CANADA

DEPARTMENT OF MINES

AND

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GEOLOGICAL SURVEY OF CANADA

PAPER 50-19

SALMO MAP-AREA BRITISH COLUMBIA

(REPORT AND MAP)

By

H. W. Little

OTTAWA

1950

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(Summary Account)

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Preliminary map -- Salmo, B.C. ..... In envelope

SALMO MAP-AREA, BRITISH COLUMBIA

INTRODUCTION

Since the publication of Walker's report and map on Salmo map-area (20)[1] in 1934, many parts of the area have become more accessible and much additional information, both published and unpublished, relating to the geology of the area has accumulated. In 1941, Rice (17, Map 603A) delineated the formations named and described in Windermere (19) and Lardeau (21) map-areas, and linked them with those of Salmo map-area.

Subsequently, Park and Cannon (16) discovered fossils in the Metaline quadrangle, immediately south of Salmo map-area, indicating that most of the formations that Walker had regarded as late Proterozoic are of early Palaeozoic age.

In the meantime, detailed mapping by mining geologists had revealed the fact that the structure of parts of Salmo map-area is more complex than had previously been realized. The results of some of this detailed work were published by McGuire (11), and his general conclusions were confirmed in 1948 by Mathews (oral communication), who carried on detailed geological mapping in the Sheep Creek mining camp for the British Columbia Department of Mines.

In 1947, the writer commenced systematic geological mapping of the Nelson area, West Half, which includes the Salmo area; and during this and the succeeding two field seasons obtained much new palaeontological, stratigraphic, and structural information. The results of this work have seemed significant enough and in sufficient detail to justify the present report and revision of the geology of the Salmo area.

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[1] Numbers in parentheses are those of references in bibliography at end of this report.

The accompanying map may be regarded as a supplement to Map 299A by Walker. Liberal use of his information has been made by the writer, and in many parts of the map-area no additional field work was done.

The writer wishes to express his gratitude to those who have assisted him in his work. V. J. Okulitch spent 6 weeks of the field seasons of 1947 and 1949 in Salmo map-area, collecting fossils and studying the stratigraphy, and much of the information in his unpublished reports has been incorporated in this account. W. H. Mathews mapped in detail the Sheep Creek camp during the field seasons of 1948 and 1949, and kindly offered the present writer much of his information. H. C. Gunning of New Jersey Zinc Explorations Limited, G. Gilbert of the Consolidated Mining and Smelting Company of Canada Limited, H. Lakes of Canadian Exploration Limited, and A. E. Buller of Pend Oreille Mines and Metals Company have contributed geological data. A. L. McAllister and R. Mulligan, who examined the map-areas to the north, assisted greatly in the interpretation of stratigraphy and structure. Mr. Mulligan is also responsible for the mapping of that part of the map-area that lies north of the Great Northern railway. Efficient assistance was rendered in the field by A. L. McAllister, W. H. Dow, and R. G. McCrossan in 1947; by R. Mulligan, W. O. Pollock, and P. G. Hughes in 1948; and by W. H. Dow, E. M. Wilson, L. E. Marjanen, and W. Panasiuk in 1949.

The writer is especially grateful to W. A. G. Bennett of the Washington State Survey, and to J. P. Thomson of Colville for their generosity in taking time to show him some of the stratigraphy and fossil localities of Stevens and Pend Oreille counties, Washington.

GENERAL GEOLOGY

TABLE OF FORMATIONS

Era	Period or epoch	Group of formation	Lithology
Cenozoic	Pleistocene and Recent		Glacial till; clay, sand, and gravel
	Unconformable contact		
	Tertiary (?)		Conglomerate
		Relationship not known	
		Sheppard intrusions	Leucocratic granite
Relationship not known			
Mesozoic	Cretaceous(?)	Nelson intrusions	Granite, granodiorite, quartz diorite, monzonite, syonite, and diorite; aplite and lamprophyre dykes.
	Intrusive contact		
	Jurassic or Cretaceous	Beaver Mountain formation	Andesite, agglomerate, breccia, tuff, latite; minor argillite
	Conformable contact		
	Jurassic and (?) Cretaceous	Hall group	Argillite, sandstone, conglomerate; minor volcanic flows
	Conformable contact		
	Triassic(?)	Elise formation	Agglomerate, andesite, latite; minor argillite

