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Geology of the Cambria Icefield and regional setting for the Red Mountain Au deposit, northwestern British Columbia.

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Greig, C.J., Anderson, R.G., Daubeny, P.H., Bull, K.F., and Hinderman, T.K., 1994: Geology of the Cambria Icefield and regional setting for the Red Mountain Au deposit, northwestern British Columbia; in Current Research, Part A; Geological Survey of Canada, Paper 94-1A, p. xxx-xxx.

ABSTRACT

Lower Jurassic (LJr) Hazelton Group (HG) volcanic and volcaniclastic rocks underlie much of the Cambria Icefield area and host LAC Minerals' Red Mountain Au deposit. They occur with similar Upper Triassic and older rocks in a structural culmination outlined by the contact between competent felsic and mafic volcanic rocks of uppermost HG and overlying, relatively incompetent late LJr and younger, westerly-derived clastic rocks.

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Stratigraphy of HG is complex, but locally traceable units show that LJr stratigraphy helped localize mid-Cretaceous(?) structure. The newly-recognized mafic-felsic association in upper HG has significant exploration and tectonic implications. Plutonic styles suggest the age and exploration potential of plutons be reconsidered. Genesis of the Red Mountain deposit has yet to be firmly established, but the main mineralizing event pre-dated regional deformational events, implying significant stratigraphic control and potential in the area mapped, and areas nearby, for similar deposits.

[EDITOR: ABSTRACT WORD COUNT = 147]

INTRODUCTION

An Industrial Partners Program project involving the Cordilleran Division of the Geological Survey of Canada and Lac Minerals Ltd. in 1993-94 encompassed mapping a little-known but highly prospective region east of Stewart and between Kitsault River and American Creek in northwestern British Columbia. Mineral potential in the region is high, as manifest in LAC's Red Mountain Au deposit, which is in the initial stages of underground exploration. The work will help place the Red Mountain precious and base metal deposit into a district-wide geological context and facilitate more effective mineral exploration.

This paper presents preliminary results of 1:50,000 scale mapping in the Cambria Icefield area, including parts of 103P/13, 103P/14, 104A/3 and 104A/4 NTS map areas (Fig. 1). The new work links recent mapping to the southeast (Greig, 1991, 1992; Alldrick et al., 1986) with that to the northwest (Grove, 1971, Alldrick, 1993). Reconnaissance scale maps encompassing the Cambria Icefield (McConnell, 1913; Hanson, 1929, 1935; Grove, 1986), and recent new stratigraphic and structural data from adjacent areas (Evenchick et al., 1992; Greig and Evenchick, 1993; Anderson, 1993) proved useful. The present mapping incorporates more detailed, unpublished work from the Cambria Icefield area by Bull et al. (LAC Minerals, 1991). Permanent ice and high relief characterize the Cambria Icefield area, and the easiest access is by helicopter except along Highway 37A.

REGIONAL GEOLOGY AND STRATIGRAPHY

The Cambria Icefield area lies near the boundary of the Intermontane and Coast belts in northwestern Stikinia, along the southwestern margin of the Bowser Basin. Uppermost Lower Jurassic to Upper Jurassic well-bedded marine clastic rocks stratigraphically overlie and form the less competent structural cover to a generally more massive and competent basement of Paleozoic to Lower Jurassic oceanic arc volcanic and volcaniclastic rocks (see Anderson, 1993) exposed in structural culminations of the latest Jurassic or Early Cretaceous to Tertiary Skeena Fold Belt (Evenchick, 1991).

Cambria Icefield area strata are mainly Jurassic (Fig. 2). The central and higher parts of the area, coinciding with the major icefields, are underlain by resistant Lower Jurassic felsic and mafic pyroclastic and subordinate flows and volcaniclastic rocks which mark the top of both the structural basement and the volcanic part of the Hazelton Group. The less rugged eastern part is underlain by upper Lower Jurassic to Upper Jurassic clastic rocks correlative to the Salmon River Formation (of the Hazelton Group) and Bowser Lake Group. Upper Triassic clastic rocks and Triassic or older basalt occur locally.

Hazelton Group clastic rocks were divided into three units by inferred stratigraphic position and sedimentological maturity. The uppermost unit (MUJ, Salmon River Formation) is the best stratified and sorted and finest grained. The common debris flow conglomerate and ash tuff of the middle unit (Jdf) is least mature; the lowest unit (Jvc) is intermediate in these characteristics. Stratigraphic relationships of the three units are poorly known because they contain few fossils, their contacts are gradational and(or) structurally modified (Figs. 3, 4), and locally they resemble each other and other units. It is likely that rocks mapped as one unit include rocks of another, particularly where traverse density was low. All three units are at least partial facies equivalents of volcanic units (e.g., Fig. 5), and commonly include pyroclastic rocks or flows.

Basement Rocks

Crowded Feldspar-phyric Basalt (unit PTb)

Crowded feldspar-phyric basalt of probable Late Triassic or older age underlies an area between the Nelson glaciers and South Willoughby Creek. Typically, aligned feldspar phenocrysts outline discontinuous centimetre- to decimetre-sized irregular to subround shapes (Fig. 6) but the unit is otherwise massive. Contacts with bounding Upper Triassic and(or) Lower Jurassic clastic units are faulted and the age of the unit is inferred from the presence of distinctive basalt clasts of it in conglomerate of the bounding units, and from probable interfingering of the volcanic and Upper Triassic clastic rocks north of Willoughby Glacier.

Upper Triassic Volcaniclastic Rocks (unit Tv)

A belt of Upper Triassic volcaniclastic rocks bounds the feldspar-phyric basalt to the west. Rocks near the Cambria fault at Entrance Peak may be dextrally-offset equivalents. Silty mudstone, siltstone, sandstone, and local conglomerate and debris flow conglomerate are typical but locally are difficult to distinguish from Jurassic rocks. Contacts between Triassic and Jurassic rocks have been structurally modified. Bedding across these contacts is discordant, and north of Willoughby Glacier, stratigraphic facing directions are opposed (Fig. 4, section OP). The contact is likely an unconformity or a normal fault, but the data are equivocal.

It is possible that the unit is partly equivalent to the lower Lower Jurassic clastic unit. If so, the Upper Triassic unit may be slightly older than but correlative with the Jack formation of Henderson et al. (1992). Bivalves of probable Late Norian age (H.W. Tipper, personal communication, 1993) were collected from two localities near Willoughby Glacier.

