BRITISH COLUMBIA
Ministry of Employment and Investment
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(Sheet 1 of 3)

GEOLOGY OF THE WEST-CENTRAL PURCELL MOUNTAINS BRITISH COLUMBIA

NTS 82K/2, 7 & PARTS OF 8, 10

Geology by
Marian J. Warren

Scale 1:75 000

Contour interval: 1000 feet
Elevations above mean sea level

Topography digitized from NTS sheets 82K/2, 7, 8, 9 and 10 (1:50,000)
SURVEYS AND MAPPING BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES CANADA

N.A.D. 1927
Universal Transverse Mercator Projection
UTM Zone 11

Magnetic declination (1980) approximately 21 20 E at centre of map, decreasing approximately 10' annually

Mapping by M. Warren was completed on 1:20,000 (N.A.D. 1983) and 1:50,000 (N.A.D. 1927) topographic bases, coupled with the use of 1:15,000 (1991) and older 1:60,000 air photos (1:20,000 maps and air photos available from MAPS B. C.)

British Columbia
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(Sheet 2 of 3)

GEOLOGY OF THE WEST-CENTRAL PURCELL MOUNTAINS BRITISH COLUMBIA

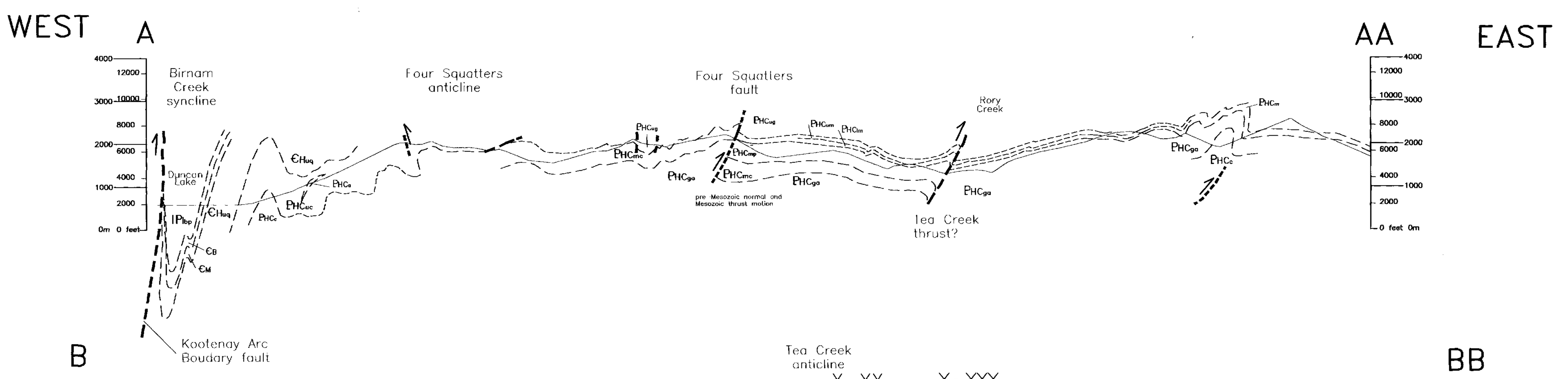
NTS 82K/2, 7 & PARTS OF 8, 10

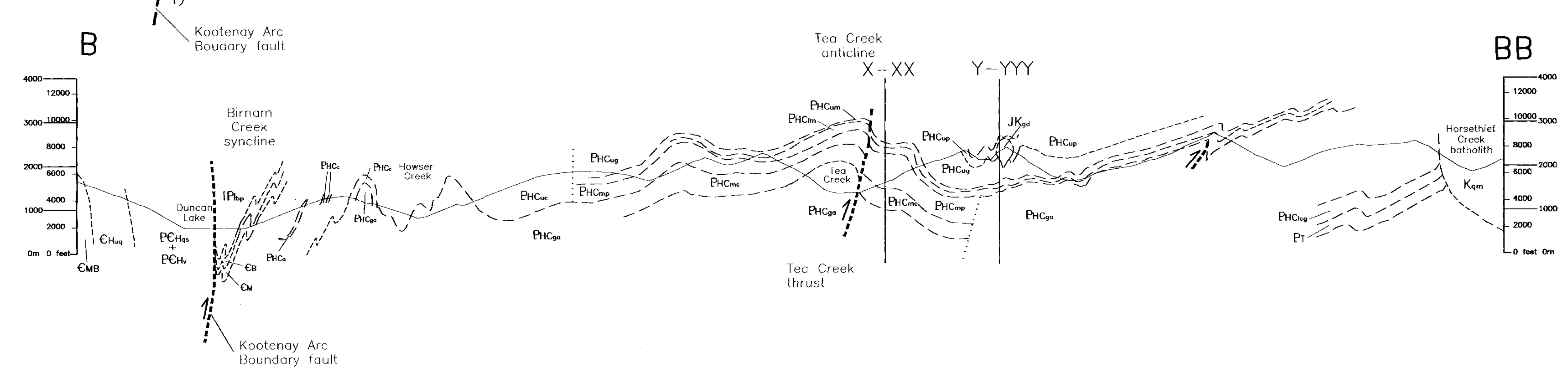
Geology by
Marian J. Warren

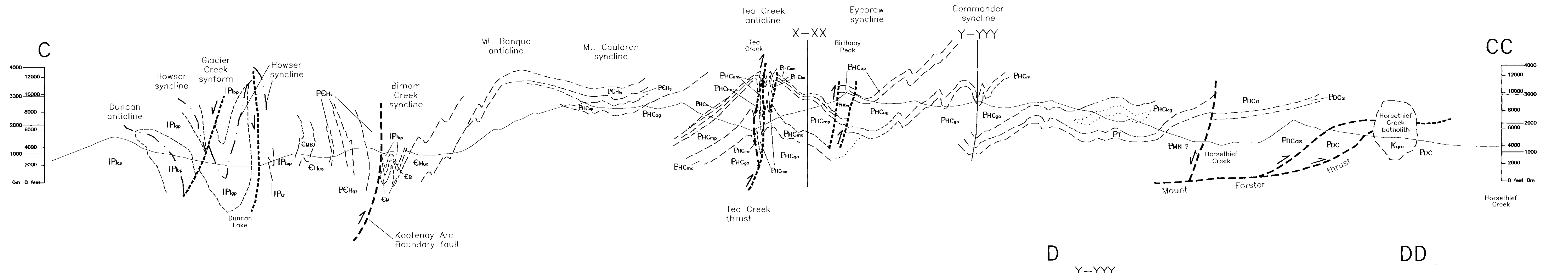
Scale 1:75 000

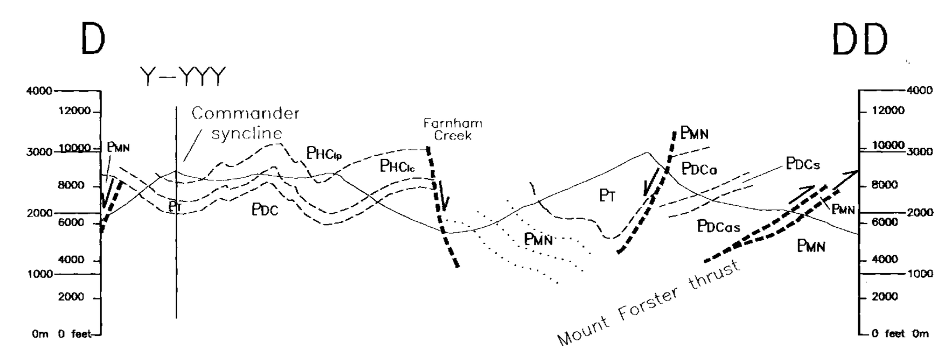
Metres 1000 0 1000 2000 3000 4000 Metres

Eastern segments of sections C–CC, E–EE, F–FFFF, G–GGGG and H–HHH are after sections by Fyles, 1964
Segment FFF–FFFF by Root, 1987

