN CREEK FORMATION (lJTC)

West of Kwanika Creek, near Twin Creek, the red basalt at the top of the Plughat Mountain formation (uTrPMb) is overlain by heterolithic lapilli tuff, agglomerate, crystal tuff and local heterolithic volcanic conglomerate, all with significant to dominant plagioclase phenocrysts plus augite and hornblende (Figure 1-7-3). Augite-hornblende, plagioclase-augite, plagioclase and plagioclase±quartz porphyry flows also occur. These are all included in the informal Twin Creek formation. Heterolithic lapilli tuffs predominate in the lower, more northerly exposures where augite is more prominent near the base. Less abundant, strongly heterolithic plagioclase-rich fragmental units are also present and high-level intermediate intrusive clasts occur in the conglomerate. Stratigraphically higher exposures southwest of Twin Creek include large-plagioclase and plagioclase-±quartz porphyry flows and related fragmental units. In general the section is consistent with progressive felsic differentiation of volcanic magmas through time. The presence of quartz is noteworthy.

The base of the heterolithic lapilli tuffs rests sharply on the red basalt. The contact is irregular on both minor and major scales. It undulates over 50 to 100 metres of elevation on mountain sides. In outcrop and hand sample scale the top of the basalt shows sharp irregularities, with clasts incorporated or partly incorporated in the overlying debris (Plate 1-7-2). Bedding in the red sandstones of the underlying basalt unit approximately parallels the overall attitude of the contact. Both dip very gently to the south. These attributes describe a low-angle unconformity or paraconformity, corresponding to a volcanic hiatus with no significant deformation.

We assume that the Plughat Mountain formation is entirely Late Triassic in age. By lithologic analogy with the Chuchi Lake formation we assign a provisional Early Jurassic age to the Twin Creek formation, pending zircon dating of one of the plagioclase porphyry flows near Groundhog Creek. The lapilli tuff - red basalt contact detailed above is considered to represent the Triassic-Jurassic boundary (Plate 1-7-2).

WILLY GEORGE SEQUENCE (uTrWL)

A distinctive pyroclastic-epiclastic sequence is exposed on the ridge east of Willy George Creek in western 93N/14E (Figure 1-7-3). Overall, this package is strongly heterolithic, although many of the individual lapilli tuff units within it are monolithic. The lapilli tuffs represent variations on a theme of augite-plagioclase, augite, plagioclase-augite and plagioclase porphyry volcanic clasts. Consistent volcanic textures within some units suggest sourcing from single volcanic events; others are strongly heterolithic and chaotic.
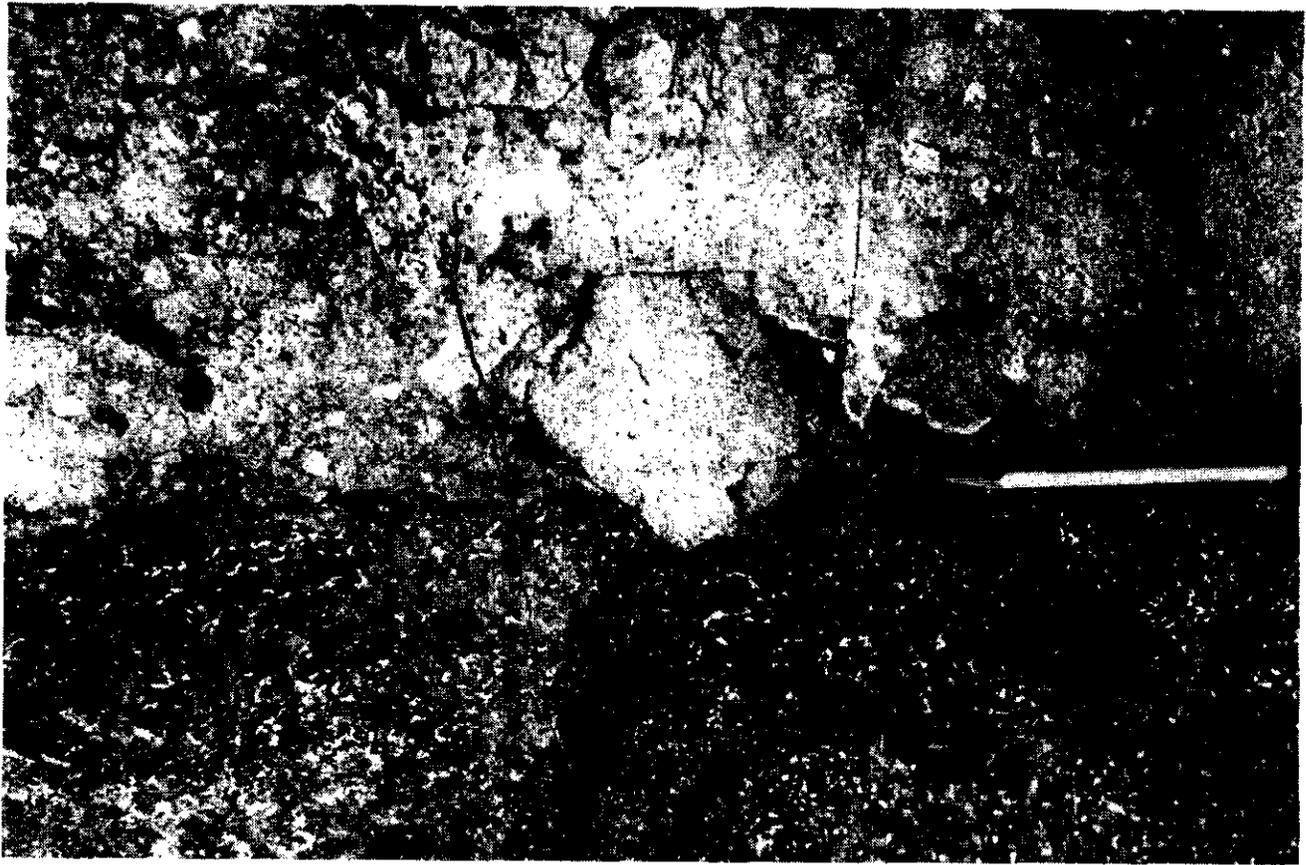
Plate 1-7-2. Triassic-Jurassic contact marked by an irregular surface between maroon basalt (uTrᴘᴍb) and overlying heterolithic agglomerate and breccia of the Twin Creek formation (lJᴛc).

