GEOLOGICAL SURVEY OF CANADA
OPEN FILE 1195

Geological notes
Nelson west half (82F, W1/2) map area

H.W. Little

1985

Natural Resources Canada
Ressources naturelles Canada

Canada

GEOLOGICAL NOTES
NELSON WEST HALF (82F, W1/2) MAP AREA
(H.W. LITTLE)

O.F. 1195

GEOLOGICAL NOTES

NELSON WEST HALF (82F, W1/2) MAP AREA

(H.W. Little)

These notes are to accompany the geological map of Nelson, west half map area (82 F, W1/2). Since publication of an earlier edition (Map 1090A), based on field work 1948-52, more detailed field work has been done, some by this writer. This revised edition incorporates the newer work, mainly published as shown on the accompanying index map and in the list of references. Some additional field work was done to integrate the various studies.

The map legend and the map unit descriptions that follow are divided into 3 parts that correspond to 3 geographical parts of the area (see legend) that have distinctive geological elements.

SOUTHEAST PART

Gneisses and schists of unknown age (gn)

Small areas are underlain by quartz-feldspar gneiss, and micaceous or chloritic schist of unknown age. Most of these are enclosed in granitic rocks of the Nelson batholith satellites, or are partly so, being at the periphery of such bodies.

Proterozoic units

Windermere Supergroup

The Hadrynian Windermere Supergroup is exposed in the southeastern corner of the map area where it comprises many tens of metres of the uppermost part of the Toby Formation (Ht), the Irene Volcanic Formation (Hiv), the Monk Formation (Hm), and the Three Sisters Formation (Hts).

Toby Formation (Ht)

The uppermost part of the Toby Formation, where exposed in Nelson map area, west half, consists of polymictic conglomerate with argillaceous interbeds. The clasts range in size from a few millimetres to 25 cm in diameter, and are mainly slabs of buff dolomite that may have been tectonically distorted into their present shape. Lower in the section conglomerate predominates and quartzite clasts are numerous. Aalto (1971) concluded that the formation is the result of fluvio-glacial deposition. Previous and subsequent investigators, however, favour a largely mud-slide origin from adjacent land-masses of high relief. It is equivalent to the Shedroof Conglomerate of Metaline quadrangle to the south (Park and Cannon, 1943).

Irene Volcanic Formation (Hiv)

The Irene Volcanic Formation is mainly schistose greenstone. The volcanics contain pillows in the equivalent Leola volcanics south of the International Boundary and in Nelson map area

(Glover, 1978, p. 37). Minor agglomerate, tuff, phyllite and stromatolitic dolomite and black limestone have been noted. The maximum thickness near the International Boundary apparently exceeds 1500 m. At its lower contact the formation is gradational or intercalated with the underlying formation.

Monk Formation (Hm)

The Monk Formation extends south of the International Boundary, and is equivalent to the lower, pelitic part of the Horsethief Creek Group to the northeast. The name 'Monk' has been retained south of the Border. The formation consists of poorly exposed green to grey and brown argillaceous schist or phyllite, with minor grit, conglomerate, and grey limestone. The base is marked by a continuous conglomerate, which Glover (1978, p. 43) found to be 60 to 150 m thick. The clasts, many of which are of pisolitic, dolomitic limestone, are up to 15 cm in diameter. Because this material was derived by erosion of older formations, the basal contact is regarded as uncomformable, at least locally. The top of the formation is placed where the mainly pelitic beds give way to the overlying coarser arenaceous and psephitic strata. The apparent thickness exceeds 1500 m but due to folding and faulting, the beds are repeated and the true thickness is much less.

Three Sisters Formation (Hts)

The Three Sisters Formation is equivalent to the upper, largely arenaceous and rudaceous, part of the Horsethief Creek

Group, and to the lower part of the Gypsy Quartzite of Metaline quadrangle to the south. It consists largely of green to grey green, and lesser white, grits and orthoquartzite, with minor argillaceous schist and an extensive bed of interformational pebble conglomerate up to 75 m thick, a lithology also present elsewhere in the succession. Crossbeds are common in the grit and quartzite. In the Baldy Anticline some limestone occurs in the formation. The formation is 1272 m thick near the Forty-ninth parallel (Glover, 1978, p. 50) and 796 m on the west side of Baldy Anticline where the base is not exposed. The top of the formation in Nelson map area, west half, is marked by a transition from grey grit to white quartzite except in Baldy Anticline, where the uppermost part of the formation is largely chloritic schist. The Three Sisters Formation is regarded as the youngest of the Hadrynian succession.

Paleozoic units

Lower Cambrian

Quartzite Range Formation (1Cqr)

Massive, white, commonly crossbedded orthoquartzite beds are predominant in the Quartzite Range Formation. Some 500 m above the base along the eastern monocline is a continuous argillaceous quartzite and micaceous schist about 60 m thick. Farther west, on the limbs of Sheep Creek and Baldy anticlines, the quartzite beds are thinner and finer grained, and several argillaceous members appear.

The formation is 1340 m thick near the International Boundary, 1373 m north of latitude 49°15'N and averages 600 m on the western limb of Sheep Creek anticline, thus it appears to thin in a westward direction. The age of the Quartzite Range Formation has been established as Lower Cambrian based on tribolites collected near the top of the formation in Metaline quadrangle, and because it is stratigraphically below Lower Cambrian archeocyathids in Nelson map area, west half. Support for placing the base of the Cambrian at the base of the Quartzite Range Formation is provided by Miller (1983) who states that in Pend Oreille County it is marked by an unconformity. This horizon (which is also the base of the Hamill Group) has been traced more than 100 km northward into the Lardeau map area (Reesor, 1973) and beyond.

The Quartzite Range Formation is correlated with the upper part, excepting the uppermost part, of the Gypsy Quartzite of Park and Cannon (1943) and it is probably largely equivalent to the Addy Quartzite of Addy district, Washington, the lower part of the Hamill Group, and the Cranbrook Formation of East Kootenay district, British Columbia. The upper contact is conformable with the overlying formation.

Reno Formation (1€r)

The Reno Formation consists for the most part of brown, massive, argillaceous quartzite, argillite and light brown micaceous schist and phyllite. Rough measurements of thickness

along the eastern monocline range from 350 to 400 m. On the east limb of the Laib syncline near 49°15'N latitude it measures 225 m and farther north 183 m. To the west on Sheep Creek anticline its thickness is 175 to 189 m, on the west limb of Laib syncline it is only 40 m, and near Reeves-MacDonald mine 73 m. Like the Quartzite Range Formation, the Reno thins westward and northward. The Reno Formation grades upward into the Laib Formation, the contact being placed by Fyles and Hewlett (1959, p. 24) at a thin bed of limestone 3 to 6 m thick. It is not known how continuous this bed is, and farther east the top is placed at the base of a limestone bed about 60 m thick.

The Reno Formation is of Lower Cambrian age and is correlated with the uppermost part of the Gypsy Quartzite of Park and Cannon (1943) in Metaline quadrangle to the south, and the upper part of the Hamill Group to the northeast.

Laib Formation (l€l)

The Laib Formation occupies the trough of the Laib Syncline. It comprises a succession of phyllite, micaceous schist, argillaceous quartzite, and limestone. The thickest limestone member in most places marks the base of the formation. In the eastern monocline it is about 40 to 60 m thick. On the limbs of the Sheep Creek anticline it ranges from 30 to 90 m in thickness, but farther west in the lead-zinc mine zone, where it has been named the Reeves Member by Fyles and Hewlett (1959, p. 25, it is apparently 90 to 107 m thick. The thickness of the

formation was measured at latitude 49°15'N as 967 m. Farther west poor exposures render such measurement impossible, but at the Jersey mine (west of Nevada Mountain) where the top of the formation is not exposed the thickness was estimated to be 1043 m.