Andesite/Dacite Lapilli and Ash Tuff (unit Jt)

A thick (> 1000 m) and very weakly stratified, dark greenish-grey, lapilli and ash crystal-lithic tuff underlies the lower slopes of Bear River Pass. It contains common intermediate to felsic volcanic lithic lapilli and chloritized fiamme, and is dacitic to andesitic (Fig. 7). Its base is not exposed but it is conformable with overlying felsic volcanic rocks. The tuff is not recognized southwest or northeast of the Bear River Pass, across the Bitter Creek and Cornice Mountain antiforms. Its distribution to the northwest is unknown. Much thinner, muddy debris flow conglomerates common within Hazelton Group on the limbs of the Bitter Creek and Cornice Mountain structures (parts of units Jdf and Jd) may be facies equivalents because they contain angular intermediate to felsic volcanic clasts. If so, the locus of facies change coincides with and localized regional structures. Tuff deposition probably also reflects pronounced local subsidence; overlying upper Lower and Middle Jurassic clastic rocks suggest deposition in an environment of subdued local relief. The Bear Pass tuff represents a restricted, syn-volcanic basin rather than a constructional volcanic edifice.

Lower Jurassic Volcaniclastic Rocks (unit Jvc)

The unit occurs in two belts: one bounds Triassic or older basalts on the east, and the other occurs in the core of the Bitter Creek antiform. Weakly calcareous arkosic sandstone, siltstone, muddy debris flows and volcanic debris flows, and local limestone and polymict conglomerate are typical, and the rocks are commonly Fe-carbonate altered. Conglomerate is discontinuous and minor but widespread, and its diverse clast compositions distinguish it from conglomerate in other units. It contains abundant feldspar-phyric volcanic clasts, probably derived from the Triassic or older basalt, common coralline limestone boulders, and scattered plutonic cobbles. The conglomerate may be the expression of latest Triassic-earliest Jurassic deformation and uplift recognized elsewhere in Stikinia (e.g., Brown and Greig, 1990; Greig 1992; Greig and Gehrels, 1992; Henderson et al., 1992; Anderson, 1993).

Maroon Feldspathic Pyroclastic and Epiclastic Rocks (unit Jm)

Interbedded maroon, lavender, purple or green feldspathic pyroclastic and volcaniclastic rocks locally are useful marker units. Where traverse density allowed, pyroclastic (unit Jmp) and epiclastic (unit Jme) facies were recognized.

Epiclastic rocks consist of poorly to moderately well stratified and sorted conglomerate (Fig. 8), sandstone, siltstone and mudstone, all cemented by patchy carbonate. Clast compositions are dominantly volcanic, with very fine grained felsic volcanic clasts conspicuous and common. Andesitic or basaltic, hornblende- or pyroxene-phyric pyroclastic rocks are massive, crystal-lithic lapilli tuff-breccia, coarse to fine lapilli tuff and ash. Oxidization and alteration of the unit are common.

The epiclastic rocks resemble the Betty Creek Formation of Grove (1986), but unlike these rocks in eastern Iskut map area (Anderson, 1993) the Cambria Icefield equivalents have no unique stratigraphic position within the Lower Jurassic succession.

Pyroxene-bearing Volcanic and Volcaniclastic Rocks (unit Jp)

Dark green, pyroxene- and plagioclase-phyric pyroclastic and volcaniclastic rocks are common and distinctive in the upper Hazelton Group. They are locally interbedded with felsic volcanic rocks (unit Jd) and are a significant component of the maroon unit (unit Jm). Commonly amygdaloidal lapilli tuff-breccia (Fig. 9), lapilli and ash tuff, as well as local flows, volcanic debris flows, and rare pillowed basalt make up the unit. Pyroxene phenocrysts are typically 2-3 mm in diameter but reach 0.5 cm. Clastic rocks include pyroxene arkosic litharenite, mafic siltstone, and local volcanic conglomerate. Northeast of Sutton Glacier, coarse lapilli tuff contains mafic plutonic fragments.

Near Mount Gladstone, the mafic volcanic unit is traceable across the Bitter Creek antiform to a mainly clastic section to the west. This suggests that the clastic rocks on the west flank of the Bitter Creek structure (and east of Bitter Creek) are a facies equivalent of volcanic rocks east of the structure and constrains kinematics on associated structures.

Felsic Volcanic Rocks (unit Jd)

Dacite, dacitic andesite and rhyolite correlated with the Mount Dilworth Formation (Alldrick, 1993) occur near the top of the volcanic part of the Hazelton Group, where they commonly delineate the basement-cover contact. They are widespread, commonly interfingering with limy mudrocks of units Jdf and Jc, but in bodies too small to show on Figure 2. The felsic rocks weather distinctively pale grey to white and are commonly rusty due to disseminated pyrite. Lithic lapilli tuff and lapilli tuff-breccia are most common. Ash and dust tuff, and flow-foliated and flow-folded flows and flow breccias occur locally. Pillowed flows are rare. About 6 km east of Mount Andreas Vogt, felsic flows and flow-breccias are continuous with their intrusive counterparts.

Hornblende Feldspar-phyric Volcanic Rocks (unit Jh)

In many places, very resistant, massive (amygdaloidal) hornblende feldspar-phyric dacitic andesite or andesite flows, flow-breccias and coarse crystal lithic lapilli to lithic crystal ash tuff are associated with the felsic volcanic rocks described above. They are also commonly pyritic and interfinger with clastic rocks, locally producing striking hyaloclastite matrix breccias and syn-depositional loading structures. Some breccias grade into and interfinger with volcanic debris flows, and compose a significant proportion of the overlying debris flow unit (Jdf).

Red Mountain Sequence (unit Jrm)

The Red Mountain sequence is steeply west-dipping, probably west-facing, and consists of thin-bedded (1-10 cm, average 3 cm beds) to very thickly bedded, well-indurated felsic(?) to mafic(?) dust, ash and subordinate lithic crystal (hornblende and feldspar) lapilli tuff, and siliceous (cherty) argillite and rare bedded radiolarian chert. Much of the sequence is pyritic and strikingly rusty weathering, giving Red Mountain its name. Massive tuff contains scattered fine lapilli compositionally similar to matrix ash. Centimetre- to decimetre-scale, syn-sedimentary deformation structures are not uncommon. Sills and dykes of (biotite quartz) hornblende feldspar porphyry (Goldslide intrusions) intruded the sequence, which itself may contain their extrusive equivalents.

The Red Mountain sequence is continuous with volcaniclastic units to the north (Jdf, Jvc, Fig. 2), but is generally more siliceous or altered. Radiolarian fauna from chert in the various successions may help to corroborate these correlations. Clastic rocks, chert and fine- grained tuffaceous rocks with close similarities to, but less altered than, those at Red Mountain also occur to the southwest and south.