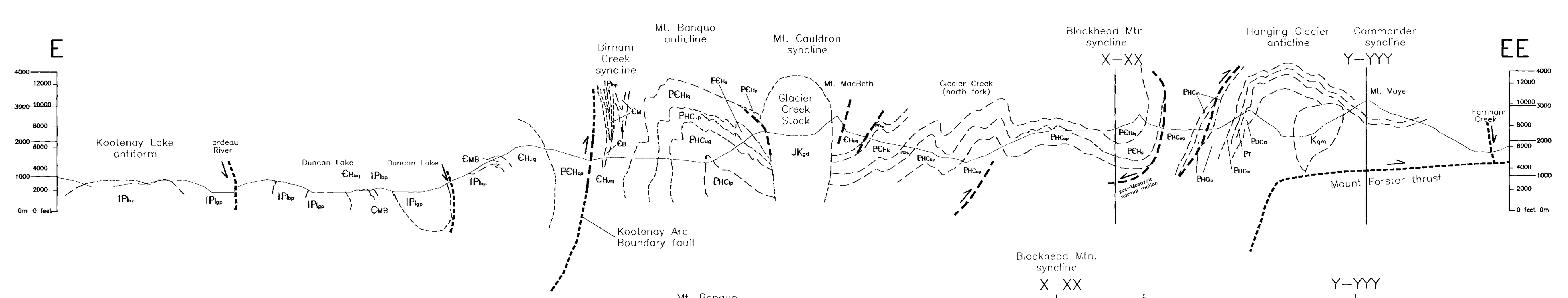


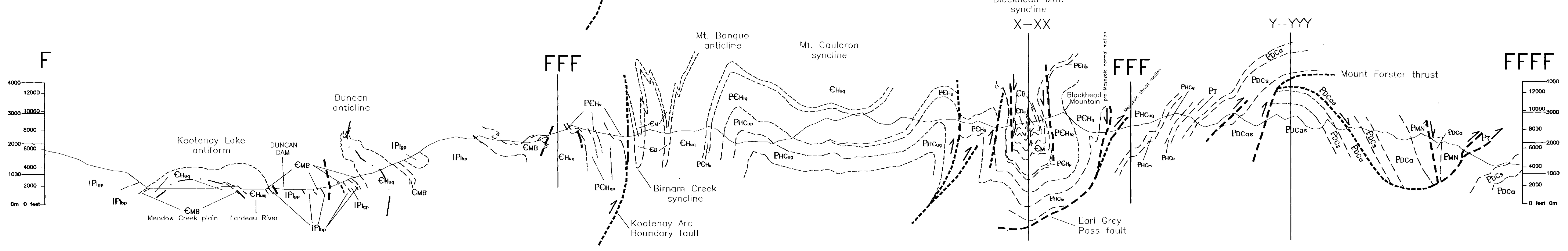


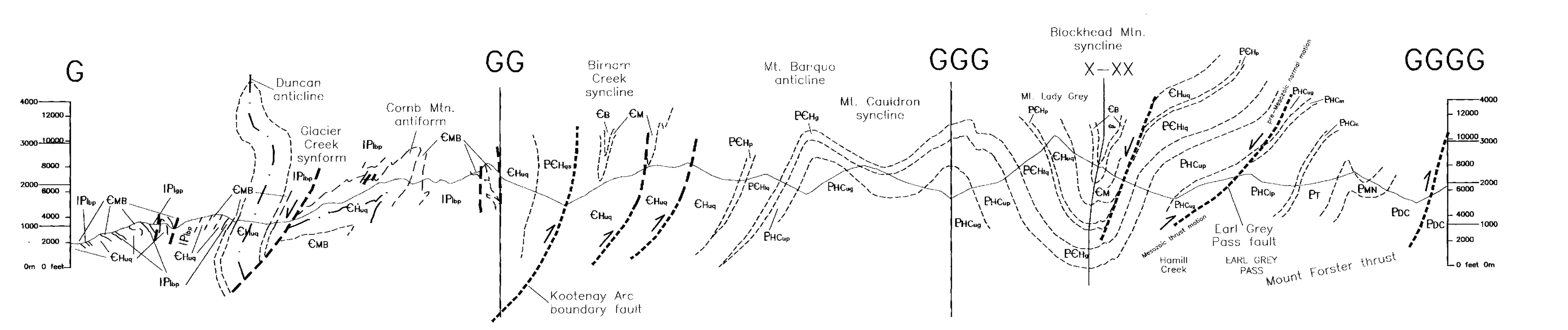


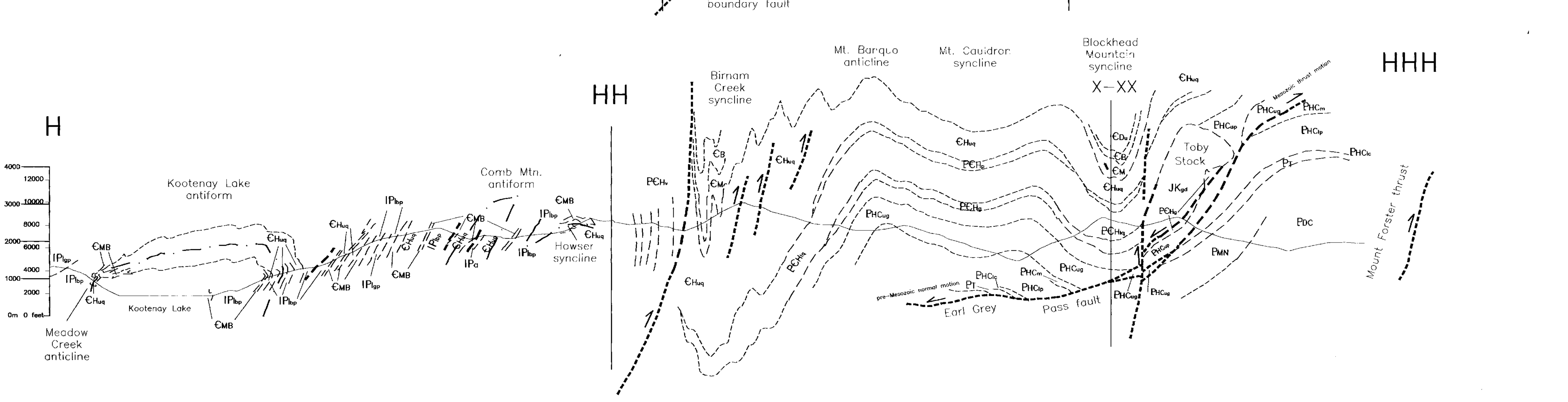


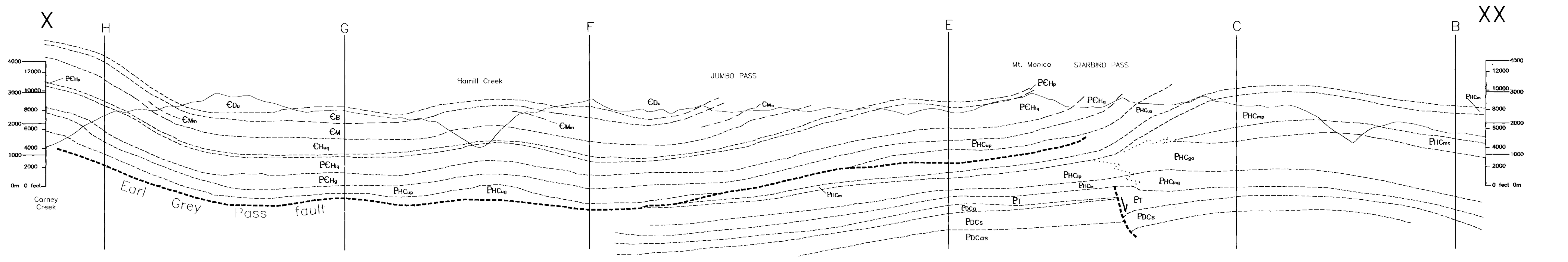
STRUCTURAL CROSS SECTIONS





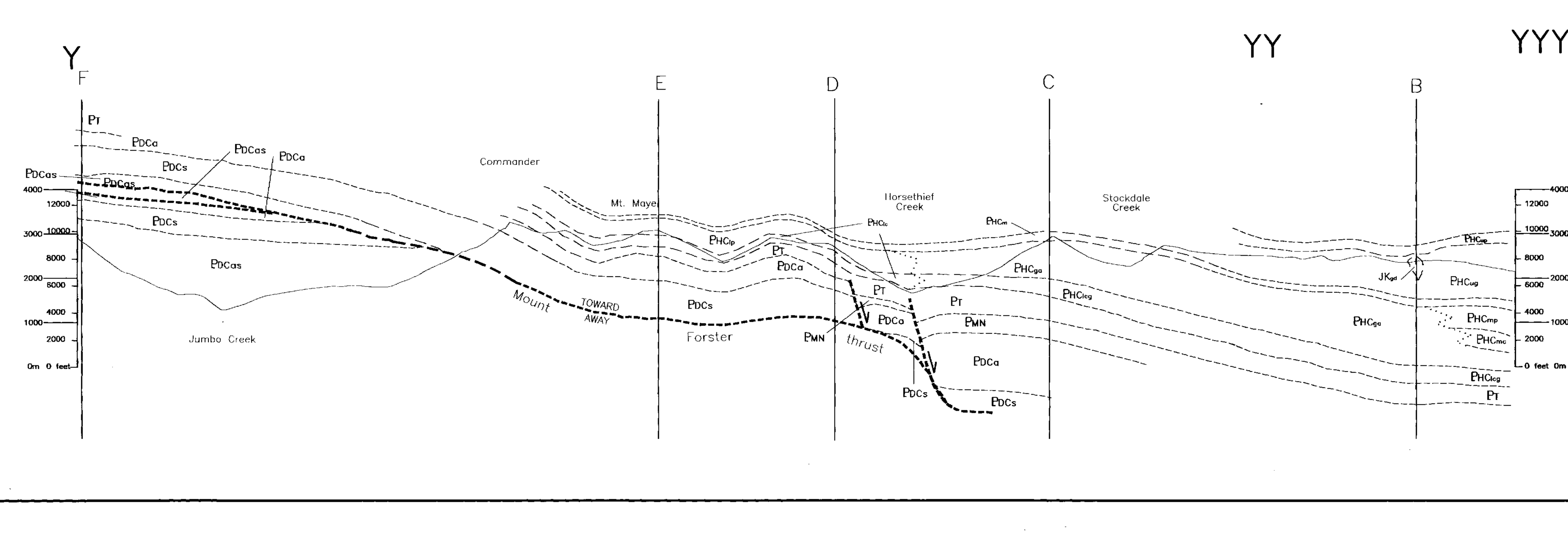






SOUTH

NORTH



LONGITUDINAL SECTIONS

X–XX = subvertical section along axial surface of Blockhead Mountain syncline from Carney Creek to Starbird Pass; joins axial surface of unnamed syncline to north

Y–YYY = vertical section in footwall of Mount Forster thrust; follows axial surface of Commander syncline and Eyebrow syncline to north

LEGEND

LAYERED ROCKS

EASTERN KOOTENAY ARC
(HANGINGWALL OF KOOTENAY ARC BOUNDARY FAULT)