The top of the Laib Formation is gradational with the overlying Nelway formation. The contact is placed at the base of the lowest continuous bed of argillaceous limestone. The main basal limestone bed has yielded archeocyathids from several localities along the eastern monocline. The age is therefore Lower Cambrian, and the boundary between the Lower and Middle Cambrian is arbitrarily set at the top of the formation. The Laib Formation is correlated with the Maitlen Phyllite of Metaline quadrangle and in part with the Old Dominion Limestone of Stevens County, Washington, which contains similar fauna. It is correlated in part with the Badshot Formation of Rogers Pass map area (Wheeler, 1963, p. 6, 7) which also contains archeocyathids, the Badshot-Mohican Formations of Lardeau map area (Reesor, 1973, p. 58), and Nelson, east half, map area (Reesor, in preparation).

Middle Cambrian

Nelway Formation (m€n)

The Nelway Formation is correlated with much of the Metaline Limestone which occurs south of the International Boundary. There is consists of a lower member of bedded limestone and limy

shale, a middle member of mainly, buff dolomite, and thinner upper members of limestone the lower part with numerous chert nodules. There the total thickness is about 915 m but in Nelson map area the upper members are poorly exposed and an accurate section cannot be measured.

Fossils collected from the Lehigh quarries near Metaline, Washington in the lower member of the formation are of middle Middle Cambrian age. No upper Cambrian fossils have been reported, so the age of the formation is largely Middle Cambrian, although an Upper Cambrian age for the upper part is not ruled out. The top of the formation in Metaline quadrangle appears to be conformable with the overlying slates. The Nelway Formation is correlated in part with the lower part of the Stephen Formation of Banff region, the Lakeview of Idaho, and Damnation and Pagoda Formations of Montana.

Ordovician

Active Formation (Oa)

The Active Formation consists of black argillite and slate, with minor limestone, dolomite, and argillaceous quartzite. In Nelson map area the thickness cannot be accurately determined because the base is poorly exposed and the top is nowhere exposed. Furthermore, slaty cleavage obscures bedding. South of the International Boundary, the equivalent Ledbetter Slate (Dings and Whitebread, 1965, p. 23) is estimated to be 670 to 760 m thick.

The age of the Active Formation is Ordovician. Graptolites of Deepkill (Canadian) age were collected at the type locality on the slopes of Active Creek. In Metaline quadrangle graptolites of Normanskill (Champlainian) age are present, so that both Lower Middle Ordovician ages are established. The Active Formation is correlated in part with the Glenogle shale of the western Rocky Mountains. Ordovician beds may be present in the Lardeau Group to the northeast of Nelson, but no fossils have been found there.

Silurian(?), Devonian, and (?) Carboniferous

'Pend d'Oreille Sequence' of Yates (Dpo)

A thick assemblage of black argillite and grey massive limestone, with minor chert, greenstone, and phyllite occupies much of the valley of Pend d'Oreille River and has been traced southwestward into the Northport area of Washington by Yates (1971), where he named it informally the 'Pend d'Oreille Sequence'. As neither the top nor the base are known, the thickness is unknown, but some 2000 m must be present; it is everywhere bounded by faults.

In Nelson map area the only fossils collected from this map unit are *Leiorhynchus* sp. (?) of Devonian to Permian age (Little, 1982a, p. 9). Subsequently material collected from thin limestones in the sequence in Northport area, 1.5 km upriver from Northport contained conodonts of Fammenian(?) (Late Devonian) age, of upper Fammenian age about 9.5 km west of

Northport, and of Couvinian (early Middle Devonian) age about 4 km east and a little south of the latter locality (Webster and Beka, 1980). Part of the sequence is established as Lower and Middle Devonian. Farther east, in the adjacent Metaline quadrangle a succession of black argillites capped by massive limestone occurs in fault blocks. The limestone contains megafossils of Onandaga (Middle Devonian) age and R.G. Yates collected graptolites from the argillites that are of Silurian age (Dings and Whitebread, 1965, p. 29). Therefore, Silurian strata may occur in the 'Pend d'Oreille Sequence' and Carboniferous strata may also be present. Thus the age of the sequence is assumed to be Silurian(?), Lower and Middle Devonian, and Carboniferous(?).

Lower Paleozoic (undivided) (lPs)

In the upper reaches of Hidden Creek, highly deformed and metamorphosed micaceous quartzite, argillite, slate, and limestone outcrop east of the Hidden Creek stock. These rocks are sharply folded and westward dipping at the north end of Sheep Creek anticline and probably are composed of the mainly Lower Cambrian strata within that structure. Bedding tops cannot be determined in these metamorphosed rocks, but they appear to be sharply refolded and eastward dipping north of Hidden Creek and emerge north of Hewlett Peak as recognizable Quartzite Range Formation.

Paleozoic (undivided) (Pu)

A thick sequence of metamorphosed micaceous quartzite and schist, argillite, slate, phyllite, and limestone has been traced from the north contact of the Hidden Creek stock north-northeasterly to the eastern edge of the map area between latitudes 49°24'N and 49°29'N. The assemblage is in faulted contact with other formations or in intrusive contact with granitic bodies. These rocks in part resemble those of the Quartzite Range, Reno, and Laib Formations (Fyles and Hewlett, 1959, p. 41). At the northern end of the zone, at the boundary with Nelson map area, east half, the assemblage, north of the thrust fault south of Seeman Creek, abuts against rocks mapped by Leclair (1982, 1983) as Hamill Group (which is roughly equivalent to Quartzite Range Formation). A little farther north the assemblage abuts against Index Formation (which overlies the Lower Cambrian Badshot-Mohican Formations, and so is probably mainly equivalent to the Laib Formation). Still farther north, between latitudes 49°28'N and 49°29'N, where it is bounded by a granodiorite body, the rocks are mapped as Milford Group, which is Carboniferous. According to Leclair, the Milford Group and Index Formations are separated by a normal fault. Thus, the map-unit designated as 'Paleozoic, undivided' may contain beds ranging in age from Lower Cambrian to Carboniferous.

Mesozoic units

Ymir Group (JTy)

The Ymir Group, comprising argillaceous quartzite, slate, argillite, and minor limestone, has been traced from Ymir northerly to the West Arm of Kootenay Lake between Nelson and Harrop, and in isolated areas to the west. The base of the group is not exposed, being in contact with granitic intrusions, or faulted against Paleozoic(?) rocks. The top, which is well exposed in Ymir Creek appears to be conformable below lavas of the Elise Formation.

No fossils have been collected from the Ymir Group although much time has been spent in the search. The group has the identical relationship to the Elise Formation as does the Archibald Formation to the southwest so that the upper part of the group is probably Lower Jurassic. Lower parts resemble the Slocan Group and therefore may be of Triassic age. The Ymir Group is thus correlated in part with the Archibald Formation and the Slocan Group.

Lower Jurassic

Rossland Group (may include the upper part, at least of the Ymir Group)

Archibald Formation (lJa)

The Archibald Formation is made up of black, brittle siltstone that commonly shows graded bedding, argillaceous quartzite, argillite, and minor tuff and lava. The base is

nowhere exposed. In the type locality in Archibald Creek the upper contact with lavas of the Elise Formation is sharp and apparently conformable. Farther west the siltstones are intercalated with lavas, and so are included in the Elise.

The age of the formation is lower Lower Jurassic, numerous collections of Sinemurian ammonites having been obtained, but at one locality a Hettangian age is suggested. Sinemurian beds are widely reported throughout British Columbia and Yukon Territory.

Elise Formation (lJe)

The Elise Formation comprises mainly andesite and propylitized basalt, metamorphosed to subgreenschist and greenschist facies (Beddoe-Stephens and Lambert, 1981; Beddoe-Stephens, 1982). Also included are agglomerate, flow breccia, tuff, volcanic conglomerate, and minor shales and siltstone. The lavas are characterized by augite phenocrysts, and irregular sill-like bodies of augite porphyry are common. The top of the formation is interbedded with soft, carbonaceous shale of the overlying formation. The thickness of the formation is greatest in the type locality on Mount Elise, where it is estimated to be about 2750 m; elsewhere it is as little as 1000 m.