Debris Flow Conglomerate and Volcanic Debris Flows (unit Jdf)

Very poorly stratified muddy debris flow conglomerate (Fig. 10) and subordinate volcanic debris flows typify the unit; less common silty mudstone, siltstone, sandstone, pebble conglomerate and limestone are partly correlative with and indistinguishable from Lower to Middle Jurassic(?) clastic rocks (unit Jc). Most rocks in the unit are weakly carbonate-cemented. Discontinuous limestone pods are typically sandy or pebbly and locally contain bivalves. North of Willoughby Glacier, colonial corals occur in limestone several metres thick. Debris flows are typically feldspathic and tuffaceous and clasts are angular to subrounded fine grained clastic rocks and intermediate to felsic, commonly pyritic volcanic rocks. Uncommon, centimetre-scale, massive pyrite fragments in the debris flows, along with the pyritic felsic fragments and the general pyrite-rich, rusty weathering character, are important because they suggest a widespread Early Jurassic mineralizing event occurred.

Cover Rocks

Lower to Middle(?) Jurassic Clastic Rocks (unit Jc)

Thin-bedded silty mudstone and siltstone, with local thin-bedded sandstone and carbonate mudstone lenses, occur only in the southwest. They were not differentiated from clastic rocks of probable older age in much of that area (hence unit Jcv). Unit Jc is probably partly correlative to the Red Mountain sequence (unit Jrm), the debris flow unit (Jdf), and to the Middle to Upper Jurassic clastic rocks (unit MUJ). It is better stratified than the debris flow unit and less siliceous than either the Red Mountain sequence or unit MUJ.

Middle to (Upper?) Jurassic clastic rocks (unit MUJ)

Fine-grained clastic rocks of Middle (to Late?) Jurassic age are exposed nearly continuously in a narrow belt to the east and in an outlier near Mount Strohn. Similar rocks occur in outliers near Bitter Creek and near Yvonne Peak. In the east the rocks are characteristically thin bedded and siliceous or less commonly limy; near Bitter Creek, thick- bedded to very thick-bedded (3-6 m, on average) massive to laminated silty mudstone and local muddy debris flow conglomerate containing exclusively sedimentary clasts are typical. The general siliceous nature and association with very thin bedded (2 cm on average) and laminated, varicoloured tuffaceous chert, chert and cherty argillite are characteristic. Fossils collected from the unit suggest Toarcian, Bajocian and Callovian ages (H.W. Tipper, G. Jakobs, E. Carter, personal communication, 1993), but near Bitter Creek, the unit may include Upper Jurassic rocks. In the east, unit MUJ corresponds to the lower part of the Surprise Creek facies of the Middle Jurassic Salmon River Formation, as mapped by Evenchick et al. (1992). The laminated and siliceous beds are likely equivalent to Anderson's (1993) Troy Ridge facies of the Salmon River Formation.

Upper Jurassic Clastic Rocks (unit UJ)

This unit conformably overlies unit MUJ (Fig.4, section EF; Fig. 11) and is similarly distributed. Silty mudstone and metre-scale (1-6 m) arkosic litharenite A-E turbidites predominate. The thicker sandstone beds and the less siliceous and thicker-bedded character of the mudstone distinguish rocks of unit UJ from those of unit MUJ. Unit UJ resembles the upper member of the Salmon River Formation to the south (Greig, 1991), and coincides in the northeast with the upper part of the Surprise Creek facies (Evenchick et al., 1992). However, an improved paleontological database suggests that the rocks are Upper Jurassic and equivalent in age to nearby Bowser Lake Group. Greig (1991) and Evenchick et al. (1992) have pointed out that they are distinctly different than nearby Bowser Lake Group rocks. East-trending paleocurrent indicators (Fig. 1) suggest at least a local western source for these westernmost Upper Jurassic Bowser Basin sedimentary rocks.

INTRUSIONS

Previously, plutonic rocks in much of the area were undivided and considered Tertiary and older(?) (Carter, 1981; Grove, 1986). Five Middle Jurassic and younger and Tertiary(?) suites of plutons were distinguished by composition and mineralogy, alteration, intrusive relationships and internal fabrics. Only the Goldslide and related intrusions are described in detail because of their close association with the Red Mountain deposit. The Tertiary suite, similar to Middle Eocene Hyder plutonic suite intrusions (Grove, 1986) vary in composition from quartz monzonite and monzogranite to granodiorite or quartz diorite, commonly contain scattered pink potassium feldspar megacrysts, and are typically medium grained and unfoliated.

Two prominent dyke swarms also occur: the west-southwest-dipping Portland Canal swarm (lamprophyre and basalt to dacite, rhyolite and granite), which underlies Bitter Creek, Mount Dickie, and Ore Mountain; and the subvertical, northwesterly-striking Nelson glaciers swarm (homogeneous (biotite-quartz-) hornblende-feldspar porphyry) (Fig. 12). The Portland Canal dykes likely were emplaced along pre-existing bedding and cleavage in the host rocks (see Grove, 1986).

Middle Jurassic and Younger Intrusive Rocks

Goldslide pluton and related intrusions (unit JKg)

The Goldslide intrusions comprise small plutons and related sills and dykes of hornblende plagioclase porphyritic to seriate quartz monzodiorite, granodiorite or diorite, locally containing phenocrysts of quartz, biotite or potassium feldspar. They include the main intrusion on Red Mountain (Goldslide pluton, 160 and 200 Ma $^{40}Ar/^{39}Ar$; LAC Minerals Ltd., unpublished data cited in Schroeter et al., 1992) and similar bodies 6-7 km south and southwest of Red Mountain, north of Homestake Ridge, northwest of North Flat Glacier, and west of Willoughby Glacier. They intrude probable upper Lower Jurassic rocks and are commonly dyked, veined and altered, Locally they have the regional cleavage prominent in their hosts and are likely pre-Cretaceous. At Red Mountain, and locally elsewhere, contact relations between the Goldslide intrusions and their country rocks are equivocal and the bodies have been interpreted as flows or as sills and dykes. Their discordant map pattern at the property scale at Red Mountain is consistent with an intrusive origin. Host tuffaceous rocks are locally highly disrupted, with common plastically-deformed fragments suspended in a compositionally-similar ash matrix. These textures are interpreted to indicate intrusion into unlithified or poorly lithified host rocks.

STRUCTURE

Several domains and their bounding structures are distinguished on the map of structural elements (Fig. 3) and on cross-sections (Fig. 4). The northeast-trending Cambria fault separates domains containing structures of different vergence. The fault probably was the locus of limited pre-Tertiary(?) right lateral displacement; the crosscutting Tertiary(?) Nelson glaciers dyke swarm is apparently not offset across it.