One unit, traceable over several kilometres, contains white dacite blocks with sedimentary and other volcanic clasts.

The lapilli tuffs are interbedded with crystal tuffs and sandstones, which make up about half of the section. Sedimentary breccias like those in the Inzana Lake formation in 93K/16 (Nelson *et al.*, 1991a) are also present. Limestone clasts occur in the sedimentary breccias and also in the volcanic-dominated fragmental units. Some lapilli tuffs have a limy matrix. An interval of pale grey lithic arkose/wacke, argillite and siltstone lies within the sequence.

The Willy George sequence strikes northwest and dips and faces steeply west. Its uppermost unit is a fine to coarse monolithic pyroclastic rock, in which clasts show a distinctive texture of very large augite and tiny plagioclase phenocrysts in a grey groundmass. This unit apparently underlies the Plughat Mountain formation in exposures north of the Omineca River. Thus, the Willy George sequence is a stratigraphic and facies equivalent of the Inzana Lake formation, but the prominence of plagioclase within it contrasts strongly with the Inzana Lake. If it is Late Triassic in age, then it implies the existence of a so-far undocumented Late Triassic intermediate volcanic centre. Such centres must have existed in Late Triassic time, as plagioclase-porphyritic volcanic clasts, thin trachytic tuff beds and intermediate hypabyssal intrusive clasts occur in the Inzana Lake, Witch Lake and Plughat Mountain formations. The

Willy George sequence is the closest indication of a more felsic Triassic volcanic centre observed thus far in the Takla arc.

TAKLA FELSIC UNIT (TrJᴛf)

A Triassic or Jurassic mixed volcanic and volcaniclastic package crops out in the southeasternmost corner of 93N/14E (Figure 1-7-3). In contrast to the neighbouring Plughat Mountain formation, it has a large component of felsic material. Lithologies includes heterolithic lapilli tuff, agglomerate-conglomerate, amygdaloidal augite-porphyritic flows and crystal-ash tuffs with plagioclase dominant over augite phenocrysts. Fragments in the coarser units include plagioclase+subordinate augite-porphyritic volcanics, monzonite to diorite intrusives, maroon augite-porphyritic volcanics, silicified tuffaceous sediments and cherty argillite.

This unit continues beyond the Discovery Creek map area into low ridges northwest of Plughat Mountain (93N/15; Ferri *et al.*, 1989). Planar bedded, quartz-rich conglomeratic sandstones, sandstone, siltstone and cherty sediments together with maroon quartz-bearing amygdaloidal plagioclase-porphyritic volcanics attest to the felsic nature of this unit.

The age of this sequence is unknown. The presence of volcanic quartz in some of the volcanics and sediments

suggests a link to the Jurassic Twin Creek formation. However, the presence of the nearby Willy George sequence supports the possibility of a Triassic age for these felsic rocks.

UPPERMOST LOWER JURASSIC SEDIMENTARY SEQUENCE (lJs)

Lower Jurassic clastic sedimentary rocks form small cliffs along Discovery Creek for approximately 4 kilometres north of the road bridge (Figure 1-7-3). The most abundant lithologies are green to brown-weathering lithic arkose and greywacke with interbedded siltstones. Minor, local conglomerates contain green to maroon plagioclase-augite-porphyritic volcanic clasts. Many of the sandstones are composed of grit-sized grains and crystals of plagioclase, orthoclase, hornblende, biotite and augite that appear to be the immature eroded remnants of a plutonic source. The most likely candidate is the nearby Hogem intrusive complex. Less than 1 per cent detrital muscovite occurs in some of the beds.

Three fossil localities were identified on Discovery Creek. The macrofossil collections were examined by Giselle Jakobs and Howard Tipper of the Geological Survey of Canada. Two localities with ammonites similar to the one in Plate 1-7-3, yielded Toarcian ages. An internally radiat-

ing belemnite fossil suggests a post latest middle Toarcian age for the third locality (Table 1-7-1).

The presence of plutonic debris and detrital muscovite in these late Early Jurassic sediments provides important information on Jurassic tectonics. Potassium-argon mineral ages for the Jurassic phases of the Hogem intrusive complex range from 206±8 to 171±6 Ma (Garnett, 1978; data converted to new decay constants, R.L. Armstrong, unpublished data). Toarcian time is bracketed between 187±15 and 178±11 in the new time scale of Harland et al., (1990). The plutonic debris in these late Toarcian sediments shows erosion of the Hogem intrusive complex while parts of it were still forming and cooling.

The positive identification of muscovite in this Toarcian sequence would require a pericratonic, miogeoclinal or cratonic source. The deposition of these sediments was approximately coeval with the emplacement of Quesnellia onto the North American margin (181 to 173 Ma; Murphy et al., in press; or possibly as early as 186 Ma, G. Nixon, personal communication, 1992). They predate the subsequent uplift of metamorphic core complexes in the Omineca Belt. The oldest known cooling age for a metamorphic rock in the Ingenika Group is 174 Ma (K-Ar whole rock; Ferri and Melville, in preparation). The source of muscovite may lie farther east, perhaps in the craton; or alternatively within an accreted pericratonic terrane.

Plate 1-7-3. Hand sample of late late Toarcian ammonite from Discovery Creek sediments (lJs).