The Elise Formation is underlain by beds of Sinemurian age. It is overlain by beds containing ammonites of Pliensbachian and Toarcian age, according to Tipper (1984) who states that those formerly stated to be Bajocian (Frebold and Little, 1962, p. 21,

25) were misidentified. The Elise Formation is therefore Lower Jurassic.

Hall Formation (lJh)

The Hall Formation extends southward in the type locality of Hall Creek to a point south of Salmo, near the head of Kelly Creek, and in Beaver Creek valley. It consists mainly of carbonaceous argillite and shale, with some phyllite, siltstone, and, locally, conglomerate and thin lavas and tuff. The top is not exposed. The thickness exposed in Hall Creek is about 600 m. Farther south it may be thicker, but the structure is imperfectly known. In Beaver Creek it is not more than 300 m.

Tipper (1984) has stated that only Pleinsbachian and Toarcian fossils are present, so that there is no evidence of Middle Jurassic fauna, and the age is now limited to late Lower Jurassic. Beds of similar age occur in the Fernie Group, in Queen Charlotte Islands and other localities.

Jurassic(?)

Map-unit Jp

Pseudodiorite occupies both sides of the valley of the West Arm of Kootenay Lake and Kootenay River to the west (Little, 1982b). Small bodies of pyroxene-biotite hornblende rock are peripheral and are included here in the unit. The pseudodiorite is believed to be of metamorphic origin. It is cut by Nelson intrusions.

Jurassic

Nelson Intrusions (Jn)

In the southeast part of the map area the southern tail of the Nelson batholith extends from the West Arm of Kootenay Lake, narrowing southward to lower Porcupine Creek. This body is mainly granite, characterized by phenocrysts of orthoclase. Monzonite, granodiorite, quartz diorite, and diorite have also been identified. Ten to 15 km west of Nelson, three small bodies outcrop along Kootenay River. These were recently tentatively correlated with Coryell intrusions (Little, 1982b) but later Parrish *et al*. (1985) established radiometrically a Middle Jurassic (Nelson) age, for similar syenites some kilometres to the northwest. Mulligan's earlier observations that the syenite is related to the pseudodiorite are confirmed.

Elsewhere in the southeast part of the map area several satellite bodies of the batholith occur. The largest of these straddles upper Erie Creek and extends some distance westward. The composition of most of these bodies is noted in the legend. An unusual phase, which seems to be related to the Nelson, forms irregular, elongate bodies on the west slope of Mount Elise north of Ymir. These are composed of pale green, medium-grained albite porphyry.

Nelson intrusions in the southeast part cut Rossland Group rocks as young as Hall Formation and so are post-Toarcian. The

oldest reliable radiometric dates are about 165 Ma (R.L. Armstrong, per. comm., 1984) so that the probable age is Middle Jurassic.

Jurassic or Cretaceous

Silver King Porphyry (Jski)

The Silver King porphyry forms an irregular mass underlying the northeast slope of Toad Mountain. Smaller adjacent bodies lie to the northeast and south. The rock consists of porphyritic hornblende quartz diorite. Its relationship to the Nelson intrusions is uncertain. It may be contemporaneous or possibly of Cretaceous age.

Mesozoic or Cenozoic

Cretaceous or Tertiary

Map-Unit KTp

A pegmatitic granite is exposed on the ridge about 3 km west of Ymir. It does not resemble other facies of the Nelson intrusions, and may be younger.

Cenozoic

Tertiary

Eocene

McGregor Intrusion (Em)

A single body of shonkinite occurs near the east border of Nelson map area, west half, between Cultus and Laib Creeks. It

is consanguinous with four small bodies of syenite that occur to the east on McGregor Mountain. Reesor and Leclair (Reesor, per. comm., 1984) have identified a body of similar rock to the west of McGregor Mountain. These bodies resemble plugs, satellitic to the Coryell batholith and so are probably Middle Eocene.

Coryell Intrusions (Ec)

Many small bodies of alkaline rock, all believed to be related to the Coryell batholith are scattered throughout much of this part of the map area. Most are biotite-augite monzonite (Ec2), but some are of basic syenite (Ec1). Confirmation of the age is to be found in the "Salmon River syenite" which yielded a radiometric (K-Ar) age of 50 $\pm$ 1.5 Ma on biotite (R.L. Armstrong, per. comm., 1984).

SOUTHWEST PART

Age unknown

Trail Gneiss (tgn)

The Trail gneiss was identified and named by Simony (1979), who regarded it as possibly (Aphebian) Hudsonian basement, but the age is unknown, other than that it is pre-Carboniferous, and is separated from the Carboniferous Mount Roberts Formation by a mylonite zone. The map-unit lies on both sides of Columbia

River north of the Trail batholith to China Creek on the west side, and beyond Champion Creek on the east side. It terminates to the east against the Champion Lake fault. It consists of migmatite and quartz diorite to quartz monzonite plutons that have been metamorphosed to orthogneiss.

Castlegar Gneiss (cgn)

The Castlegar gneiss was also named and described by Simony (1979), who believes that, in part at least, it is metamorphosed Trail Gneiss and Mount Roberts Formation. The Castlegar gneiss outcrops on the west side of Columbia River and extends from the lower valley of China Creek to 2 or 3 km north of that part of Columbia River which is west of Castlegar. It comprises mainly layered, foliated and lineated augen gneiss that is cut by irregular and sill-like bodies of pegmatite. Pelitic material north of the east end of Mackie pluton contains sillimanite. Gneisses in the valley of Norns Creek west of Sentinel Mountain are correlated with the Castlegar gneiss by Parrish *et al*. (1985).

Paleozoic units

Silurian(?), Devonian, and (?) Carboniferous

'Pend d'Oreille Sequence' of Yates (Dpo)

See under Southeast Part

Pennsylvanian(?)

Mount Roberts Formation (Pmr)

The Mount Roberts Formation comprises a thick assemblage of

argillaceous quartzite, black siltstone, slate, greywacke, chert, pebble conglomerate, limestone, and minor lava. In the northern part of the area underlain by this formation, the rocks have been metamorphosed into paragneiss. The base of the formation is nowhere exposed; the top has been deeply eroded prior to the deposition of the Rossland Group, and the contact is unconformable.

The age of the Mount Roberts Formation, from fossils collected near Paterson and on O.K. Mountain, is Permo-Carboniferous, a Pennsylvanian age being favoured. It is tentatively correlated with part of the Milford Group of Lardeau map area, the Attwood Group of Greenwood map area, and the Cache Creek Group, as well as Pennsylvanian beds in northeastern Washington.

Ultramafic Intrusions (P?um)

Serpentinite bodies ranging in size up to 6.2 km^2 occupy a narrow, discontinuous belt stretching from a point near Rossland southwestward to Big Sheep Creek. Another body lies in the southwest corner of the map area, and others extend westerly from that point beyond the map area almost to Kettle River. The age of the ultramafite is not certain; the bodies are typical of ophiolite association and are regarded as initially related to the Mount Roberts Formation and so are possibly Pennsylvanian. They do, however, cut the Rossland Group rocks, but this is assumed to be cold intrusion. They are cut by Nelson intrusions.

Lower Jurassic

Rossland Group

Archibald Formation (lJa)

The black siltstones of the Archibald Formation do not occur west of the valley of Beaver Creek, and are entirely missing near Paterson.