Northwest of the fault, the domain is characterized by structures with southwest vergence on the northeast and northeast vergence on the southwest. It is a broad structural culmination comprising a central, relatively undeformed area underlain primarily by volcanic rocks (North Cambria and Todd icefields), and flanking, more strongly deformed areas (limbs) to the southwest and northeast underlain by clastic, well-bedded rocks. In the central area, gentle to moderate dips prevail and the basement-cover contact is deformed into broad, open folds. On the limbs, typical smaller-scale, tight and overturned folds are parasitic to the larger scale, basement-cored, central structure. Although the magnitude of shortening on the limbs is difficult to estimate, it appears to be much greater on the southwest, where overturned folds and thrust (or reverse) faults duplicate stratigraphy. On the northeast, folds are less common and stratigraphic overlap is small. The boundaries between the central culmination and the limbs are coincident with faulted antiforms, the Bitter Creek and Cornice Mountain antiforms (Fig. 4). Correlations of pyroxene-bearing volcanic rocks, discussed above, suggest that strike-slip displacement on the Bitter Creek structure, manifest in small-scale structures, is minimal. Alternatively, if a large scale structure is present, it lies west of the mafic volcanic rocks.

Southeast of the Cambria fault, southwest-verging structures dominate. In the northeasternmost part (section OP, Fig. 4), partly underlain by Upper Triassic and older rocks, structures are complex and may record a polyphase history, perhaps involving Triassic-Jurassic deformation similar to that observed near Kinskuch Lake (Greig, 1992). In this area, however, Hazelton Group rocks have also been affected by both northeast- and younger(?) southwest-vergent structures (Fig. 3). Southwest-directed shortening dominates here compared to the domain on the northwest (c.f. sections IJ and ST). The reason for this is uncertain, but speculatively, the Cambria fault may be a tear fault separating fold-thrust subsystems within the Skeena fold belt.

Basement and cover structural styles are dissimilar. The apparent disparity in magnitude of shortening is probably accommodated by detachments within the lower part of the cover sequence (e.g., section ST), by thrust faults within the basement (e.g., the thrust near the South Flat Glacier), and by detachments beneath basement culminations (Evenchick, 1991).

DISCUSSION

The stratigraphic position and distribution of the mafic volcanic rocks (e.g., units Jp and Jd) are important in mineral exploration and for Early Jurassic tectonics. Their discontinuous distribution down the southwest margin of the icefield to west of Homestake Ridge permits a speculative correlation with mafic volcanic rocks mapped by Alldrick et al. (1986) along strike west of Kitsault River valley (Fig. 1). Although Alldrick et al. (1986) correlated them with mafic rocks **east** of the Kitsault Valley, mafic rocks there occur at the base of a very thick section of Hazelton Group rocks and may be as old as Upper Triassic (Cordey et al., 1992). Mafic rocks west of the valley are likely much younger.

If so, the area underlain by upper Hazelton Group volcanic rocks is considerably expanded. The strata host the nearby Torbrit, Dolly Varden and Kit stratiform base metals deposits, and more precious metals-rich occurrences such as Red Mountain and Homestake Ridge. If the mafic rocks west of Kitsault River are part of the upper Hazelton Group, it would support the view that the Anyox pendant, which includes mafic volcanic and Jurassic (Goutier et al., 1990) clastic rocks, is part of Stikinia. It follows that the Anyox massive sulphide deposit might be similar in age to the Torbrit, Dolly Varden and Kit deposits, and(or) to those at Granduc(?) and Eskay Creek (Anderson et al., 1993).

CONCLUSIONS

1) Lower Jurassic Hazelton Group volcanic and volcaniclastic rocks, with a common bimodal composition, underlie much of the Cambria area and possibly overlie previously deformed Upper Triassic and older volcanic and clastic rocks. A shallow marine arc or extensional arc setting is indicated.

2) mafic, pyroxene-rich volcanic rocks are an important part of the succession and their recognition has consequences for regional metallogeny and tectonics.

3) the volcanic rocks are overlain by a Middle and Upper Jurassic clastic succession characterized by increasing sedimentological maturity upsection and a westerly provenance.

4) Middle Jurassic and younger and Tertiary plutons intrude the successions; the Jurassic plutons, particularly the porphyritic Goldslide intrusions, are altered and associated with mineral deposition (such as at Red Mountain), and predate inception of the Cretaceous Skeena Fold Belt.

5) apparent disparity in magnitude of shortening between cover and basement reflects differences in structural style that are attributable to contrasts in lithologic competency.

6) mineral deposition at Red Mountain is Early Jurassic based on: intrusive relations and age of the spatially associated Goldslide pluton; occurrence of pyritic volcanic rock fragments and sulphide clasts in Lower to Middle Jurassic clastic units; and pre-kinematic structural setting of host rocks and mineralization. An Early Jurassic age for the deposit is consistent with its setting in a mining district characterized by a widespread Early Jurassic mineralizing event.

ACKNOWLEDGMENTS

We acknowledge the geologic input of LAC Minerals geologists, the hospitality of LAC and J.T. Thomas Diamond Drilling at the Red Mountain camp, and the flying skills of the pilots of Vancouver Island Helicopters Ltd., particularly Thanh Pham and Tom Schnieder. Carol Evenchick and Glenn Woodsworth provided helpful reviews, Bev Vanlier helped in preparation of the final manuscript, and Tonia Williams drafted the figures.

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FIGURE CAPTIONS

Figure 1. Location of study area.

Figure 2. Geology of the Cambria Icefield area.

Figure 3. Structural elements of the Cambria Icefield area.

Figure 4. Geologic cross-sections.

Figure 5. Facies change units Jcv and Jd (pale, capping ridge and as tongues in darker rocks) west of Homestake Ridge; view to west, elevation gain on ridge 200 m.

Figure 6. Basalt of unit Ptb, showing characteristic grain size variation.

Figure 7. Crystal lithic tuff of unit Jt.

Figure 8. Conglomerate of unit Jme; note very large clast and crude stratification.

Figure 9. Mafic pillow breccia/coarse lapilli tuff of unit Jp.

Figure 10. Debris flow conglomerate with felsic volcanic rock

fragments in muddy matrix; unit Jdf.

Figure 11. View south southwest of basement-cover contact and fossiliferous cover succession 3.5 km south of Cornice Mountain; see section EF, Fig.4.

Figure 12. Nelson glaciers pluton and related dyke swarm; pluton in foreground and lowermost part of ridge in background; view northwest, Cornice Mountain upper right (relief 1200 m).