LOWER PALEOZOIC

LARDEAU GROUP

INDEX FORMATION

IP$_{lgp}$ — Green phyllite and chlorite–actinolite schist, grey marble and calcareous schist, minor metabasite

IP$_{lbp}$ — Dark phyllite or schist, locally graphitic, black marble and dark quartzite

LOWER CAMBRIAN

MOHICAN AND BADSHOT FORMATIONS (Undivided):

€MB — Grey marble, dolomitic marble, tan, green and grey calcareous or dolomitic schist, minor pelitic schist and micaceous quartzite

LATEST NEOPROTEROZOIC TO LOWER CAMBRIAN

HAMILL GROUP (Informal subdivisions)

UPPER QUARTZITE

€H$_{uq}$ — (Designated age based on correlation with western and northern Purcell anticlinorium) Lower part: discontinuous lower white orthoquartzite (equivalent to MT. GAINER FORMATION of Fyles and Eastwood, 1962, and Read and Wheeler, 1976); upper part: intercalated grey and tan quartzite, micaceous quartzite and pelitic schist (MARSH ADAMS FORMATION of Fyles, 1964)

LOWER VOLCANIC AND CLASTIC

P€H$_{v}$ — Metabasite and biotite–chlorite schist, minor dolostone and grit

P€H$_{qs}$ — Laterally discontinuous intercalated green, dark and white quartzite, dark schist, feldspathic grit and minor pebble conglomerate

WESTERN PURCELL ANTICLINORIUM
(HANGINGWALL OF MOUNT FORSTER THRUST)

LOWER PALEOZOIC

INDEX FORMATION (Birnam Creek syncline)

IP$_{lbp}$ — Black phyllite and quartzite, minor dark grey marble

LOWER CAMBRIAN

UPPER DONALD FORMATION (Blockhead Mountain syncline)

€D$_{u}$ — Thinly interbedded silver muscovite schist or phyllite, light green chlorite schist or phyllite, tan calcareous or dolomitic schist

BADSHOT FORMATION

€B — Tan or grey marble, dolomitic marble and minor calcareous or dolomitic schist

MOHICAN FORMATION

€M — Thinly interbedded tan dolomitic schist and dolostone, minor impure quartzite,light green phyllite and quartzose schist

€M$_{m}$ — Three laterally continuous, thickly cross–bedded coarse quartz arenite intervals, up to 10 m thick each, separated by thinner intervals of rusty–weathering schist (Blockhead Mountain syncline)

LATEST NEOPROTEROZOIC TO LOWER CAMBRIAN

Designated ages based on correlation with partly fossiliferous strata in the Dogtooth Range (Evans, 1933; Kubli and Simony, 1992)

HAMILL GROUP (Informal subdivisions)

€H — Undivided Hamill Group

UPPER QUARTZITE

€H$_{uq}$ — Thinly to medium bedded, commonly cross–bedded white quartzite, minor dark quartzite and pelite (lower part); interbedded dark, pink and green quartzite and dark pelite (upper part). Lower and upper parts are separated by distinct rusty–weathering pelitic interval in Blockhead Mountain syncline

MIDDLE PELITE

P€H$_{p}$ — Rusty–weathering dolomitic schist, black pelite, dolostone and blue quartz pebble conglomerate, minor dolostone breccia and cobble conglomerate, cross–bedded orthoquartzite (Blockhead Mountain syncline); fine–grained rusty–weathering pelitic schist, green chlorite schist and minor dolomitic schist (Mt. Cauldron syncline)

LOWER QUARTZITE

P€H$_{lq}$ — Thickly bedded to massive orthoquartzite, coarse quartz arenite and grit, locally feldspathic grit and pebble conglomerate. Tabular cross beds common

BASAL GRIT

P€H$_{g}$ — White and light grey tabular and trough cross–bedded quartz and arkosic sandstone, grit and conglomerate containing abundant blue and purple quartz, and minor interbedded tan dolostone or dolarenite, black pelite and dark green chlorite schist (Blockhead Mountain and Mt. Cauldron synclines); light grey micaceous quartzite, grey phyllite or schist and tan dolostone (Eyebrow syncline)

NEOPROTEROZOIC

WINDERMERE SUPERGROUP

HORSETHIEF CREEK GROUP (Informal subdivisions)

PHC — Undivided Horsethief Creek Group

SOUTHERN AND EASTERN SUCCESSION

UPPER PELITE

PHC$_{up}$ — Thinly interbedded graded micaceous quartzite and grey slate, phyllite or muscovite schist, minor grit and pebble conglomerate, minor dolostone and coarse dolomitic sandstone toward top

UPPER GRIT

PHC$_{ug}$ — Thinly to thickly bedded fining– and thinning–upward succession of feldspathic grit and pebble conglomerate and interbedded pelite and micaceous quartzite

MARKER UNIT (Undivided)

PHC$_{m}$ — Thinly bedded tan dolomitic siltstone (upper part) and competent, homogeneous green argillite or green micaceous quartzite (lower part)