Elise Formation (lJc)

West of Beaver Creek the Elise Formation contains rather thick interbeds of Archibald-like sediments that contain Sinemurian fossils. These intercalations become thinner toward Little Sheep Creek, and do not occur at all west of Sophia Creek. Near Paterson the basal flow breccias and agglomerates contain ellipsoidal fragments of limestone from the underlying Mount Roberts Formation.

Hall Formation (lJh)

The soft black shales of the Hall Formation do not occur west of Beaver Creek Fault except on a spur east of Lamb Creek. There a few metres of beds containing fossils of Toarcian age are exposed. These beds are overlain by lithic sandstone of the Kettle River Formation.

Jurassic

Rossland Monzonite (Jrm)

The Rossland monzonite forms two large stocks, one at Rossland and one to the east, and some smaller bodies north of

Rossland, and in the valley of Champion Creek. It is mainly an inequigranular, green, medium-grained rock composed of feldspar, augite, hornblende, and biotite. It intrudes the Elise Formation; its relationship to the Trail Pluton is conflicting, but it is believed to be genetically related to the Nelson intrusions. The age is therefore probably Middle (?) Jurassic.

Nelson Intrusions (Jn)

Satellite bodies of the Nelson batholith occur throughout the southwest part of the Nelson map area, west half. The largest of these are the Bonnington, Mackie, and Trail plutons. The Bonnington and Mackie plutons comprise mainly hornblende quartz diorite, grading into tonalite, granodiorite, and diorite. The Mackie also has a monzodiorite and a porphyritic and non-porphyritic granite facies (Simony, per. comm., 1983). The Trail is mainly biotite-hornblende granodiorite grading into quartz diorite and diorite. The smaller bodies are largely granodiorite. The age is Middle Jurassic.

Cretaceous(?)

Map-unit Kqp

On the east side of the valley of the Big Sheep Creek about 2 km north of the Boundary is a body of chloritized quartz-feldspar porphyry, the quartz phenocrysts forming round "eyes" that are distinctive. It intrudes the Elise Formation

but was not observed to cut the Sophie Mountain Formation. It is assumed to be of Cretaceous age.

Cretaceous

Sophie Mountain Formation (uKsm)

Conglomerate of the Sophie Mountain Formation caps Mount Sophia (formerly known as Sophie Mountain) and extends south of the International Boundary (Yates, 1971) where it is more extensive. Other, smaller areas underlain by the conglomerate occur on Grouse Ridge to the east, and in the southwest corner of the map area. The formation consists almost entirely of conglomerate, with a few thin intercalations of arenaceous argillite and grit. The clasts in the conglomerate are almost entirely purplish red quartzite, with a few of black chert, argillite, white quartz, greenstone, microgranite, serpentine, older conglomerate, sandstone, gneiss, jasper, and limestone. The source of the purplish red quartzite is unknown. The thickness appears to be greater than 100 m. Plant fossils establish the age as Upper Cretaceous, probably Cenomanian-Campanian. No other continental Upper Cretaceous beds are known within hundreds of kilometres.

Cenozoic

Tertiary(?)

Map-unit Ti

On Blizzard Mountain extending in many directions up to 3 km from the summit are small, but mappable, bodies of

hornblende-feldspar and hornblende porphyries of dioritic composition that are believed to be of Tertiary age.

Tertiary

Eocene (Middle)

Kettle River Formation (Ekr)

A small outlier of the Middle Eocene Kettle River Formation, which is best exposed in Greenwood map area to the west (Little, 1983), occurs on a ridge east of Lamb Creek. There some tens of metres of tuffaceous arkose rests upon Hall Formation and is overlain by Marron lava. Another larger and thicker outlier outcrops some 2 km to the northeast. These apparently represent the most easterly extent of the formation because near Rossland, the Marron rests directly upon Elise Formation. The Kettle River Formation is correlated with the O'Brien Creek Formation of northeastern Washington.

Marron Formation (Emv)

The Marron Formation is widespread, exposed intermittently from the Okanagan Valley to the southwest part of Nelson map area, west half, where it underlies an area extending from Old Glory Mountain 4 km northward, and a few small, adjacent areas. It underlies a larger area extending 10 km southward from Hanna Creek, and a much smaller area south of Violin Lake. It consists of andesite, trachyandesite, latite, and basalt(?) flows and minor tuff and agglomerate. As the structure is not

known in detail, an accurate estimate of thickness is not possible, but is indicated to be more than 900 m. The top of the formation is not exposed.

The age of the Marron Formation is Middle Eocene; K-Ar ages obtained from Greenwood map area and on equivalent lavas in northeastern Washington average 51 $\pm$ 1.5 Ma. The formation is correlated with the Sanpoil Volcanics of northeastern Washington.

Sheppard Intrusions (Es)

Bodies of Shepparad intrusions occur in the lower part of the valley of Pend d'Oreille River and west of lower Columbia River for 13 km. The main rock type is sodic leucogranite, with minor syenite. The intrusions may be the source of the widespread tuffs and minor rhyolite flows of the Kettle River Formation, and if so are slightly older than the Coryell intrusions, but still Middle Eocene.

Coryell Intrusions (Ec)

Much of the Coryell batholith underlies the southwest part of the map area on both sides of Big Sheep Creek. Several satellite bodies occur north and east of the batholith. In the batholith, the coarse-grained phase is red to pink, but grades into pale buff syenite that is locally porphyritic. In places quartz exceeds 10 per cent, so some of the rock is granite. These rocks are traversed by numerous hypobyssal alkaline phases dominated by perthitic orthoclase. Most of the satellite bodies are of syenite or quartz monzonite.

A number of small bodies and dykes of porphyritic augite-biotite monzonite are scattered between Christina Lake (to the west) and Salmo River, and as far north as Ymir and the valley of Rover Creek. Several of these are exposed in the southwest part of the map area. These alkaline intrusions are believed to be genetically related to the Coryell, and so are assumed to be Middle Eocene also.

NORTHERN PART

Age Unknown

Miscellaneous gneiss and minor schist (gn)

In the valley west of Sentinel Mountain and extending northward some 12 km is layered augen gneiss of unknown age. This, however, has been correlated by Parrish *et al*. (1985) with the Castlegar gneiss (cgn). A small body of similar gneiss outcrops high on the ridge a few kilometers southwest.

Along the north shore of Lower Arrow Lake west of Syringa Creek a heterogeneous mixture of gneisses occurs. These gneisses cannot be assigned to specific map-units and so are included in the miscellaneous gneiss category.

In the valleys of Ladybird and Grizzly Creeks, and on the west slopes of Koch Creek valley the rocks exposed are classified as gneiss. They consist of a heterogeneous mixture of inclusions of granitic, amphibolitic, and migmatitic rocks

cemented by leucogranitic material. In places foliation and layering can be discerned. Their age and relationship to other map-units is unknown.

On the south side of lower Snow Creek layered gneisses may be a western extension of map-unit uPTgn but this is not a certainty. Similar gneiss exposed on the west side of upper Burton Creek may be part of the same map unit.

Upper Paleozoic and/or Triassic (?)

Map-unit uPTgn

Extending from the west shore of Slocan Lake westward into the valley of Snow Creek is the 'Nemo Lakes Belt' as named and described by Parrish (1981). This contains a succession of high grade metasedimentary rocks that were intensely folded during two, possibly related orogenic events. The metamorphosed rocks are probably sediments of the Milford or Slocan Groups, or both.

Pre-Middle Jurassic(?) to Eocene

Valhalla Gneiss Complex

The Valhalla Gneiss Complex was named by Reesor (1965) who spent three field seasons (1958-1960) in the study of it. The complex is a domal structure centred in upper Gwillim Creek. It extends northward to the northern border of the map area, westward almost to Burton and upper Koch Creeks, southward to Columbia River, and is terminated on the east by the Slocan Lake fault zone. A subsidiary dome east of Passmore (from which it is named) is also terminated by the fault zone.