	Conformable contact		
Mesozoic and (?) earlier	Triassic and (?) earlier	Ymir group	Argillite, slate and argillaceous quartzite; minor limestone
	Gradational contact		
	Ordovician(?) and later	Seeman group	White quartzite, schist, limestone; minor argillite
	Conformable contact		
	Ordovician	Active formation	Slate, argillaceous quartzite
	Disconformable (?) contact		
Palaeozoic	Middle Cambrian	Nelway formation	Cream weathering dolomite; limestone and argillite
	Gradational contact		
	Lower Cambrian	Laib group	Argillite, argillaceous quartzite; limestone abundant in western part of the map-area.
		Conformable contact	
		Reno formation	Argillaceous quartzite, schist, argillite
		Conformable contact	
		Quartzite Range formation	White, some green and pinkish quartzite; minor argillaceous quartzite
	Conformable contact		

Proterozoic (?)	Windermere (?)	Three Sisters formation	Green grit, quartzite, and conglomerate
		Conformable contact	
Proterozoic	Windermere	Monk formation	Green argillite, phyllite, argillaceous schist; minor limestone; basal conglomerate
		Unconformable(?) contact	
		Irene Volcanic formation	Greenstone; minor interbedded argillite and limestone
		Gradational contact	
		Toby formation	Conglomerate; minor interbedded argillite at the top

SEDIMENTARY AND VOLCANIC ROCKS

WINDERMERE

The Windermere 'series' was defined by Walker (19, pp. 13-20). In the type area it consists of two formations, the Toby conglomerate and the Horsethief, which overlie unconformably the Purcell 'series' and are overlain unconformably by Upper Cambrian strata. In several localities to the south of the Windermere map-area, the Windermere system is succeeded unconformably by Lower Cambrian strata. Its two formations were traced southward to the International Boundary by Rice (17), who found that the upper part of the upper formation, which he renamed Horsethief Creek series, grades laterally into the coarse clastic rocks of the Three Sisters formation of Salmo map-area.

The present writer has, therefore, placed the Toby, the Irene Volcanic, and the Monk formations in the Windermere system, and regards the Three Sisters formation as probably belonging to the same system and, therefore, also of Precambrian age.

Toby Formation

The Toby formation was first described by Daly (4, pp. 141-144) who named it the Ireno conglomerate. In 1926, Walker (19, pp. 13-14) described a similar conglomerate in the Windermere map-area to which he applied the name Toby conglomerate. This formation was traced southward to the International Boundary by Rice (17, pp. 14-15). Although the name Irene conglomerate has priority over others, the name Toby has become more widely accepted, and in order to avoid confusion with the overlying volcanic formation, the writer refers to the conglomerate as the Toby formation.

The Toby formation has been fully described by the above authors and by Park and Cannon (16, pp. 7-9) under the name Shedroof conglomerate.

The thickness of the formation where it crosses the International Boundary is estimated to be about 5,000 feet, but only the upper few hundred feet are exposed in the southeast corner of the map-area, where it was examined by the writer. At this locality, the roundstones vary in size from 1/8 inch to 10 inches or more in diameter. They consist mainly of white quartzite, but buff weathering dolomite containing chert bands is also common. The roundstones of dolomite are more angular than those of quartzite, possibly due to their relative incompetence under stress. In some places the roundstones are very abundant, but elsewhere they may be relatively scarce, and in one zone about 100 feet thick near the top of the formation they are entirely lacking.

The matrix of the Toby formation consists of fine-grained,

green, argillaceous schist, in which the schistosity is nearly parallel with the contacts between conglomerate and interbedded schist.