USLIKA FORMATION (KTu)

The Uslika Formation is a clastic package that occurs as a panel within the Discovery Creek fault zone. The rocks are contiguous with the Conglomerate Mountain exposures in 94C/3 (Ferri et al., 1992c). In the northern part of 93N/14E (Figure 1-7-3) conglomerate and coarse sandstone predominate with minor occurrences of siltstone and mudstone with rare broadleaf and coniferous macrofossils. The conglomerate is composed of well-rounded coarse cobbles and boulders of monzonite, syenite, augite-porphyritic volcanics, plagioclase-porphyritic volcanics, green and maroon tuffs, green, red and pale beige chert, black and grey siliceous argillite, quartzite (often weakly foliated) and vein quartz. The rocks are clast supported, poorly sorted and very well indurated. Hematite in the matrix gives clasts a shiny coating and imparts a reddish hue to outcrops. Bedding is weakly visible in conglomerate beds and better defined in sandstones and conglomeratic sandstones. In general the stratigraphy strikes northwest to north. Dips vary from gentle to steep.

Approximately 15 kilometres south of these exposures in Discovery Creek, grey and black conglomerate occurs with interbeds of arkosic sandstone, siltstone, and mudstone. A bituminous coal bed 1 metre thick outcrops along the stream bank. The conglomerate contains small cobbles and pebbles of two main lithologies, dark grey to black chert and siliceous argillite, and lithified grey arkose. Minor components include vein quartz, turquoise green chert and quartz biotite granite. Bedding strikes northwest and dips steeply to the southwest.

Clasts in the Uslika Formation are probably derived from local sources: intrusive clasts from the Hogem intrusive complex, volcanic rocks from the Takla Group, quartzite from the Atan Group and cherts from the Lay Range assemblage and the Nina Creek group. Metamorphic clasts were not recognized in the study area, however, Roots (1954) documented rare clasts of quartz-mica schist and quartz-mica-feldspar gneiss less than 2 centimetres in diameter. The absence of abundant metamorphic clasts may indicate a more local source for the majority of clasts in the Uslika Formation; or perhaps the bulk of the metamorphic core complexes in the Omineca crystalline belt were not unroofed at the time of erosion and deposition. A syenite clast from the conglomerate yielded a 168±1 Ma U-Pb zircon age (Parrish and Tipper, 1992), placing a maximum age of Late Jurassic on the Uslika Formation. Rare quartz-biotite-bearing intrusive rocks and coarse orthoclase porphyries are more akin to Cretaceous phases of the Hogem intrusive complex than Jurassic. This evidence supports a Cretaceous to Tertiary age for the Uslika Formation.

The Uslika Formation is bounded by faults of the Discovery Creek fault system. It is probable that it was deposited in graben structures along the fault in response to transcurrent motion (see Structure; Figure 1-7-5C; Ferri et al., 1992a). The grabens are likely long-lived growth structures that contain different fans of clastic material derived from various areas. This structural scenario would also explain the large variation in inclination of beds in a seemingly undeformed sequence.

The Uslika Formation may be broadly correlatable with the Sustut Group in the area. Although Sustut clastics are less cemented and have better fossil control, the Sustut Group and the Uslika Formation are clastic packages of similar age, deposited in similar sedimentary and structural environments.

CRETACEOUS – TERTIARY(?) SEQUENCE WEST OF GERMANSEN LAKE (KTvs)

A variable suite of volcanic and clastic rocks is exposed at the west end of Germansen Lake in West Dog Creek (Figure 1-7-3). Pale pink-grey to buff-coloured hornblende-biotite-bearing, quartz-eye rhyolite is the most abundant lithology. It is locally flow banded and has a chalky weathering appearance. Less abundant but diagnostic quartzofeldspathic conglomerate with angular and rounded fragments of rhyolite, medium-grained equigranular biotite granite, volcanic quartz and vein quartz occurs with green sandstone, siltstone and volcaniclastics.

The contact of this unit with the Takla Group is not exposed. The steep dips in this section, its restricted aerial extent, and the lack of Takla volcanic fragments in the conglomerates, support deposition in a small, fault-bounded graben. The volcanic quartz is probably derived from the rhyolites and the vein quartz and intrusive clasts may have been shed from the Germansen batholith. This graben represents the southernmost extent of the Discovery Creek fault system and is most likely Cretaceous to Tertiary in age.

CRETACEOUS – TERTIARY(?) MAROON TUFFS IN DISCOVERY CREEK (KTv)

Bright maroon crystal-lithic tuffs outcrop in the lower part of Discovery Creek in narrow fault-bounded panels. The lack of bedding and the homogeneous texture of these tuffs suggests subaerial deposition, perhaps an ash flow. The volcanics contain phenocrysts of plagioclase, orthoclase and embayed quartz with lithic fragments of feldspar porphyry and carbonate. In one exposure the massive tuff grades into bedded red sandstone and mudstone. A similar unit is exposed in the eastern tributary creek next to a splay of the Discovery Creek fault.

The age of these rocks is unknown. They may be coeval with the Uslika Formation or as young as Tertiary. No evidence of interbedding with other lithologies was seen. These small felsic accumulations may have been localized along the faults, or in ancient stream valleys that followed faults.

INTRUSIVE UNITS

VALLEAU CREEK INTRUSIVE COMPLEX (TrJvc)

The Valleau Creek intrusive complex is a tabular, composite mafic to ultramafic body. It extends southeasterly from the southern part of 93N/11 along the Valleau Creek valley for 30 kilometres to the vicinity of Klawli Lake. There it turns abruptly eastwards and ends (Figure 1-7-3). This complex is reflected by a very strong linear north-

westerly trending aeromagnetic anomaly (Geological Survey of Canada, 1963). The most widespread lithologies are fine to medium-grained diorite and gabbro. Plugs or rafts of coarse-grained pyroxenite and hornblendite with up to 10 per cent magnetite are scattered within it. The linear nature of the Valleau Creek complex and the presence of mylonitic float on its eastern margin suggest the complex is fault bounded and structurally controlled. A Late Triassic to Early Jurassic age for the complex is inferred as its northern end is truncated by a probable Early Jurassic monzonite phase of the Hogem intrusive complex.