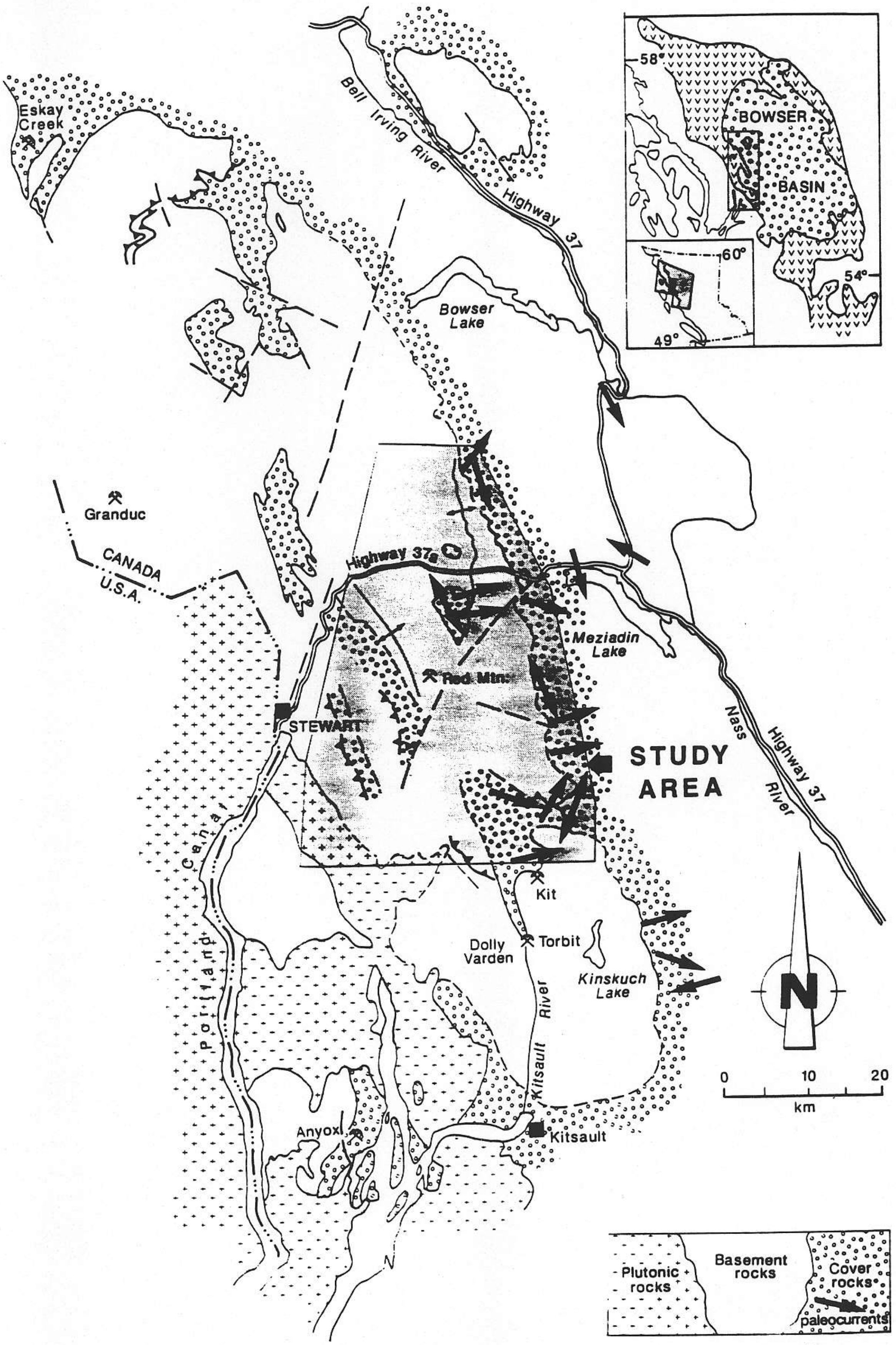
Eskay Creek
Bell Irving River
Highway 37
Bowser Lake
Granduc
CANADA
U.S.A.
Highway 37a
Meziadin Lake
Red Mtn.
STEWART
STUDY AREA
Nass River
Highway 37
Portland Canal
Kit
Torbit
Dolly Varden
Kinskuch Lake
Kitsault River
Kitsault
Anyox
N
0
10
20
km
58°
BOWSER
BASIN
54°
60°
49°
Plutonic rocks
Basement rocks
Cover rocks
paleocurrents

Fig 1

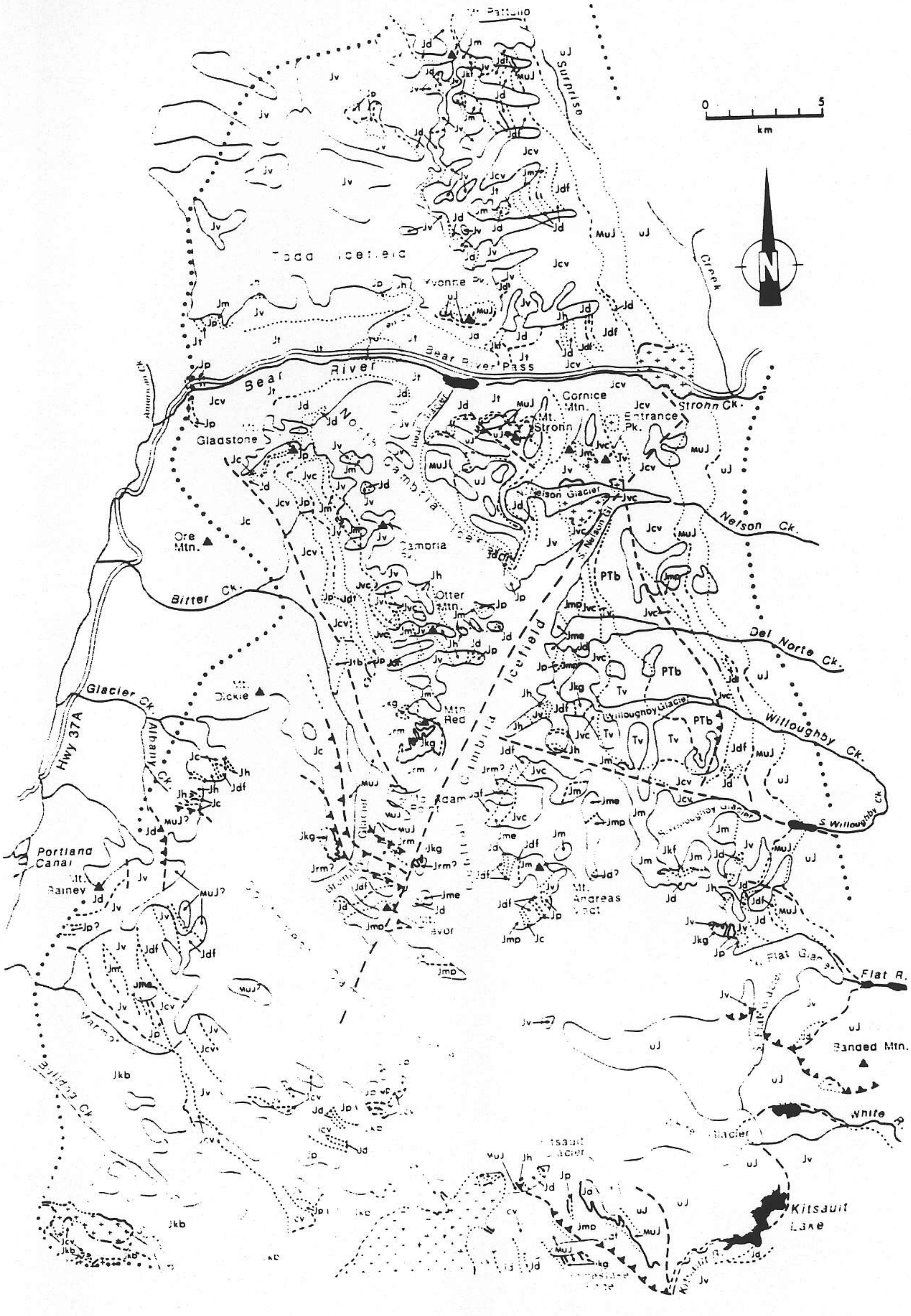
Mt. Pattullo
Surprise Creek
0 5 km
N
Todd Icefield
Yvonne Pk.
Bear River
Bear River Pass
Cornice Mtn.
Mt. Strohn
Entrance Pk.
Strohn Ck.
Gladstone
North Cambria Icefield
Nelson Glacier
S. Nelson Gl.
Nelson Ck.
Ore Mtn.
Cambria
Otter Mtn.
Bitter Ck.
Del Norte Ck.
Cambria Icefield
Mt. Dickie
Mtn. Red
Willoughby Glacier
Willoughby Ck.
Glacier Ck.
Albany Ck.
Hwy 37A
Mt. Adam
S. Willoughby Glacier
S. Willoughby Ck.
Portland Canal
Mt. Rainey
Mt. Andreas
Flat Glacier
Flat R.
Banded Mtn.
White R.
White Glacier
Kitsault Glacier
Kitsault Lake
Kitsault R.
Bulldog Ck.
Jv
Jd
Jm
Jcv
Jdf
Jvc
Jp
Jt
Jh
Jc
MuJ
uJ
PTb
Tv
Jkg
Jmp
Jme
Jrm
Jkb
Jkf