LOWER PELITE

PHC$_{lp}$ — Brown–weathering thinly interbedded slate to schist, siltstone or quartzite, dolomitic siltstone or schist, minor grit lenses

LOWER CARBONATE

PHC$_{lc}$ — Light grey marble and dark calcareous slate or schist

NORTHERN AND WESTERN SUCCESSION

UPPER CLASTIC

PHC$_{a}$ — Garnet amphibolite, apparently concordant with sedimentary contacts

PHC$_{uc}$ — Pelitic schist, calc–silicate schist, tourmaline–muscovite schist, graded quartzite, grit, calcareous grit and marble, locally intruded by felsic dykes or sills (west of Four Squatters anticline only)

PHC$_{c}$ — Dark grey to black marble and siliceous marble or dark calcareous schist (in contact with PHC$_{um}$); medium grey siliceous marble or dolostone and dolomitic coarse sandstone and pebble conglomerate (stratigraphic position uncertain)

UPPER MARKER UNIT

PHC$_{um}$ — Rhythmically interbedded dolomitic siltstone, cream dolostone and green phyllite or slate with minor lenses of carbonate conglomerate; locally capped by black pelite and/or marble

LOWER MARKER UNIT

PHC$_{lm}$ — Competent homogeneous green argillite, siltstone or schist and minor dolomitic siltstone

MIDDLE PELITE

PHC$_{mp}$ — Brown weathering pelite, siltstone or quartz schist, minor grit

MIDDLE CARBONATE

PHC$_{mc}$ — Thickly interbedded and laterally continuous intervals of light to medium grey marble, siliceous marble and dark grey calcareous grit; thickens to north and west

PHC$_{mcm}$ — Two tan or white marker intervals of competent dolomitic and/or feldspathic grit and pebble conglomerate (west of Four Squatters anticline only)

LOWER CLASTIC

PHC$_{ga}$ — Thickly interbedded, laterally discontinuous intervals of light feldspathic grit or pebble conglomerate and darker calcareous grits and marble conglomerate (eastern exposures); interbedded green and grey slate, phyllite or schist, minor grit and pebble conglomerate and siliceous marble (western exposures); proportion of argillite increases to west and north

LOWER CALCAREOUS CLASTIC

PHC$_{lcg}$ — Calcareous and dolomitic grit, conglomerate, coarse sandstone, slate and siliceous marble containing abundant blue and white quartz and feldspar (mappable arkosic grit and conglomerate lenses in Horsethief Creek valley shown as dotted contact)

TOBY FORMATION

PT — Homogeneous cream dolostone

PT$_{d}$ — Diamictite, dolostone and slate; diamictite comprises well–rounded to angular pebbles to boulders primarily of quartzite, marble and dolostone in red argillaceous, grey calcareous or tan sandy matrix; upper part interbedded with and capped by feldspathic grit (Horsethief Creek valley) or by homogeneous cream dolostone (Toby and Jumbo creeks)

MESOPROTEROZOIC

PURCELL SUPERGROUP

MOUNT NELSON FORMATION (Lower part only)

PMN — Primarily white quartzite and tan micaceous quartzite, minor brown dolostone

DUTCH CREEK FORMATION (Subdivisions after Root, 1987)

PDC — Undivided Dutch Creek Formation

PDCa — Grey, black and green argillite, rhythmically interbedded siltstone and argillite

PDCs — Brown sandstone and minor dolostone and argillite

PDCas — Grey and green argillite, siltstone and argillaceous sandstone, minor sandstone and argillaceous dolostone

EASTERN PURCELL ANTICLINORIUM
(FOOTWALL OF MOUNT FORSTER THRUST)

PALEOZOIC

UPPER DEVONIAN

STARBIRD FORMATION

DS — Fossiliferous grey dolostone and limestone, and interbedded black limestone and argillite, red and brown siltstone, minor argillite and microcrystalline quartz

MIDDLE DEVONIAN

MOUNT FORSTER FORMATION

DMF — Red dolomitic sandstone, grit and minor conglomerate, metabasalt and argillite

NEOPROTEROZOIC

HORSETHIEF CREEK GROUP (Undivided)

PHC — Grit and pebble conglomerate, grey marble and calcareous slate, dolostone and slate

TOBY FORMATION

PT — Diamictite and breccia with argillaceous, sandy or calcareous matrix, grit and slate, local mafic volcanic rocks

MESOPROTEROZOIC

PURCELL SUPERGROUP

MOUNT NELSON FORMATION (Undivided)

PMN — Well–stratified succession of white and light brown quartzite, purple and green argillite, siltstone, commonly laminated dolostone, minor grit and pebble to boulder conglomerate

DUTCH CREEK FORMATION

PDC — Undivided Dutch Creek Formation

PDCa — Grey, black and green argillite, rhythmically interbedded siltstone and argillite