LOUNGE LIZARD INTRUSIVE COMPLEX (TrJLL)

Most of Lounge Lizard Mountain north of the Omineca River and east of Discovery Creek is underlain by a composite diorite-gabbro body with a wide variety of textural variants (Figure 1-7-3). In general, the body shows increasing average grain size away from its southern margin, where it intrudes Plughat Mountain pillow basalt. Finer grained phases usually cut coarser units, although the reverse is sometimes observed. Near the southern margin, fine to medium-grained diorite is most abundant. The summit of the mountain is underlain by very coarse grained to pegmatitic diorite with areas of igneous layering, intruded by white plagioclase-clinozoisite pegmatites. Large plagioclase-phyric diorite dikes cut all other phases.

The age of this body is not known. It intrudes pillow basalts inferred to be Upper Triassic. Texturally, it resembles the diorite-gabbro border phase of the Hogem intrusive complex near Chuchi Lake (Nelson et al., 1992a, b).

APLITE CREEK INTRUSIVE COMPLEX (EJAC)

The Aplite Creek intrusive complex is centred on a low mountain 5 kilometres southeast of Ahdatay Lake (Figure 1-7-3). Like the Valleau Creek complex, it is dominated by fine to medium-grained diorite and gabbro. Textures range from nearly equigranular to porphyritic with large augite phenocrysts. These rocks, mapped as volcanic in previous work (Paterson and Barrie, 1991), are distinguished by their holocrystalline matrix and lack of fragmental or amygdaloidal textures. Minor amounts of intrusive breccia, consisting of hypabyssal augite-hornblende-porphyritic monzodiorite and epidotized clasts, occur in Aplite Creek. Several small outcrops of hypabyssal crowded monzonite porphyry are present and later aplite, syenite and monzonite dikes are also part of the complex.

HOGEM INTRUSIVE COMPLEX (EJH, EKH)

The map area includes parts of the eastern edge of the Hogem intrusive complex. Two broad lithologic suites are present: a quartz-deficient suite of monzonite, quartz monzonite, granodiorite and diorite of probable Early Jurassic age (EJH) and a quartz-rich granite suite of probable Cretaceous age (EKH) with textures identical to those in the Germansen batholith (EKG) and Klawli stock (EKK; Figure 1-7-3). The quartz-deficient suite is characterized by medium to coarse-grained equigranular and rare porphyritic

textures. The quartz-rich suite is represented b / two disc ete granite plutons, one west of Valleau Creek that intrudes the Valleau Creek intrusive complex and one at the headwaters of Twin Creek. Orthoclase megacrysts are characteristic o these plutons. Orthoclase-megacrystic, medium-grained granite dikes intrude the Takla Group in and north of the Twin Creek valley. A small body of syenite west of Eaglenest Mountain is assigned to the Cretaceous suite.

A vertical mylonite zone, 250 metres wide with steep lineations, is exposed along the eastern margin of the Hogem complex 1 kilometre southwest of Goat Ridge. This substantiates structurally controlled emplacement of the Early Jurassic monzonite-granodiorite phase of the composite intrusion in this area.

GERMANSEN BATHOLITH (EKG)

The Germansen batholith outcrops on the eastern edge of 93N/11E near Moly Lakes and in the northern part of 93N/7W at the headwaters of Valleau Creek (Figure 1-7-3). At the first locality the batholith is a fine to medium-grained equigranular hornblende granite. It has intruded and metamorphosed black shales and slates of the Slate Creek formation to biotite schist and strongly hornfelsed phyllite. The contact is sheared and folded; kinematic indicators in the metasediments show southwest-side-down shear sense on moderate to steeply dipping foliation planes. This is consistent with the upward emplacement of the western margin of the Germansen batholith along a southwest-dipping contact zone.

Near Valleau Creek, the Germansen batholith is a coarse-grained equigranular to orthoclase-megacryst c biotite granite. Minor syenite and aplite dikes cut the intrusion. The host lithologies are sheared and foliated metatuffs and metavolcanics of the Inzana Lake formation. Minor amounts of molybdenite occur on fractures here and near Moly Lakes.

An Early Cretaceous, 106±4 Ma age for the Germansen batholith has been obtained by a K-Ar dating on a biotite sample (Ferri and Melville, in preparation).

KLAWLI STOCK (EKK)

The Klawli stock extends onto 93N/7W from the area mapped in 1991 (Nelson et al., 1992a). Orthoclase-megacrystic hornblende biotite granite outcrops in small glaciated gullies on the north side of Klawl Lake (Figure 1-7-3). The body has a rim of microdiorite and gabbro that probably represents the southeastern tail of the Valleau Creek intrusive complex and its associated aeromagnetic high. The Klawli intrusion is texturally identical to large parts of the Germansen batholith and is therefore assigned an Early Cretaceous age.

STRUCTURAL GEOLOGY

VALLEAU CREEK FAULT; A SYNVOLCANIC STRUCTURE?

The tabular nature of the Triassic-Jurassic Valleau Creek intrusive complex (Figure 1-7-3) and the associated linear magnetic signature suggest a strong structural control for its

emplacement. This mafic-ultramafic complex is similar to the earliest identified phase of the Hogem intrusive complex and is probably synchronous with Takla volcanism. Long-lived synvolcanic structures are key to the generation of alkaline porphyry copper-gold systems (Nelson *et al.*, 1991a). The Valleau Creek fault may be one of the best examples of a synvolcanic structure in the Takla arc. The presence of Jurassic Chuchi Lake formation west of the complex and Triassic Inzana Lake formation to the east suggests that the fault was active until at least the Jurassic and had an overall displacement of roughly 1 kilometre, west side down. The lack of crowded porphyry intrusions and porphyry mineralization and alteration may be a function of a deep level of erosion. Minor disseminated malachite was noted south of Wudtsi Lake.

Another fault structure occurs east of the Valleau Creek complex near the headwaters of Valleau Creek. The fault is represented by an iron-carbonate, quartz and sericite alteration zone 1.5 to 2 kilometres wide with minor pyrite and

mariposite(?). Motion and offset on the structure are unknown as it lies entirely within the Inzana Lake formation. To the north this fault may have helped control the western margin of the Germansen batholith.