The complex has been divided into several units that comprise either metasedimentary or intrusive bodies. The units are described from the lowest to the highest, but this does not imply that the units are progressively younger upward. The units described by Reesor have been re-examined by Parrish, et al (1985) and reinterpreted on a structural basis aided by U-Pb age determinations on zircons. Late Cretaceous and early Tertiary ages predominate and suggest that the components of the Valhalla Gneiss Complex are much younger than the other gneiss dome complexes in the Omineca Crystalline Belt.

Hybrid Gneiss in Gwillim Creek (pmJhgn)

In the valley of Gwillim Creek two small areas are underlain by layered paragneiss of sillimanite grade in which Parrish et al (1985) have recognized quartzite-pebble conglomerate and calcareous gneiss, and so correlate these rocks with Milford Group or older formations. Reesor (1965, p. 12) remarked that the upper contact of the hybrid gneiss is intensely sheared across 3 to 5 m. In recent field studies Parrish et al (op. cit.) have concluded that this the contact is a fault. This and related faults may be either extension or thrust faults; they are shown as the latter on the accompanying map.

Veined Augen Mafic Granodiorite-Gneiss (uKgdgn)

This map-unit is described by Reesor (1965, p. 5, 8) as chiefly hornblende-biotite or biotite gneiss with variable amounts of conspicuous augen of potash feldspar. Mafic minerals

average nearly 30 per cent. It forms the main mass of the core of Valhalla Dome, and is a metasedimentary unit. It is intruded by leucocratic orthogneiss and petmatite. Map unit uKgdgn is everywhere overlain by gneiss similar to that in Gwillim Creek. Reesor (1965, p. 12) described the contact as gradational, with increase in leucocratic material upwards.

The age of the veined augen mafic granodiorite-gneiss has been determined by U-Pb analysis of zircons as about 90 Ma (Parrish et al., 1985), and is therefore Upper Cretaceous or younger.

Hybrid Gneiss (pmJhgn) surrounding map-unit uKgdgn

Layered metasedimentary Gneiss map-unit pmJhgn lies above the augen granodiorite-gneiss and has been traced around the latter, from Slocan Lake westward to the Little Slocan Lakes, thence northeastward to Slocan City. It also extends from Little Slocan Lakes southwestward to Slocan River Valley where it forms the lowest level of the Passmore Dome. The gneissic layering everywhere dips outward from the dome, for the most part gently. Reesor (1965, p. 15) has estimated the thickness at 600 m to more than 3000 m.

Map-Unit Pmgn

At a higher level in the Valhalla Gneiss Complex Reesor (1965, p. 26, 27) described a unit of 'mixed gneiss', with a sharply defined lower contact against the hybrid gneiss (pmJhgn) in Passmore Dome, but a gradational contact in Valhalla Dome

where there is a gradual upward decrease in metasedimentary rock content. The unit is mainly foliated granodiorite to leucogranite, but throughout is extremely heterogeneous with inclusions of metasediments, amphibolite and augen gneiss; the latter is locally up to 600 m thick. Parrish et al. (1985) describe the unit as "K-feldspar megacrystic biotite-hornblende quartz monzonite". Reesor (op. cit.) gives its thickness as up to 2400 m.

U-Pb age determinations on zircons are about 63 Ma, so that the age of map-unit Pmgn is Paleocene (Parrish et al., op. cit.)

Biotite quartz monzonite (PEgm)

Reesor (1965, p. 37) described bodies of non-porphyritic, more or less foliated biotite leucoquartz monzonite that are exposed along the outer fringes of the Valhalla Gneiss Complex, but he did not include them with the complex. Parrish et al. (1985) however have concluded that this map-unit is part of the complex.

Paleozoic Units

Pennsylvanian(?)

Mount Roberts (?) Formation (Prm)

In the valley of Cayuse Creek four areas are underlain by roof pendants of argillaceous quartzite, mica schist, and greywacke. Some limestone is exposed and is fairly abundant to the west, beyond the boundary of the map area. The largest of

these roof pendants is some 15 km long. The rocks most closely resemble those of the Mount Roberts Formation, with which they are correlated.

Carboniferous

Milford Group (Cm)

The Milford Group has been traced into the southeast part of Nelson map area by LeClair (1982, 1983) where it lies on the northwest side of the Index Formation of the Lardeau Group on the north side of valley of Kutetl Creek. It is separated from the Index by a fault, and both formations are mapped west of longitude 117°W as Paleozoic undivided (Pu). Reesor (per. comm., 1985) has also traced the Milford group from Ainsworth on Kootenay Lake southward to the slopes south of Balfour Knob where the metasediments lie between the Nelson Batholith and Quaternary deposits, and the writer traced them westward to Redfish Creek. Hyndman (1968) has mapped the metasedimentary rocks outcropping between Wee Sandy Creek and the lower part of Snow Creek, formerly regarded as Slocan Group (Little, 1960), as probably Milford, and this tentatively accepted.

In Kutetl Creek the Milford Group consists of thinbedded grey quartzite and chert with some intercalated greenstone and amphibolite (LeClair, 1983). Between Laird and Redfish Creeks the Milford(?) Group comprises paragneiss, argillaceous quartzite, marble, and calc-silicate rocks. Hyndman (op. cit.) described the rocks around Grey Wolf Mountain as amphibolite,

schist, and calc-silicate rocks, where bedding is well enough preserved to obtain some attitudes. Two to five kilometres east of the northeast corner of the map area the top of the Milford Group is well exposed. It is overlain unconformably by the Marten greenstone conglomerate (Klepacki, 1983). Previous collections of corals and brachiopods are of Late Mississippian age (Fyles and Eastwood, 1962, p. 32). Orchard (1985) has identified conodonts of Tournasian, Visean, and Namurian (Mississippian and lower Pennsylvanian) age in Milford limestone that outcrops beyond the limits of the map area; therefore the age of the Milford is both Early and Late Mississippian, and Pennsylvanian . The Marten conglomerate is Lower Permian (Orchard, 1985).

Permian

Kaslo Group (Pk)

The Kaslo Group outcrops in the northeast corner of the map area east of Kaslo River. There it comprises andesitic and dacitic flows and sill-like bodies, and some pyroclastic rocks. East of the map area, and lower in the section, some serpentine and carbonate rocks are included. The thickness is about 900 m. The Kaslo Group rests unconformably on the Marten conglomerate (Klepacki, 1983), and is overlain disconformably by the Slocan Group. Orchard (1985) identified Leonardian conodonts in chert from the formation which is therefore at least partly middle Permian.

Mesozoic

Lower Jurassic(?) and Triassic

Slocan Group (Ꞧs)

The Slocan Group underlies a large area extending from Kaslo River and Keen Creek westward to Slocan Lake. Roof pendants of gneiss and schist in the valleys of Springer Creek, lower Enterprise Creek, and upper Keen Creek have been assigned to the Slocan Group. Farther south in the Nelson batholith, smaller roof pendants were formerly assumed to be Ymir Group, but here are indicated as Slocan Group; the two groups are probably partly equivalent.

The Slocan Group is composed of a thick assemblage (estimated by one geologist as more than 11,000 m thick) of mainly pelitic rocks, but limestone and fine-grained quartzite are fairly abundant, and some tuffaceous beds and conglomerate are also present. The top of the Slocan Group is not exposed. Early collections of fossils were not diagnostic, but a Triassic age was indicated. Conodonts examined by Orchard (1985) from limestones that lie to the north of the map-area, and are in the lower part of the group are of Carnian and Norian age. Thus the age of the lower part of the Slocan Group is Upper Triassic. No diagnostic fossils have been collected from higher parts of the group, but some 10 km northeast of Burton a fossil of Sinemurian age was obtained (Little, 1960, p. 57). The rocks there were subsequently identified as a klippe (Hyndman, 1968) and were correlated by him on lithological grounds with the Slocan Group. Thus the upper part of the group may be Lower Jurassic.