PDCs — Brown, green and grey sandstone, dolomitic sandstone, dolostone and argillite

PDCas — Grey and green argillite, siltstone and argillaceous sandstone, minor sandstone and argillaceous dolostone

INTRUSIVE ROCKS

CRETACEOUS (Reesor, 1973; D. A. Archibald, unpublished 40Ar/39Ar data, Queen's University)

K$_{qm}$ — Primarily quartz monzonite, some granodiorite (Bugaboo batholith), granite, quartz diorite

MIDDLE JURASSIC TO EARLY CRETACEOUS (Reesor, 1973; Warren, 1996; unpublished 40Ar/39Ar data)

JK$_{gd}$ — Primarily granodiorite, some quartz monzonite, quartz diorite, with hornblende– and pyroxene–rich rims

MIDDLE JURASSIC (Smith et al., 1992)

Area intruded by biotite– and hornblende–bearing granitic dykes and sills

LOWER PALEOZOIC ? (Fyles, 1964)

IP$_{a}$ — Coarse–grained amphibolite (intrudes Hamill Group and Mohican Formation in Kootenay Arc)

IP$_{u}$ — Ultramafic to mafic dikes or sills (intrude lower part of Index Formation in Kootenay Arc)

MAP SYMBOLS

Stratigraphic contact (defined, approximate, assumed)

Approximate location of lateral facies changes in Horsethief Creek Group

Thrust fault (defined, approximate, assumed)

Neoproterozoic to Early Paleozoic normal fault (defined, approximate, assumed)

Mesozoic normal fault (defined, approximate, assumed)

Normal fault; age unconstrained (defined, approximate, assumed)

Fault; motion sense undetermined (defined, approximate, assumed)

Axial trace of upright anticline or antiform, syncline or synform [F2]

Axial trace of overturned anticline or antiform, syncline or synform [F2]

Axial trace of early refolded anticline, syncline in Kootenay Arc [F1]

Location of structural cross–section — A — AA'

Location of longitudinal section along axial trace of fold — X– –XX

Glacier

STRUCTURAL DATA

(Deformation "phases" not necessarily correlative across map area)

Bedding; top known (upright, overturned)

Bedding; top unknown (inclined, vertical, horizontal)

Dominant, regional penetrative schistosity or cleavage [S2] (inclined, vertical)

Bedding–parallel schistosity or cleavage [S1], older than regional penetrative foliation S2 (inclined, vertical)

Bedding–parallel schistosity [S1], locally stronger than S2 (inclined, vertical)

Composite foliation [S2/S1 or S3/S2] (inclined, vertical)

Late spaced or crenulation cleavage [east] or schistosity [west], locally developed [S3] (inclined, vertical)

Igneous foliation, not necessarily primary (inclined, vertical)

Sinistral kink bands [S4] (inclined, vertical)

Intersection lineation, minor fold axis or pebble stretching lineation

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(Sheet 3 of 3)

GEOLOGY OF THE WEST-CENTRAL PURCELL MOUNTAINS BRITISH COLUMBIA

NTS 82K/2, 7 & PARTS OF 8, 10

Geology by

Marian J. Warren

Scale 1:75 000

Metres 1000 0 1000 2000 3000 4000 Metres

SUMMARY OF GEOLOGY

The west–central Purcell Mountains of southeastern British Columbia expose Mesoproterozoic to Lower Paleozoic rocks that were deposited on the western margin of ancestral North America during at least two episodes of continental rifting. These strata were subsequently deformed, regionally metamorphosed and intruded by at least two suites of granitic plutons during Mesozoic terrane accretion.

The map–area is divisible into three distinct stratigraphic and structural domains. These comprise, from east to west, the eastern Purcell anticlinorium in the footwall of the Mount Forster thrust, the western Purcell anticlinorium in the hangingwall of the Mount Forster thrust and the Kootenay Arc. New mapping by M. Warren has focused in the western Purcell anticlinorium, in order to investigate the evolution of Proterozoic and Paleozoic stratigraphic contrasts between the hangingwall and footwall of the Mount Forster thrust, as outlined by Reesor (1973) and Root (1987), and the evolution of structural contrasts between the Purcell anticlinorium and the more complexly deformed Kootenay Arc, as documented by Fyles (1964) and Reesor (1973).