Fig 2

STRATIFIED ROCKS

COVER

Middle to Upper Jurassic

Bowser

UJ	Upper Jurassic clastic rocks
MUJ	Middle and Upper Jurassic clastic rocks
Jc	Lower to Middle(?) Jurassic clastic rocks

BASEMENT

Lower to Middle(?) Jurassic

Jdf	debris flow conglomerate and volcanic debris flows
Jrm	Red Mountain sequence

Lower Jurassic

Jh	hornblende-feldspar-phyric volcanic rocks
Jd	felsic volcanic rocks J-F
Jp	pyroxene-bearing volcanic and volcaniclastic rocks
→ Jmp	maroon pyroclastic rocks
Jme	maroon epiclastic rocks
Jm	maroon feldspathic pyroclastic and epiclastic rocks
Jvc	volcaniclastic rocks
Jt	andesite / dacite lapilli and ash tuff
Jcv	undivided clastic and volcanic rocks
Jv	undivided volcanic rocks

Upper Triassic

Tv	volcaniclastic rocks

Triassic or older

PTb	crowded feldspar-phyric basalt

PLUTONIC ROCKS

Tertiary(?)

+ +	quartz monzonite to diorite

Middle or Late Jurassic to Tertiary

Jtb	Bromley Glacier pluton

Middle Jurassic to Cretaceous

Jkf	felsic intrusions
Jkbp	Bear Pass pluton
Jkb	Bulldog Creek pluton
Jkg	Goldslide intrusion

Highway

••••••• limit of mapping

limit of permanent ice

thrust or reverse fault

▲ ▲ ▲ ▲ high angle fault

geological contact: known, inferred, assumed

Fig 2

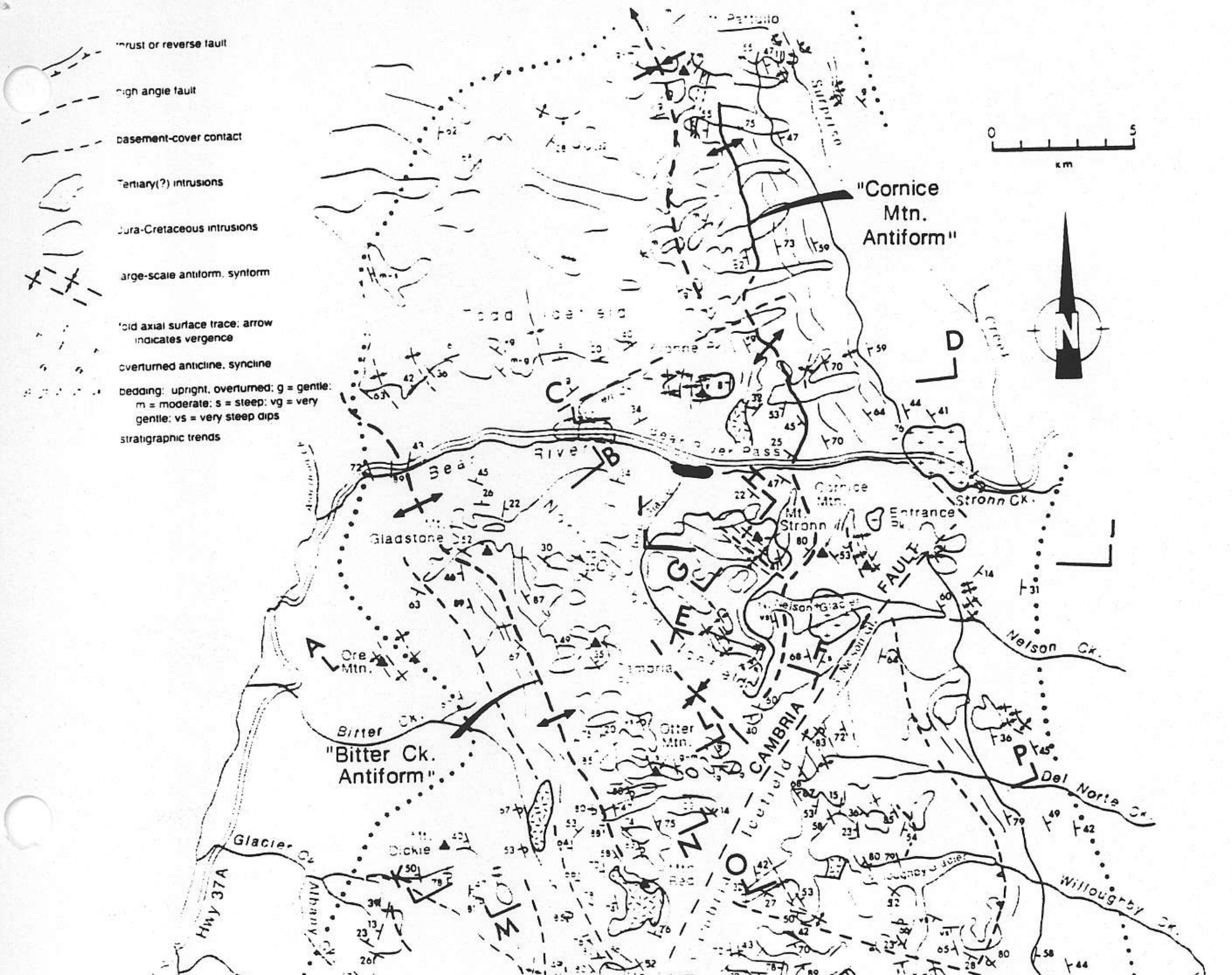
Thrust or reverse fault
High angle fault
basement-cover contact
Tertiary(?) intrusions
Jura-Cretaceous intrusions
Large-scale antiform, synform
Fold axial surface trace; arrow indicates vergence
overturned anticline, syncline
bedding: upright, overturned; g = gentle; m = moderate; s = steep; vg = very gentle; vs = very steep dips
stratigraphic trends
0
5
km
N
"Cornice Mtn. Antiform"
"Bitter Ck. Antiform"
A
B
C
D
E
F
G
H
I
J
L
M
N
O
P
Q
R
S
Todd Icefield
Bear River
Bear River Pass
Mt. Gladstone
Ore Mtn.
Cornice Mtn.
Mt. Stronn
Entrance Pk.
Stronn Ck.
Nelson Glacier
Nelson Ck.
CAMBRIA FAULT
Cambria Icefield
Otter Mtn.
Del Norte Ck.
Bitter Ck.
Glacier Ck.
Mt. Dickie
Albany
Willoughby Glacier
Willoughby Ck.
Hwy 37A
Portland Canal
Mt. Fainey
Flat R.
Banded Mtn.
White R.
Kitsault Lake
Pattullo
Surprise