Jurassic (Middle?)

Nelson Intrusions (Jn)

The Nelson batholith occupies most of the northeast quarter of the map area and terminates on the west against the Slocan Lake fault zone. The rock is mainly porphyritic, with large phenocrysts of alkali feldspar, and ranges in composition from granite (where phenocrysts are abundant) to granodiorite. Hornblende predominates over biotite in most places. East of Slocan Valley an extensive area is underlain by white to pinkish hornblende syenite which is transected by many dykes of microgranite.

In the northwest quarter of the map area bodies of biotite hornblende granodiorite are assigned to the Nelson intrusions, along with some of quartz monzonite, quartz diorite, and diorite. The largest of these bodies is granodiorite and underlies the valley of Cayuse Creek.

As a result of many age determinations of Nelson intrusions, R.L. Armstrong (per. comm., 1984) concluded that the most probable age is about 165 Ma, or Middle Jurassic.

Eocene (Middle)

Coryell Intrusions (Ec)

A body of batholithic dimensions lies on both sides of Lower Arrow Lake and extends into Nelson map area between Mount Stanley and Sangrida Peak. Reesor (1965) mapped another body of Coryell 'quartz-poor' rocks that extends a few kilometres north from Hilda Peak. An adjacent body to the west is also

quartz-poor but also 'mafic-rich'. This too is regarded as part of the Coryell suite, and is younger than Nelson porphyritic granodiorite. A third, smaller body of porphyritic augite monzonite outcrops about 7 km south of Mount Stanley and this body, as similar bodies elsewhere, is included in the Coryell suite. The body north of Mount Stanley comprises typical pinkish syenite to monzonite, and Reesor (1965, p. 38-41) identified the rocks in the bodies north of Hilda Peak as monzonite and syenodiorite. Two K-Ar ages have been determined on these bodies by Loudon et al (1968, p. 11, 12) as 53 and 32 Ma. The first agrees well with determinations on Coryell and correlated rocks elsewhere, but there appears to have been argon loss from the latter specimen. The age is Middle Eocene.

STRUCTURE

In the southeast corner of the map-area the structure is monoclinal, and has been termed the Homocline Belt by Yates (1971; Little, 1982a). To the northwest, it is succeeded by the Outer Fold Belt which comprises mainly isoclinal folds including the Laib Syncline, Sheep Creek Anticline, Western Syncline, and Western Anticline. To the northwest of this belt is the Thrust Belt which is marked by the Black Bluff Thrust Fault and contains the Argillite and Waneta thrusts, and several unnamed minor thrust faults, in all of which the movement is directed northwesterly. Farther northwest is the Inner Fold and Thrust Belt which contains mainly open folds and steeply-dipping transverse faults. In Beaver Creek Valley, the Beaver Creek

fault thrusts lower Lower Jurassic rocks of the Archibald and Elise Formations eastward over upper Lower Jurassic Hall Formation. In Kelly Creek to the east rocks were believed to be Middle Jurassic and(?) younger and were named 'Upper Rossland Group' (Little, 1965). Subsequent field work (Little, 1982a, p. 15) showed that these rocks are Elise Formation which apparently is thrust over Hall Formation. This thrust plate is bounded on the north and south by Doubtful Creek and Kelly Creek Faults, respectively.

In the valley of upper Next Creek, and terminating against Wall Stock, Monk Formation is exposed in the core of an unnamed anticline. The southern end of Sheep Creek Anticline is disrupted by the Ripple Creek Fault, a transverse fault in which Fyles and Hewlett (1959, p. 62) estimate the vertical displacement to be about 750 m and the horizontal displacement about 300 m, the south side having moved down and westward. A similar fault occurs just north of latitude 49°15'N with a left hand displacement of about 450 m.

To the west, the Porcupine Fault, which may be the folded continuation of the Black Bluff Fault, terminates against an elongate granitic body. To the east of it the Laib Creek Fault, a normal fault with left hand displacement, lies on the west side of the Laib Creek Syncline, but displaces it on its course northeastward. To the west of the Porcupine Fault is the Oxide Fault which is apparently an easterly directed thrust that terminates both north and south against granitic bodies. West of the northern part of the Laib Syncline is the Baldy Anticline

which may be the northern extension of the Sheep Creek Anticline where the formations are dislocated westward towards the Hidden Creek stock, then eastward to the southern end of the Baldy anticline.

In the southwestern part of the map area, the Waneta Fault has been followed westward from Waneta where its trace heads northwesterly and disappears under Eocene Marron volcanics, and apparently terminates against the Violin Lake Fault, a normal fault with right hand displacement. The Waneta Fault may, however, form the contact between the 'Pend d'Oreille Sequence' and Elise Formation west of Goodeve Creek before being terminated against an unnamed fault south of Baldy Mountain.

North of the Trail pluton, the Champion Lake Fault has been traced southward through the Trail Pluton (Simony, per. comm., 1983) where its displacement seems to be minor. Northward, it brings the Lower Jurassic Elise Formation and Middle (?) Jurassic Nelson intrusions into contact with the pre-Carboniferous Trial gneiss. The fault dips steeply eastward, and the displacement is large with the east side downthrown. It has been traced by Corbett and Simony (1984) north of the mouth of Kootenay River and has been linked to the Slocan Lake Fault Zone by Parrish _et al_. (1985).

To the west, across Columbia River, the contact between Trail Gneiss and the Pennsylvanian(?) Mount Roberts Formation is a broad mylonite zone (Simony, 1979, p. 5). West of this zone Simony has delineated an isoclinal synform and antiform in Mount Roberts Formation, whose axial planes dip steeply west.

In the northeast corner of the map area the Slocan Group is folded into a huge recumbent west facing syncline named the Slocan Fold. Farther northwest, beyond the northern boundary of the map area the axial plane steepens and the core of the syncline is occupied by greenstone of the Rossland Group (Hyndman, 1968).

On the east side of Slocan Valley is the Slocan Lake Fault Zone which dips gently eastward. Parrish et al. (1985) define it as a brittle fault with ductile shearing above and below. The upper block, comprising intrusive rocks of the Nelson batholith, has moved eastward.

West of Slocan Lake, Reesor (1965), from a detailed study of lineations, concluded that the Valhalla Dome is arched about an axis that strikes about north 10 degrees east. North of the Dome, Parrish (1981) during detailed mapping of hybrid gneiss in the Nemo Lake belt outlined overturned anticlinal and synclinal folds that generally trend easterly but are locally refolded.

Acknowledgments

Thanks are due to P.S. Simony of the University of Calgary for supplying unpublished data on the geology of part of Castlegar area, as a result of mapping by him, and by G. Crowe in 1981.

The foregoing geological notes have been reduced to a minimum for this large and complex area, where continuing studies are being pursued by others. Details of lithology and

structure as well as additional bibliographic references, especially those prior to 1955 may be found in the selected references below. Those marked with an asterisk are regarded as the most fruitful in the regard.

SELECTED REFERENCES

Aalto, K.R.
1971: Glacial marine sedimentation and stratigraphy of the Toby Conglomerate (Upper Proterozoic), southeastern British Columbia, northwestern Idaho, and northeastern Washington; Canadian Journal of Earth Sciences, v. 8, No. 7, ,p. 753-787.

Archibald, D.A., Glover, J.K., and Farrar, E.
1977: K-Ar ages from the Bayonne batholith and some nearby plutons, southeastern British Columbia, and their geological implications (abstract); Geological Association of Canada, Program and Abstracts, v. 2, p. 5.

Archibald, D.A., Glover, J.K., Price, R.A., Farrar, E. and Carmichael, D.M.
1983: Geochronology and tectonic implications of magmatism, southern Kootenay Arc and neighbouring regions, southeastern British Columbia; Part I, Jurassic to mid-Cretaceous; Canadian Journal of Earth Sciences, v. 20, p. 1891-1913.