TWIN CREEK MAP AREA

The Twin Creek map area is characterized by predominantly subhorizontal Takla volcanic stratigraphy. High-angle faults near Groundhog Creek and north of Twin Creek have displacements in the order of a hundred metres or less, determined by the offset of the maroon basalt marker bed (uTrPMb; Figures 1-7-3, 1-7-4). The northwest-trending Twin Creek fault cuts these small-scale structures. Quartz-bearing potassium feldspar porphyry dikes and associated hydrothermal alteration and polymetallic sulphide mineralization are controlled by the Twin Creek shear zone (Bailey, 1991). Many of the dikes are deformed, suggesting a probable synplutonic Cretaceous motion on the Twin Creek fault.
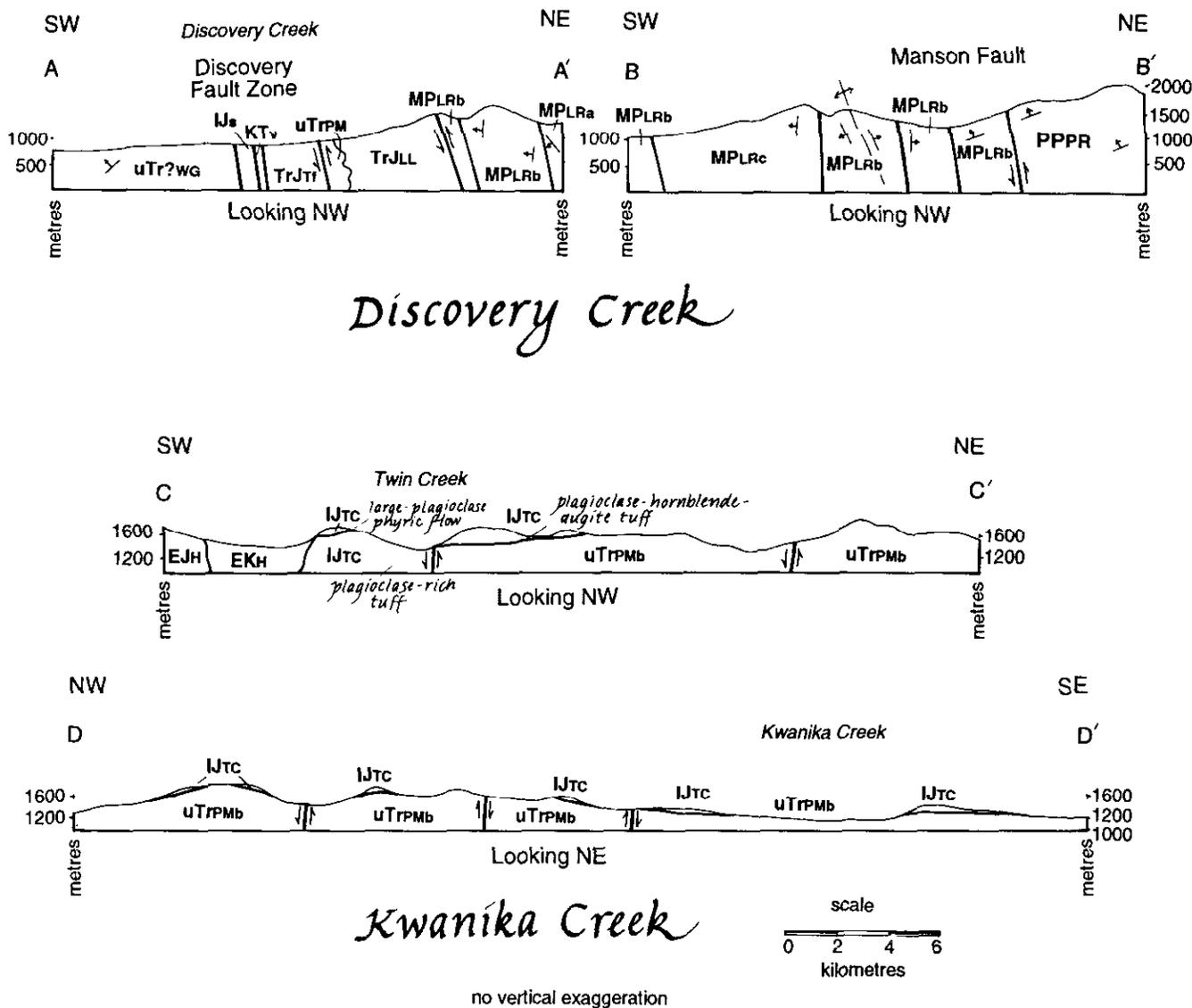

Figure 1-7-4. Cross-sections of map area. *See* Figure 1-7-3 for locations.

North-trending faults near Twentymile Creek merge into the transcurrent transfer zone in Discovery Creek (93N/14E).

THE MANSON CREEK – DISCOVERY CREEK DEXTRAL TRANSFER ZONE

The Discovery Creek area is transected by two major strike-slip fault systems; the Manson fault zone and the Discovery fault zone. The northwest-trending Manson fault zone is a vertical dextral strike-slip fault with an overall strike length of 150 kilometres. It continues southwards into the McLeod and Rocky Mountain Trench fault systems (Figure 1-7-2). Ferri and Melville (in preparation) suggest a Cretaceous age for most of the motion on this structure. The fault dies northward, as there is no apparent offset of stratigraphy across its projected location south of Wasi Lake (Ferri et al., 1992c).

The Discovery Creek fault zone is a north-northwest-trending strike-slip system that is approximately 5 kilometres wide in the map area. Its southern extent is the west Germansen Lake graben where Cretaceous to Tertiary rhyolites and sediments (KTvs) outcrop. To the north, the fault swings slightly more northwesterly and joins the Lay Range fault system (Ferri et al., 1993a) and then the Finlay-Ingenika-Pinchi fault system (Wheeler and McFeely, 1991).