Fig. 3

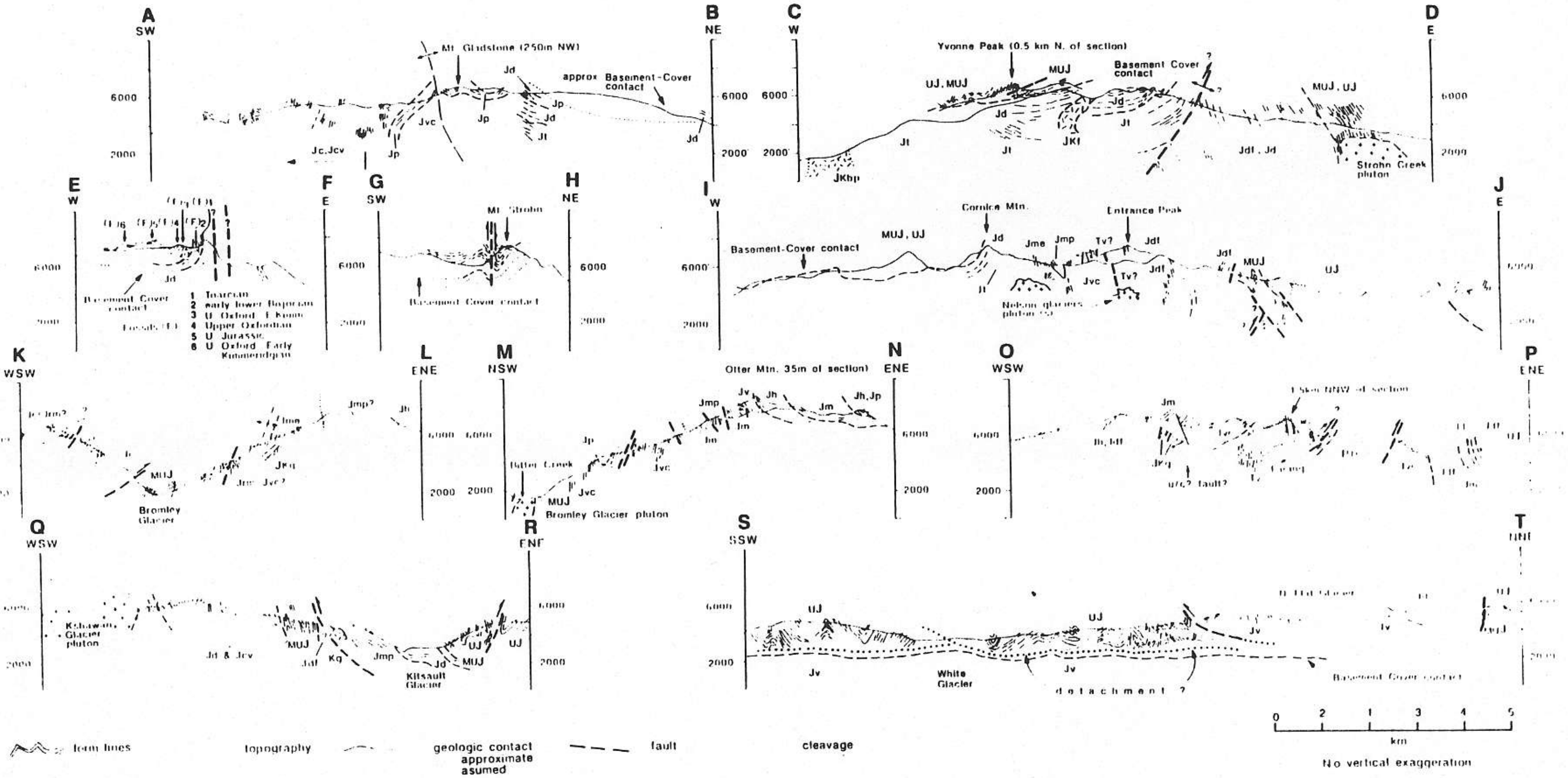
A SW
B NE
Mt. Gladstone (250m NW)
approx. Basement-Cover contact
Jd
Jp
Jvc
Jt
Jc, Jcv
6000
2000
C W
D E
Yvonne Peak (0.5 km N. of section)
UJ, MUJ
MUJ
Basement Cover contact
Jd
Jt
JKt
JKbp
Jdf, Jd
MUJ, UJ
Strohn Creek pluton
E W
F E
Basement Cover contact
1 Toarcian
2 early lower Bajocian
3 U. Oxford. E.Kimm.
4 Upper Oxfordian
5 U. Jurassic
6 U. Oxford. Early Kimmeridgian
Fossils (F)
G SW
H NE
Mt. Strohn
Basement Cover contact
I W
J E
Basement-Cover contact
MUJ, UJ
Cornice Mtn.
Entrance Peak
Jme
Jmp
Tv?
Jdf
Jvc
Nelson glaciers pluton (?)
K WSW
L ENE
MUJ
Bromley Glacier
Jmp?
M NSW
N ENE
Otter Mtn. 35m of section
Jmp
Jv
Jh
Jm
Jh, Jp
Otter Creek
Bromley Glacier pluton
O WSW
P ENE
Q WSW
R ENE
Kshawan Glacier pluton
Jd & Jcv
MUJ
Kg
Jmp
Kitsault Glacier
UJ
S SSW
T NNE
White Glacier
Jv
detachment ?
Basement Cover contact
form lines
topography
geologic contact approximate asumed
fault
cleavage
0 1 2 3 4 5
km
No vertical exaggeration