Archibald, D.A., Krogh, T.E., Armstrong, R.L., and Farrar, E.
1984: Chronology and tectonic implications of magmatism and metamorphism, southern Kootenay Arc and neighbouring regions, southeastern British Columbia; Part II, mid-Cretaceous to Eocene; Canadian Journal of Earth Sciences, v. 21, No. 5, p. 567-583.

Anderson, P.
1977: Time-space tectonic model for initiation of regional metamorphism and rise of infrastructure in S.W. British Columbia (abstract); Geological Association of Canada, Program with Abstracts, v. 2, p. 4.

1977: Timing of Mesozoic plate tectonics in S.W. British Columbia (abstract); Geological Association of Canada, Program with Abstracts, v. 2, p. 4.

Armstrong, R.L.
1982: Late Triassic - Early Jurassic time scale calibration in British Columbia, Canada; in Numerical dating in stratigraphy, edited by G.S. Odin, John Wiley and Sons, New York, N.Y., U.S.A., p. 509-513.

Beddoe-Stephens, B.
1982; The petrology of the Rossland volcanic rocks, southern British Columbia; Geological Society of America, Bulletin, v. 93, p. 585-594.

Beddoe-Stephens, B., and Lambert, R. St. J.
1981: Geochemical, mineralogical, and isotope data relating to the origin and tectonic setting of the Rossland volcanic rocks, southern British Columnbia; Canadian Journal of Earth Sciences, v. 18, No. 5, p. 858-868.

Burmester, R.F., and Miller, F.K.
1983: Preliminary map of the Abercrombie Mountain area, Pend Oreille County, Washington; United States Geological Survey, Open File OF 83-600.

Carr, Sharon D.
1985; Ductile shearing and brittle faulting in Valhalla Gneiss Complex, southeastern, British Columbia; in Current Research, Part 85-1A, p. 89-96.

Corbett, C.R. and Simony, P.S.
1984: The Champion Lake fault in the Trail-Castlegar area of southeastern British Columbia; in Current Research, Geological Survey of Canada, Paper 84-1A, p. 103-104.

Crosby, P.
1968: Tectonic, plutonic, and metamorphic history of the central Kootenay Arc, British Columbia, Canada; Geological Society of America, Special Paper 99, 94 p.

Dings, M.G. and Whitebread, D.H.
1965: Geology and ore deposits of Metaline zinc-lead district, Washington; United States Geological Survey, Professional Paper 489.

Duncan, I.J.
1978: Rb/Sr whole rock evidence for three Precambrian events in the Shuswap Complex, southeast British Columbia; Abstracts with programs, Geological Society of America, v. 10, p. 392-393.

Duncan, I.J., and Nielson, K.C.
1977: Structural and tectonic evolution of the Shuswap Complex (abstract); Geological Association of Canada, Program with Abstracts, v. 2, p. 17.

Duncan, I.J., and Parrish, R.R.
1979: Geochronology and Sr isotope geochemistry of the Nelson Batholith: a post-tectonic intrusive complex in southeast British Columbia; Geological Society of America, 75th Annual Meeting, Cordilleran Section, Abstracts, v. II, No. 3, p. 76.

Duncan, I.J., Parrish, R.R., and Armstrong, R.L.
1979: Rb/Sr geochronology of the post-tectonic intrusive events in the Omineca Crystalline Belt, southeastern British Columbia (abstract); Cordilleran Section of the Geological Association of Canada, Vancouver, B.C., Program with Abstracts, p. 15.

Fairbairn, H.W., Hurley, P.M., and Pinson, W.H.
1964: Initial $^{87}Sr/^{86}Sr$ and possible sources of granitic rocks in southern British Columbia; Journal of Geophysical Research, v. 69, p. 4889-4893.

Frebold, Hans, and Little, H.W.
1962: Palaeontology, stratigraphy, and structure of the Jurassic rocks in Salmo map-area, British Columbia; Geological Survey of Canada, Bulletin 81.

Fyles, J.T.
1964: Geology of the Duncan Lake area, British Columbia; British Columbia Department of Mines and Petroleum Resources, Bulletin 49, 87 p.

1967: Geology of the Ainsworth-Kaslo area, British Columbia; British Columbia Department of Mines and Petroleum Resources, Bulletin No. 53.

Fyles, J.T., and Eastwood, G.E.P.
1962: Geology of the Ferguson area, Lardeau district, British Columbia; British Columbia Department of Mines and Petroleum Resources, Bulletin 45, 92 p.

Fyles, J.T. and Hewlett, C.G.
1959: Stratigraphy and structure of the Salmo lead-zinc area; British Columbia Department of Mines, Bulletin No. 41.

Gabrielse, H., and Reesor, J.E.
1964: Geochronology of plutonic rocks in two areas of the Canadian Cordillera, in Geochronology in Canada; Royal Society of Canada, Special Publication 8, p. 96-138, F.F. Osborne, ed.

1974: The nature and setting of the granitic plutons in the central and eastern parts of the Canadian Cordillera; Pacific Geology, v. 8, p. 109-138.

Glover, J.K.
1978: Geology of the Summit Creek map-area, southern Kootenay Arc, British Columbia; Ph.D. thesis, Queen's University, Kingston, Ontario 143 p.

Glover, J.K. and Price, R.A.
1976: Stratigraphy and structure of Windermere Supergroup, southern Kootenay Arc, British Columbia; in Report of Activities, Part B, Geological Survey of Canada, Paper 76-1B, p. 21-23.

Hoy, T.
1974: Structure and metamorphism of Kootenay Arc rocks around Riondel, British Columbia; Ph.D. thesis, Queen's University, Kingston, Ontario, 201 p.

1980: Geology of the Riondel area, central Kootenay Arc, southeastern British Columbia; British Columbia Ministry of Energy, Mines and Petroleum Resources, Bulletin 73.

Hyndman, D.W.
1968: Petrology and structure of Nakusp map-area, British Columbia; Geological Survey, Bulletin 161, 95 p.

Klepacki, D.W.
1983: Stratigraphic and structural relations of the Milford, Kaslo and Slocan Groups, Roseberry quadrangle, Lardeau map area, British Columbia; Geological Survey of Canada, in Current Research, Part A, Paper 83-1A, p. 229-233.

Klepacki, D.W. and Wheeler, J.O.
1985: Stratigraphic and structural relations of the Milford, Kaslo, and Slocan Groups, Goat Range, Lardeau and Nelson map areas, British Columbia; in Current Research, Part A, Geological Survey of Canada, Paper 85-1A, p. 277-286.

Leclair, A.D.
1982: Preliminary results on stratigraphy, structure, metamorphism of central Kootenay Arc rocks, southeastern British Columbia; in Current Research, Part A, Geological Survey of Canada, Paper 82-1A, p. 45-49.

1983: Stratigraphy and structural implications of central Kootenay Arc rocks, southeastern British Columbia; in Current Research, Part A, Geological Survey of Canada, Paper 83-1A, p. 235-240.

Leech, G.B., Lowdon, J.A., Stockwell, C.H., and Wanless, R.K.
1963: Age determinations and geological studies; Geological Survey of Canada, Paper 63-17, p. 7.

Lis, M.G., and Price, R.A.
1976: Large-scale block faulting during deposition of the Windermere Supergroup (Hadrynian) in southeastern British Columbia; in Report of Activities, Part A, Geological Survey of Canada, Paper 76-1A, p. 135-136.

Little, H.W.
1960: Nelson map-area, west half, British Columbia; Geological Survey of Canada, Memoir 308, 205 p.

1964: Geology, Ymir (Nelson, east half), British Columbia; Geological Survey of Canada, Map 1144A.

1965: Geology, Salmo, British Columbia; Geological Survey of Canada, Map 1145A.