The Toby formation is said (17, p. 24) to rest unconformably upon the Mount Nelson formation, which is the uppermost formation of the Purcell system. The top of the Toby is interbedded with basal strata of the Irene Volcanic formation, so that it is transitional into the latter. The contact has been drawn by the writer at the top of the uppermost band of conglomerate.

Irene Volcanic Formation

The Irene Volcanic formation is exposed only in the southeast corner of the area. It was named and described by Daly (4, pp. 144-147). The later work of Rice (17, pp. 15-17) and Park and Cannon (16, pp. 9-11) has borne out Daly's observations. The present writer also agrees that the basal strata are interbedded with the Toby formation. Near the base of the formation is a volcanic agglomerate in which both matrix and fragments are of greenstone. Near the middle of the formation a band of black limestone more than 30 feet thick was observed. Except for these two members, all parts of the formation examined by the writer are of schistose greenstone, but only the lower part is well exposed within the map-area.

The thickness of approximately 6,000 feet for the Irene Volcanic formation at the International Boundary, as recorded by Daly, appears to be correct.

Monk Formation

The Monk formation overlies the Irene Volcanic formation, and is likewise exposed only in the southeast corner of the area. It was first named and described by Daly (4, pp. 147-150) who

estimated its thickness to be greater than 5,500 feet. Walker (20, pp. 6-7) reduced the minimum thickness to less than 4,200 feet, owing to folding, which is indicated on the map accompanying his memoir. Walker renamed the formation the Horsethief Creek series owing to its lithological similarity to the Horsethief formation of the Windermere area. Rice (17, pp. 17-18), however, has shown that the Horsethief Creek series of the Salmo area is not equivalent to that of the Windermere area, where it also embraces beds that are stratigraphically equivalent to those of the overlying Three Sisters formation. For this reason, and that of priority, the writer has retained the name Monk formation, originated by Daly.

The Monk formation has been described by Walker (20, p. 7) as "a heterogeneous assemblage of sheared and schistose, argillaceous rocks with some beds of limestone and grit, with at the base a well-defined bed of boulder conglomerate, and bounded at the top by the massive grits of the overlying Three Sisters formation".

The soft, argillaceous rocks of the Monk formation are in general poorly exposed on both sides of the International Boundary. Park and Cannon (16, p. 11) for this reason have been unable to present a complete section of the Monk formation. They believe that the Monk, as described by themselves, and the Horsethief Creek series of Walker exclude the upper part of the type Monk formation of Daly. The writer, however, is inclined to regard the Horsethief Creek series of Walker as essentially the same as Daly's Monk formation.

The base of the Monk formation is marked by a continuous band of conglomerate resting upon the Irene Volcanic formation. The roundstones are largely of pisolitic magnesian limestone up to 6 inches or more in diameter. Many of the pisolites closely

resemble fusulina on the weathered surface, but an examination in thin section by R. T. D. Wickenden of the Geological Survey of Canada revealed no organic structures. Most roundstones are of greenstone; dark quartzite and argillaceous schist were also observed. The matrix consists of light brown, rusty weathering, argillaceous schist, which has a pitted surface.

Above this conglomerate the Monk formation is very poorly exposed where it was examined by the writer. All outcrops consist of fine-grained, dark green to brown, argillaceous schist except near the top where two narrow bands of coarse green grit and one of pebble-conglomerate were observed. A band of crystalline limestone near the base was traced for some distance south of Monk Creek by Walker. The top of the Monk formation is sharply defined where the fine argillaceous schists give way to thick beds of coarse green grit containing a few thin beds of fine pebble-conglomerate.

WINDERMERE (?)