The area between these two fault systems corresponds to a region of west-northwest-trending faults along the Omineca River. These faults divide stratigraphy into predominantly west-facing, steeply dipping, homoclinal packages that have a general trend of younging from northeast to southwest (Figure 1-7-4).

Kinematic indicators in the Discovery Creek area can be grouped into three categories consistent with various stress directions in a dextral transcurrent setting in which motion is stepping from one fault system to another. The result is a zone of compression linking the two fault strands (Figure 1-7-5A). Attitude a (Figure 1-7-5B) is perpendicular to the maximum stress (σ1). It predicts pure compression or thrusting along west-northwest-trending faults. This corresponds to the major west-northwest-striking faults that divide the region into structural blocks. Kinematic indicators from the northeastern margin of the Lounge Lizard intrusive complex are consistent with northeast block up; that is a high-angle thrust fault. The general facing and younging of the structural panels towards the southwest is consistent with a steep southwest-verging thrust duplex. Regions where this younging trend is violated can be explained by less prominent west-side-up reverse faults or back thrusts, as in Cook Creek where limestone of the Middle to Upper Triassic Slate Creek formation is interleaved with Mississippian to Permian Lay Range assemblage.

Attitude b in the strain ellipse (Figure 1-7-5B) corresponds to an intermediate stress field in which dextral synthetic structures prevail. These structures are manifest as tight northwest-verging folds with steep southeast-plunging axes exposed in Discovery Creek (Plate 1-7-4; Figure 1-7-6). Their vergences support relative dextral motion for the Manson-Discovery fault system. Sinistral antithetic
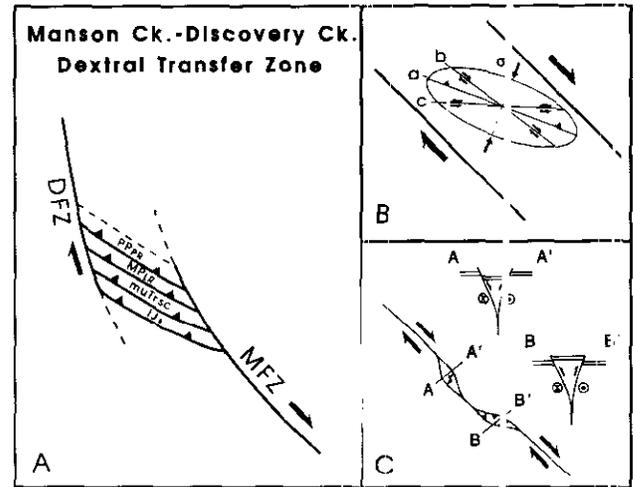

Figure 1-7-5. (A). Schematic diagram of a compressional transfer zone between the Manson Creek fault zone (MFZ) and the Discovery Creek fault zone (DFZ); stratigraphic abbreviations as in legend, Figure 1-7-3. (B. A strain ellipse for the compressional dextral transfer zone shows the maximum stress direction (σ1) and predicts thrusting along direction a, dextral offset along orientation b, and sinistral offset in attitude c. (C). Figure showing changes in attitude of a dextral strike-slip fault (after Ferri et al., 1992b). Cross-section A-A' depicts a negative flower structure forming grabens; an analogue would be the Uslika Formation (KTu). A positive flower structure (cross-section B-B') resulting in compression and thrusting as in the Manson Creek - Discovery Creek dextral transfer zone.

structures are expected along east-west trends (attitude c, Figure 1-7-5B). East-west sinistral shear is suggested by a fault zone 5 metres wide in Discovery Creek as well as numerous offset beds including a 1-centimetre layer of anthracite in the late Toarcian sediments. A carbonate alteration zone 20 metres wide, and smaller carbonate veins, also follow prominent east-west trends.

The structures observed near the Omineca River and southern Discovery Creek are consistent with the westward stepping of motion from the Manson fault zone to the Discovery fault zone through a zone of compression or positive flower structure (Figure 1-7-5C). In contrast, the Discovery Creek fault in the northern part of the map area is characterized by fault strands containing the Cretaceous to Tertiary Uslika Formation in simple grabens. This system continues northward into the Uslika Lake map area where Ferri et al. (1992a) have concluded a northeast shift in the dextral fault has produced an extensional flower structure preserving younger sediments in grabens along fault strands (Figure 1-7-5C).

The change from compressional to extensional regimes along the Manson Creek - Discovery Creek dextral fault system occurs over a very short distance. This rapid change in orientation may reflect crustal-scale inhomogeneities, such as the first appearance of the Lay Range assemblage.

Timing of movement on the Manson Creek - Discovery Creek fault system is constrained to be as old as Cretaceous, based on the most probable age of the Uslika Formation and

Plate 1-7-4. Tight folds with steep southeast-plunging fold axes, Discovery Creek. These are consistent with dextral synthetic structures predicted by attitude b in strain ellipse (Figure 1-7-5B) for the Manson Creek - Discovery Creek dextral transfer zone.
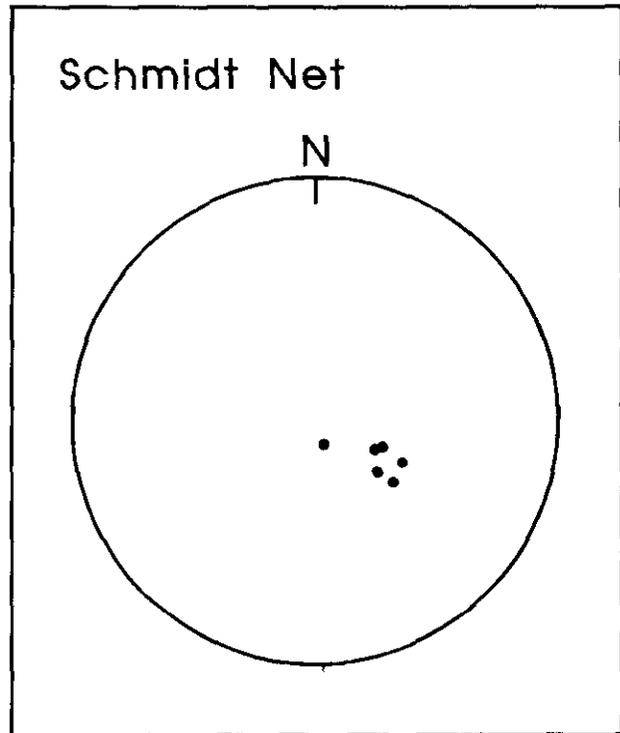