1978: The Triassic unconformity of south-central British Columbia: discussion; Canadian Journal of Earth Sciences, v. 15, No. 2, p. 322-323.

1982a: Rossland-Trail map-area, British Columbia; Geological Survey of Canada, Paper 79-26.

1982b: Geology, Bonnington map area, British Columbia; Geological Survey of Canada, Map 1571A.

1983: Geology of the Greenwood map-area, British Columbia; Geological Survey of Canada, Paper 79-29.

Lowdon, J.A., Stockwell, C.H., Tipper, H.W., and Wanless, R.K.
1968: Age determinations and geological studies - Report 3; Geological Survey of Canada, Paper 62-17.

Miller, F.K.
1983: Preliminary map of the Gypsy Peak area, Pend Oreille County, Washington; United States Geological Survey, Open File OF 83-601.

Miller, F.K., and Engels, J.G.
1975: Distribution and trends of discordant ages of plutonic rocks of northeastern Washington and northern Idaho; Geological Society of America, Bulletin 86, p. 517-528.

Monger, J.W.H., and Price, R.A.
1979: Geodynamic evolution of the Canadian Cordillera - progress and problems; Canadian Journal of Earth Sciences, v. 16, p. 770-791.

Nguyen, K.K., Sinclair, A.J., and Libby, W.G.
1968: Age of the northern part of the Nelson batholith; Canadian Journal of Earth Sciences, v. 5, No. 4, pt. I, p. 955-957.

Okulitch, A.V., and Peatfield, G.R.
1977: Geologic history of the late Paleozoic - early Mesozoic eugeocline in southern British Columbia and northeastern Washington (abstract); Geological Association of Canada, Program with Abstracts, v. 2, p. 40.

Orchard, M.J.
1985: Carboniferous, Permian and Triassic conodonts from the central Kootenay Arc, British Columbia; constraints on the age of the Milford, Kaslo and Slocan Groups; in Current Research, Part A, Geological Survey of Canada, Paper 85-1A, p. 287-300.

Park, C.F. Jr. and Cannon, R.S. Jr.
1943: Geology and ore deposits of the Metaline quadrangle, Washington; United States Geological Survey, Professional Paper 202.

Parrish, R.R.
1981: Geology of the Nemo Lakes belt, northern Valhalla Range, southeast British Columbia; Canadian Journal of Earth Sciences, v. 18, No. 5, p. 944-958.

1984: Slocan Lake Fault: a low angle fault zone bounding the Valhalla gneiss complex, Nelson map-area, southern British Columbia; in Current Research, Part A, Geological Survey of Canada, Paper 84-1A, p. 323-330.

Parrish, R.R., and Armstrong, R.L.
1983: U-Pb zircon age and tectonic significance of gneisses in structural culminations of the Omineca Crystalline Belt, British Columbia (abstract); Geological Society of America, Cordilleran and Rocky Mountain Sections meeting, Abstracts with Program, v. 15, p. 324.

Parrish, R.R., Carr, S.O., and Brown, R.L.
1985: Valhalla Gneiss Complex, southeast British Columbia: 1984 field work; in Current Research, Geological Survey of Canada, Part A, Paper 85-1A, p. 81-87.

Parrish, R.R. and Ryan B.
1983: Pb-U zircon dates reflecting late Cretaceous - early Tertiary plutonism, deformation, and isotopic resetting, Valhalla complex, southeast British Columbia; Geological Association of Canada, Program with Abstracts, v. 8, p. A53.

Parrish, R.R. and Wheeler, J.O.
1983: U-Pb zircon age of the Kuskanax batholith, southeastern British Columbia; Canadian Journal of Earth Sciences, v. 20, p. 1751-1756.

Read, P.B. and Brown, R.L.
1981: Columbia River fault zone: southeastern margin of the Shuswap and Monashee complexes, southern British Columbia; Canadian Journal of Earth Sciences, v. 18, p. 1127-1145.

Read, P.B. and Okulitch, A.V.
1977: The Triassic unconformity of south-central British Columbia; Canadian Journal of Earth Sciences, v. 14, No. 4, Part I, p. 606-638.

1978: The Triassic unconformity of south-central British Columbia: reply; Canadian Journal of Earth Sciences, v. 15, No. 2, p. 323-324.

Read, P.B. and Wheeler, J.O.
1975: Lardeau, west half; Geological Survey of Canada, Open File map OF 288. (Revised and reissued 1977 as O.F. 432).

Reesor, J.E.
1965: Structural evolution and plutonism in Valhalla gneiss complex, British Columbia; Geological Survey of Canada, Bulletin 129, 128 p.

1973: Geology of Lardeau map-area, east half, British Columbia; Geological Survey of Canada, Memoir 369, 129 p.

Ross, J.V.
1970: Structural evolution of the Kootenay Arc, southeastern British Columbia; in structure of the southern Canadian Cordillera, Geological Association of Canada, Special Paper 6, p. 53-65.

Ross, J.V. and Kellerhals, P.
1968: Evolution of Slocan Syncline in south-central British Columbia; Canadian Journal of Earth Sciences, v. 5, No. 4, Part 1, p. 851-872.

Simony, P.S.
1979: Pre-carboniferous basement near Trail, British Columbia; Canadian Journal of Earth Sciences, v. 16, No. 1, p. 1-11.

Steiger, R.H. and Jager, E.
1977: Subcommission on Geochronology: Convention on the use of decay constants in geo- and cosmochronology; Earth and Planetary Science Letters, v. 36, p. 359-362.

Stevens, R.D., Delabio, R.N., and Lachance, G.R.
1982: Age determinations and geological studies: K-Ar isotope ages, report 15; Geological Survey of Canada, Paper 81-2.

Thorpe, R.I. and Little, H.W.
1973: Discussion, the age of sulfide mineralization at Rossland, B.C.; Economic Geology, v. 68, No. 8, p. 1337-1340 (December 1973).

Tipper, H.W.
1984: The age of the Jurassic Rossland Group of southeastern British Columbia; in Current Research, Part A, Geological Survey of Canada, Paper 84-1A, p. 631-632.

Wanless, R.K., Stevens, R.D., Lachance, G.R., and Edmonds, C.M.
1968: Age determinations and geological studies: K-Ar isotope ages, report 8; Geological Survey of Canada, Paper 67-2, Part A, p. 47-49.

Webster, G.D. and Beka, F.T.
1980: A Devonian age for parts of the black shale northwest of Northport, Washington; Geological Society of America, Cordilleran Section, Abstracts with Programs, v. 12, No. 3, p. 159.

Wheeler, J.O.
1963: Rogers Pass map-area; Geological Survey of Canada, Paper 62-32.

Wheeler, J.O., Aitken, J.D., Berry, M.J., Gabrielse, H., Hutchison, W., Jacoby, W.R., Monger, J.W.H., Niblett, E.R., Norris, D.K., Price, R.A., and Stacey, R.A.
1972: The Cordilleran structural province; in Variations in tectonic styles in Canada, Geological Association of Canada, Special Paper No. 11, p. 1-81.

White, W.H., Harakal, J.E. and Carter, N.C.
1968: Potassium-argon ages of some ore deposits in British Columbia; Canadian Institute of Mining and Metallurgy, Bulletin, v. 61, No. 679, p. 1326-1334.

Yates, Robert G.
1970: Geological background of the Metaline and Northport mining districts, Washington; in Lead-zinc deposits in the Kootenay Arc, Washington Division of Mines and Geology, Bulletin No. 61, p. 17-39.

Yates, R.G.
1971: Geologic map of the Northport quadrangle, Washington; United States Geological Survey, Miscellaneous Geological Investigations, Map I-603.

Young, F.G., Campbell, R.B., and Poulton, T.P.
1973: The Windermere Supergroup of the southeastern Canadian Cordillera, Belt Symposium, University of Idaho, Moscow, Idaho.