Three Sisters Formation

The Three Sisters formation, which overlies conformably the Monk formation, was named and described by Walker (20, pp. 7-8). The best exposures are along the monocline in the southeast part of the area, but it also forms the core of the Sheep Creek anticline. The thickness of the Three Sisters formation is less persistent than Walker believed, particularly south of the International Boundary. Owing to folding and the intrusion elsewhere of granitic stocks, the only reliable measurements of the lower part of the formation can be made in the southern part of the map-area. The upper part has been measured in several localities. The following is a composite section of the entire formation:

	Thickness Feet
Green grits and quartzite.....	390-1,230
Conglomerate	34-250
Green grits, many crossbedded; minor quartzite, shale, and pebble-conglomerate	3,800-4,600
Total thickness	4,224-6,080

The greatest thickness of all members is near the International Boundary, with a general thinning toward the north. In the south, the roundstones in the conglomerate are the largest, many exceeding 18 inches in diameter. In the northern part of Salmo map-area, few roundstones exceed 3 inches. They consist of green grit, white and pink quartzite, and vein quartz in decreasing order of abundance. All are well rounded but are elongated along the strike of the formation.

Where the Three Sisters formation is exposed in the centre of the Sheep Creek anticline, it consists of green quartzite and grit; no conglomerate was observed. The maximum thickness of the formation exposed in this locality is about 500 feet.

The Three Sisters formation is underlain conformably by the Monk formation, and is overlain conformably by the Quartzite Range formation of Lower Cambrian age.

THE PRECAMBRIAN-CAMBRIAN BOUNDARY

The base of the Cambrian system cannot yet be accurately defined in the Salmo map-area. At the base of the Laib group is a continuous band of limestone about 200 feet thick, which contains abundant pleosponges. Collections of these were examined by Okulitch (personal communication), who states: "their similarity to the Donald fauna is rather strong. I have no doubt that the collection is indicative of the Lower Cambrian, most likely is equivalent to the Donald, and, therefore, the Olenellus zone ....."

Poorly preserved trilobite fragments of Cambrian age were collected by Park and Cannon (16, p. 15) from talus at an horizon that appears to lie several hundred feet stratigraphically below the pleosponge beds. Thus the upper part, at least, of the Quartzite Range formation is definitely of Lower Cambrian age. No evidence of an unconformity has been observed below this lowest fossil occurrence to the base of the Monk formation. For this reason Park and Cannon have placed the base of the Cambrian provisionally "at the hiatus below the Monk formation". The main objection to this suggestion is the fact that the base of the Cambrian at this locality would be 12,000 to 14,500 feet below the pleosponge beds.

In the Dogtooth Mountains of British Columbia (7, p. 118), in the Ptarmigan Peak section (5, p. 11), and in Field map-area (1, pp. 60-66) the transition from Precambrian to Cambrian is marked by a change in lithology from fine, impure, argillaceous to coarse, arenaceous, clastic rocks. If this criterion be applied to the sedimentary rocks of Salmo map-area, the Precambrian-Cambrian boundary would be placed at the base of the Three Sisters formation. Two objections to this are apparent: first, the base of the Cambrian would still be 8,000 to 10,000 feet below the pleosponge beds, and second, as has been mentioned previously, the Three Sisters formation grades laterally northward into the finer clastic rocks of the Horsethief Creek series (as delineated by Rice). Thus the base of the Cambrian would transgress the strata of the Horsethief Creek series, and would, therefore, be placed stratigraphically higher and higher to the north.

For the above reasons, therefore, and because the base of the Quartzite Range formation is a distinctive and extensive horizon, it has been chosen tentatively as the Precambrian-Cambrian boundary.

CAMBRIAN

Quartzite Range Formation

The Quartzite Range formation was defined by Walker (20, p. 8). It is best exposed along the monocline that occupies the eastern part of Salmo map-area, where it consists of the following members:

	Thickness Feet
White, grey, or pinkish, and in places green, massive, locally platy quartzite; abundant crossbedding and some ripple-marks	1,500
Massive, white quartzite	1,100
Argillaceous quartzite and schist	200
White, green, or pinkish, massive, crossbedded quartzite	1,600
Total thickness	4,400

In the Sheep Creek anticline, the Quartzite Range formation is much thinner; its thickness, however, varies considerably in adjacent limbs of the anticline. A generalized section in this locality is given by McGuire (11, pp. 173-175).