Fig 4

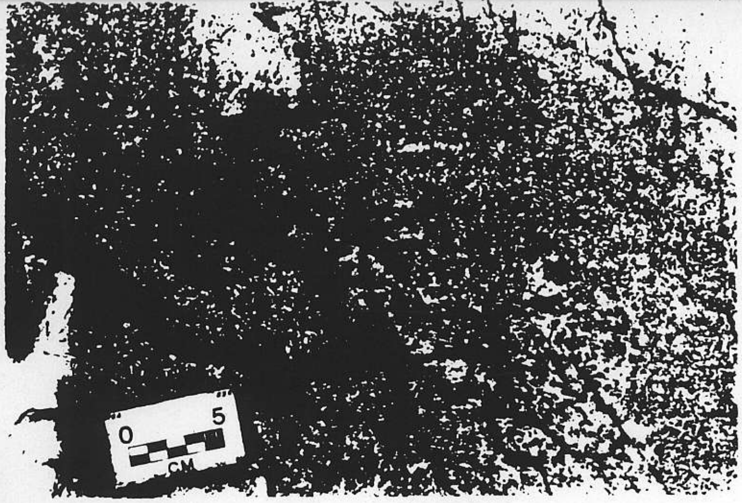

Fig 6

Fig 5

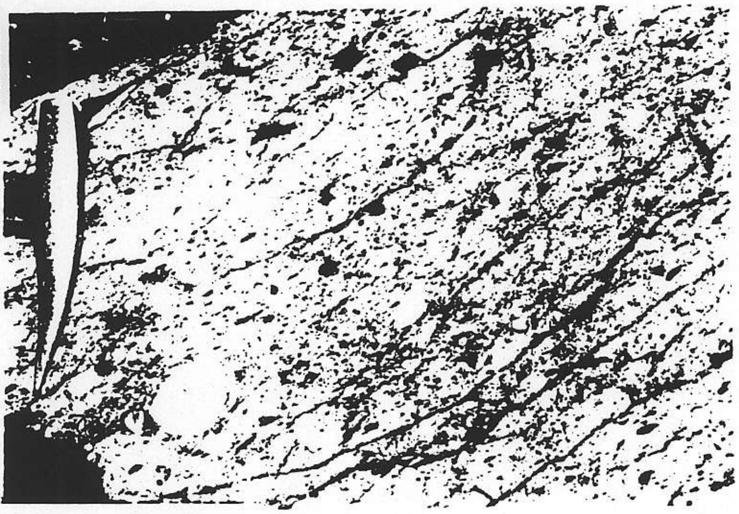

Fig. 7

Fig. 8

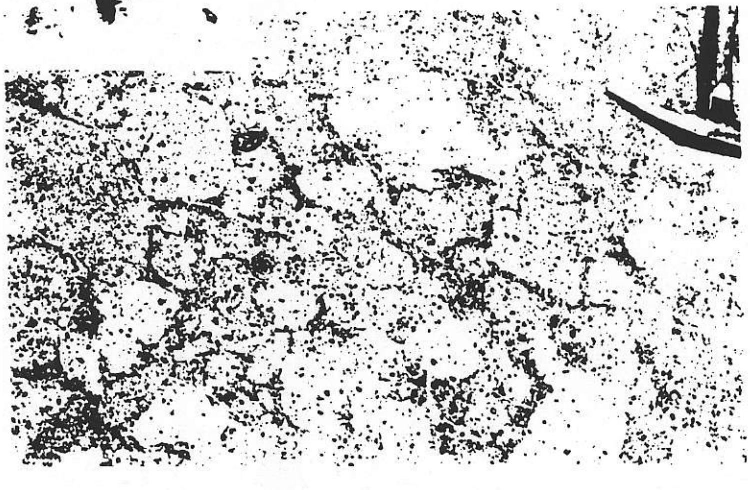

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 13

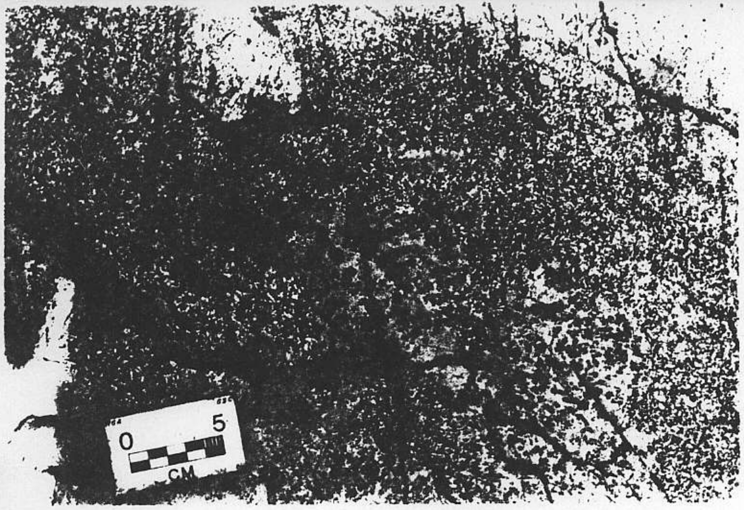

Fig 6

Fig 5

Fig. 7

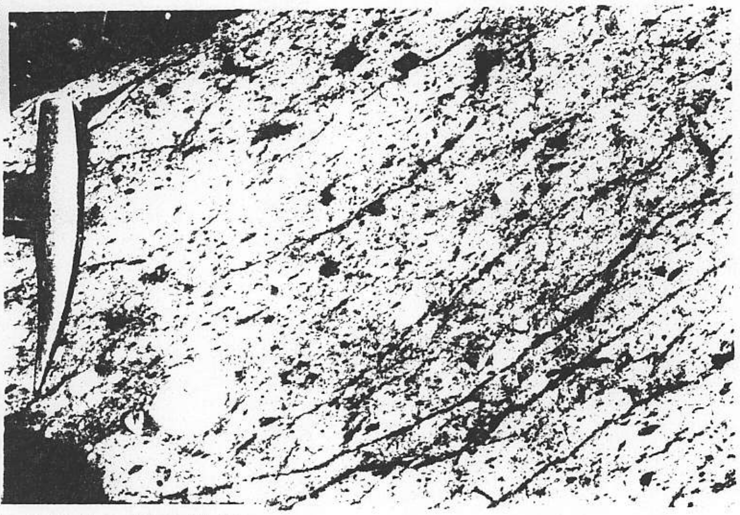

Fig. 8

Fig. 9