In the Purcell anticlinorium, the Mesoproterozoic Purcell Supergroup is unconformably overlain by the Neoproterozoic Windermere Supergroup, which comprises the Toby Formation and the previously undivided Horsethief Creek Group. The Horsethief Creek Group comprises immature siliciclastic and resedimented carbonate strata that were deposited primarily in a submarine fan setting. The Horsethief Creek Group is laterally variable, but it can be divided into southeastern and northwestern successions that can be correlated using a conspicuous marker unit. The two successions are separated by an abrupt, NE–trending facies and thickness change in the upper Horsethief Creek drainage, interpreted to record motion on a northwest–side–down normal fault that was active during the deposition of the Toby Formation and perhaps of the lower part of the Horsethief Creek Group (see figure below). Other facies changes in the northwestern part of the map–area indicate that the basin deepened to the north and west and was more distal from the sedimentary source. Abrupt E–W thickness changes and the presence of apparently conformable metabasites in the upper part of the Horsethief Creek Group, and a change in the stratigraphic succession beneath these strata across the Four Squatters fault, suggest that normal faulting also occurred during deposition of the upper part of the Windermere Supergroup. Similar syn–Windermere structures, both NE–trending and N–trending, have been documented in the footwall of the Mount Forster thrust by Root (1987) and Pope (1990).

The Windermere Supergroup is overlain by a succession of more mature siliclastic rocks, the Neoproterozoic to Lower Cambrian Hamill Group, in the hangingwall of the Mount Forster thrust. The Hamill Group is divisible into three lower shallow marine or fluvial units, more feldspathic toward the base, that thin, fine and pinch out to the west and an upper, continuous and more mature shallow marine quartzite unit that unconformably overlies the lower units or rests directly on the Horsethief Creek Group. In the Kootenay Arc, the succession of Hamill Group strata is distinctly different from that in the western Purcell anticlinorium. The lower part, whose base is not exposed, includes mafic metavolcanic rocks and possibly turbidites. The upper shallow marine quartzite is considered equivalent to the upper quartzite in the Purcell anticlinorium. In the footwall of the Mount Forster thrust, the Windermere Supergroup is unconformably overlain by Upper Cambrian to Devonian strata (Reesor, 1973; Root, 1987; Pope, 1990). These overstepping unconformities record uplift and eastward tilting of the "Windermere High" during Early Paleozoic time.

The lateral variations in the Hamill Group in both the western Purcell anticlinorium and in the Kootenay Arc imply that the lower units of the Hamill Group were deposited in two separate basins that were bounded to the east by west–dipping normal faults and were separated by an uplifted and eastward–tilted block of Horsethief Creek Group strata. The Earl Grey Pass fault, exposed on the eastern limb of the Blockhead Mtn. syncline in the hangingwall of the Mount Forster thrust, is a west–side–up thrust fault that cuts the regional cleavage, but stratigraphic relationships across it indicate that it was previously a west–side–down normal fault. It marks the eastern limit of exposure of the Hamill Group, and it could be the normal fault that bounded the eastern Hamill basin. The fault that bounded the western Hamill basin is closely followed by the Kootenay Arc boundary fault, a Mesozoic structure that separates the Kootenay Arc from the Purcell anticlinorium. The upper quartzite of the Hamill Group and the overlying Mohican and Badshot Formations were deposited across these basins and the uplifted block between them after normal faulting had ceased. Regional correlation with fossiliferous strata in other parts of the Purcell, the Selkirk and the Rocky Mountains (Warren, 1996) suggests that the lower units of the Hamill Group are Neoproterozoic to lower Lower Cambrian (Placentian) and that the upper quartzite is upper Lower Cambrian (Waucoban) in age.

Normal motion on the fault that bounded the western Hamill basin may have been renewed during Early Paleozoic time, resulting in the deposition of shallow–water siliciclastic and carbonate rocks to the east (Lower Cambrian upper Donald Formation) and deeper–water, immature clastic and volcanic rocks to the west (Lower Paleozoic Lardeau Group). The development of this fault and the basin that it bounded may have strongly influenced mineralisation of the Badshot Formation and other Lower Paleozoic carbonate strata, which host numerous sulphide deposits in the Kootenay Arc but not in the adjacent Purcell anticlinorium.

The boundary between the Kootenay Arc and the Purcell anticlinorium is a steep, locally mylonitic fault zone (the Kootenay Arc boundary fault) that juxtaposes a domain of complexly refolded, high–amplitude, west–verging ductile folds (Fyles, 1964) against a domain of upright, more open folds. Stratigraphic relationships across the fault where it intersects Duncan Lake, coupled with geobarometric data (Warren, 1996), imply west–side–up thrust motion, but motion sense indicators imply a component of late dextral strike–slip motion as well. Re–examinantion of cross–cutting relationships between axial planar foliations and dykes and sills dated at 173 Ma (Smith et al., 1992), coupled with palinspastic analysis (Warren, 1996) indicate that both the F1 and F2 folds in the eastern Kootenay Arc developed in response to west–verging crustal shortening above a blind detachment that propagated beneath the Kootenay Arc, but not the Purcell anticlinorium, in mid–Jurassic time. The location of the Kootenay Arc boundary fault, and perhaps of the eastern limit of the blind detachment, was controlled by the location of one of the syn–Hamill normal faults.

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SCHEMATIC SUMMARY OF STRATIGRAPHIC RELATIONSHIPS

WEST/ NORTHWEST — EAST/ SOUTHEAST