Figure 1-7-6. Steeply southwest plunging fold axes from tight folds in Discovery Creek, consistent with dextral synthetic structures in the Manson Creek - Discovery Creek dextral transfer zone.

the estimates of age of motion on the Manson fault zone (Ferri and Melville, in preparation). The fault probably continued to be active during the Tertiary with the deposition of the Sustut Group in the north (Ferri *et al.*, 1992c) and Cretaceous to Tertiary rhyolites at the west end of Germansen Lake.

Minor fault-bounded, maroon, quartz-feldspar-bearing volcanics in southern Discovery Creek may represent later faulting along a north-northwest trend to open up small extensional structures.

MINERAL PROSPECTS

Mineral prospects in the map area are diverse and include epithermal, lode-gold, late-stage magmatic and skarn targets. Of these, the Aplite Creek (093N 085) and Takla Rainbow (093N 082) prospects have extensive exploration

histories. New mineral prospects include the Groundhog (093N 212), Vall (093N 213), Tsay (093N 214) and Wudtsi (093N 215). The abundant alkaline porphyry systems prevalent in the Nation Lakes area do not continue northwards into the area studied in 1992.

APLITE CREEK, AHDATAY (MINFILE 093N 085)

The Aplite Creek mineral prospect is situated 4.75 kilometres east-southeast of the southern end of Ahdatay Lake, along Aplite Creek. The area has received considerable exploration sporadically since the 1970s for porphyry copper-molybdenum, and most recently for porphyry copper-gold deposits. The prospect is within the Aplite Creek intrusive complex.

The area is cut by fracture zones trending northwest (345°) or northeast (060°). Deeply incised gullies with good outcrop exposures are coincident with these subvertical fracture zones and form prominent topographic linears. Moderate to intense propylitic and potassic alteration envelopes up to 20 to 25 metres thick occur around the fractures (Paterson and Barrie, 1991).

Mineralization consists of disseminated pyrite, pyrrhotite and chalcopyrite in anastomozing quartz-carbonate veins up to 4 centimetres thick. Sulphides are also present in the matrix of the country rocks, locally up to 100 metres away from the fractures (Paterson and Barrie, 1991). Various amounts of malachite, azurite, limonite and hematite are associated with the sulphide minerals.

Takla Rainbow (MINFILE 093N 082)

The Takla Rainbow prospect lies at the headwaters of Twin Creek in 93N/11. This area was explored by various companies in the early 1970s. The Twin claims were staked in 1981 by L. Warren and N. Scarfe. Imperial Mines Limited optioned the claims in 1985 and explored them until 1989, identifying a significant zone of gold mineralization with associated copper and zinc on the West grid, referred to here as the Main zone. This zone is centred on the west-northwest-trending Twin Creek fault (Figure 1-7-3). The presence of abundant orthoclase-megacrystic granite dikes within the fault zone, many of them sheared, suggests syn-plutonic, probably Cretaceous, motion. Sulphides occur as disseminations in silicified, chloritized Takla Group and dikes within anastomosing shears of the Twin Creek fault zone. There are two other zones of alteration. The Red zone lies 1.2 kilometres northwest of the Main zone. It is an area of bleached tourmaline-matrix breccia developed in diorite of the Hogem intrusive complex. Eastfield Resources Limited drilled the Red zone in 1990. It reports low gold and copper values, propylitic alteration and disseminated sulphides that are suggestive of a porphyry-style system (Bailey, 1991). The ridge south of the Twin Creek fault is underlain by a strong quartz-kaolinite-pyrite alteration zone, capped by a discontinuous, horizontal alunite-quartz zone up to 5 metres thick that extends over 500 metres. It offers an as-yet unexplored epithermal target.

Klawli (MINFILE 093N 032)

The Klawli showing lies east of the Klawli River and is hosted by plagioclase±hornblende-porphyritic volcanics of the Chuchi Lake formation. In creek-bank trenches near old adits the volcanics are bleached and altered with zones containing pyrite, chalcopyrite, malachite and azurite. Although the rocks appear sheared and fractured, discrete shear zones and fabrics were not recognized. This showing was briefly described by Nelson et al., (1992b). Three grab samples assayed greater than 2 per cent copper, 102.8 grams per tonne silver and 2.6 grams per tonne gold (Shaede, 1984).

Groundhog (MINFILE 093N 212)

The Groundhog MINFILE locality is situated on a creek cut by the Tsayta - Germansen Lake road at Groundhog Pass, approximately 2 kilometres south of the confluence of Groundhog Creek and Twin Creek. A multi-element stream sediment anomaly was identified at the mouth of this creek during a Regional Geochemical Survey (RGS) in 1983. Follow-up assessment work by B.P. Resources Canada Limited in 1984 failed to locate the source of the anomaly (Humphreys, 1984).

Geological mapping in 1992 (this report) outlined fresh, maroon, amygdaloidal, plagioclase-porphyritic basaltic andesites underlying the Groundhog Pass area. The volcanics belong to the lower part of the Jurassic Twin Creek formation. Amygdules up to 1 centimetre in diameter are filled with massive magnetite. A grab sample from an amygdaloidal flow assayed 890 ppm copper, 100 ppm zinc and 12 ppm lead. The magnetite amygdules are the probable source of the RGS anomaly. The magnetite was probably deposited by late-stage magmatic fluids. Minor malachite was noted on a fracture surface.

Vall (MINFILE 093N 213)

The Vall occurrence is located along the northeast bank of Valleau Creek approximately 5.5 kilometres from its confluence with the Klawli River. It is a skarn 20 centimetres wide with an attitude 000/78E, associated with a small, irregular carbonate vein system. A grab sample from the showing assayed 130 ppb gold and 176 ppm copper. The occurrence is hosted by hornfelsed coarse augite and minor plagioclase-porphyritic basalts of the Jurassic Chuchi Lake formation.

Tsay (MINFILE 093N 214)

The Tsay occurrence is hosted by a northwest-trending fault structure that extends 10 kilometres from the west end of Tsaydaychi Lake to the headwaters of Valleau Creek. The zone, 1.5 to 2 kilometres wide, lies entirely within the Inzana Lake formation and is characterized by iron carbonate and quartz-sericite alteration. Disseminated green mica (mariposite?) and pyrite occur in intensely altered, pale buff coloured, foliated sediments. A grab sample returned 135 ppm arsenic and 98 ppm copper.

The presence of anomalous arsenic values with carbonate-quartz-sericite alteration and mariposite suggests a listwanite association. The fault structure has potential for hosting gold-bearing quartz veins, and is thus an interesting regional exploration target.

Wudtsi (MINFILE 093N 215)

At the headwaters of Valleau Creek, approximately 5 kilometres north of the south end of Wudtsi Lake, a small, hybrid stock intrudes the Inzana Lake formation. The intrusive is a varitextured diorite-gabbro body. A hornfelsed mesocratic hornblende diorite phase contains pyrrhotite-bearing quartz stringers that yielded analysis of 190 ppm copper. Epiclastic sandstone and siltstone hosts are hornfelsed and altered (potassic?) and contain disseminated pyrite.

CONCLUSIONS

Takla Group Internal Stratigraphy and Volcanic Facies

The Nation Lakes mapping project now includes 4.5 standard 1:50 000 topographic sheets, extending over 150 kilometres along the northern Quesnel trough. Within this area, the Takla Group shows regional facies variations but an overall magmatic evolution from mainly basaltic in the Late Triassic to mixed, more differentiated volcanism in the Early Jurassic. As Upper Triassic Witch Lake augite-phyric basalts are succeeded by the heterogeneous, Upper Jurassic Chuchi Lake volcanic suite, so is the dominantly basaltic Plughat Mountain formation succeeded by the intermediate Twin Creek volcanics, presumably of Early Jurassic age.

The Triassic and Jurassic volcanic suites probably did not form uniform blankets. Instead the Takla arc in the Nation Lakes area is composed of interfingering volcanic aprons with different volcanic styles and compositions. Significant differences occur between the Witch Lake and Plughat Mountain formations and between the Chuchi Lake and Twin Creek formations. The Plughat Mountain formation contains more flows, many with maroon colours and large amygdules, and a limestone reef. These suggest shallow marine conditions or partial emergence of the Plughat Mountain formation, in direct contrast to the Witch Lake formation. Compositional differences include abundant olivine in the Plughat Mountain and distinct trachyte flow units in the Witch Lake formation near Mount Milligan (Nelson et al., 1991a, b).

The Twin Creek formation shows textural similarities to the Chuchi Lake, for instance in its heterolithic lapilli tuffs. It lacks interbedded basic flows and in particular the Pliensbachian sedimentary marker. Unlike the Chuchi Lake, quartz occurs in the more felsic units. This evidence for greater silica saturation in the north agrees with the contrast in chemistry between the shoshonitic Witch Lake formation and the transitional Plughat Mountain formation (Ferri and Melville, in preparation; Bellefontaine and Nelson, 1992).

JURASSIC TECTONICS

The Toarcian sedimentary sequence in Discovery Creek shows evidence for early uplift and exposure of monzonites in the Hogem intrusive complex, prior to emplacement of the Ducking Creek syenite. Muscovite in these sandstones requires either a pericratonic or a North American sedimentary source. In the latter case it would support the Toarcian accretion of Quesnellia to North America. If North American, the exact identity of the muscovite source is still difficult to pinpoint. It is probably not the metamorphic core complexes of the Omineca Belt, as they were not uplifted until post-Toarcian time.

LATE CRETACEOUS – EARLY TERTIARY STRIKE - SLIP TECTONICS

At the latitude of the Omineca River, dextral transcurrent motion steps westward from the Manson to the Discovery Creek fault zone. This step occurs across a transfer zone of high-angle southwest-directed reverse faults that juxtapose various stratigraphic levels of the Nina Creek group, Lay Range assemblage, Takla Group and younger sediments.

Motion on the Discovery Creek system may have accompanied deposition of the Lower Cretaceous to Tertiary Uslika boulder conglomerates. It also postdates Uslika deposition, as strands of the system transect the Uslika Formation, dividing it into moderately to steeply dipping panels. The southern end of the Discovery Creek fault system is a graben filled with rhyolites and siliciclastic sediments at the west end of Germansen Lake. A K-Ar age on one of the rhyolites may provide further age constraint on fault motion.

MINERALIZATION

Large propylitic and potassic alteration haloes like the Mount Milligan, Taylor, Witch and BP-Chuchi centres clus-

ter near the Nation Lakes area and do not extend north into the present map area. It appears that alkalic porphyries are not scattered evenly throughout the northern Quesnel trough but are instead concentrated in camps. Delineation of these mineralized camps is an important ongoing endeavor. What are the controls for the clustering of porphyry systems?

The Nation Lakes concentration of alkalic porphyries lies at the southern end of the Hogem intrusive complex, where it turns abruptly east and either plunges or terminates (Figure 1-7-2). Also, a northwesterly trending line of porphyry deposits follows the cryptic southern extension of the Valleau Creek fault. Perhaps these regional-scale geologic features reflect fundamental discontinuities in the basement of the Takla arc. The proposed large-scale structures are shown by regional magnetic lineaments; they might also be modelled using gravity data.

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