	Thickness Feet
White and grey, massive and platy quartzite; minor argillaceous quartzite	800-900
Argillaceous quartzite and argillite	200-300
Massive, white quartzite	500-600
Total thickness	1,500-1,800

Like the Three Sisters formation, the Quartzite Range formation in the eastern part of the map-area consists of thick, massive beds in which crossbeds are conspicuous. To the west

the beds are relatively thin and platy, and show few crossbeds, and the overall thickness is much less. This indicates that the sediments composing the Three Sisters and Quartzite Range formations were derived from the region to the east or southeast of Salmo map-area.

The Quartzite Range formation is underlain conformably by the Three Sisters formation. The top is marked by a change from white quartzite to the argillaceous quartzite of the Reno formation.

The age of the Quartzite Range formation is presumed to be Lower Cambrian, as trilobite fragments were found by Park and Cannon near the top of the formation, and as it lies below the pleosponge beds.

Reno Formation

The Reno formation overlies conformably the Quartzite Range formation. It is widely distributed in Salmo map-area, where it is found in the eastern monocline, on the limbs of the Sheep Creek anticline, and in a broad belt extending from near the mouth of Sheep Creek southwestward across Pend d'Oreille River.

The formation was defined by Walker (20, pp. 9-10) from the type locality on Reno Mountain. It has been redefined by the present writer to include only those members lying between the white quartzite of the Quartzite Range formation and the limestone band that marks the base of the Laib group.

In the type locality the apparent thickness of the Reno formation is about 1,000 feet, but this is several times greater than the true thickness owing to multiple repetition of the strata by folding (Mathews, personal communication).

Farther east, where it is exposed along the eastern monocline, the formation thickens materially, and consists mainly

of argillaceous quartzite, with some schistose argillite. Its total thickness near the International Boundary is about 1,100 feet, but this decreases to the north, and just beyond the north edge of the map-area a measured section totalled only 739 feet.

Immediately east of Salmo River is a thick assemblage of tightly folded sedimentary rocks consisting of schist, white quartzite, argillaceous quartzite, and, at the top, argillite. At this locality the base of the Reno formation has not been recognized, nor has the thickness of the assemblage been established, owing to the complexity of the structure. It would seem, however, that at least,3,000 or 4,000 feet of sedimentary rocks are exposed, and that these include strata equivalent in age to those of the Quartzite Range formation. The same is probably true of the extension of these rocks, which form an anticline to the southwest in the vicinity of Pend d'Oreille River. Here they have been examined in detail by Okulitch (13), who described them as follows:

"The formation consists essentially of green chloritic schists, silvery grey sericite schists, and paragneiss. In places, especially near the top of the formation, black micaceous and argillaceous phyllite is encountered. Interbedded with the schists and phyllites are bands of quartzite, and serpentinized limestone occurs close to the middle of the formation. Bands of actinolite schist or gneiss occur near the mouth of Salmo River. They probably represent metamorphosed basic sills or flows.

"The indicated thickness of the formation as measured along Pend d'Oreille River is about 5,500 feet. However, the formation may be considerably thinner, as drag-folding, repetition of the beds due to faulting, and possible thickening due to flowage may increase the true thickness."

This assemblage of rocks mostly closely resembles the Maitlen

phyllite of the Metaline quadrangle, and Okulitch expressed the opinion that they are wholly or in part equivalent to one another. This conception, however, is incompatible with the structure of the region, and the present writer regards these rocks, like those to the northeast, as equivalent in age, or nearly so, to the Rono and Quartzite Range formations. In support of this conjecture is the fact that similar westward lateral gradation of the Reno formation was observed in Ymir map-area.

Laib Group

The Laib group is named by the writer from Laib Creek north of Salmo map-area. It is defined as the thick assemblage of argillaceous quartzites, argillaceous schist, phyllite, and minor limestone that is bounded at the base by the lowest extensive band of limestone above the Rono formation, and at the top by the limy argillite and limestone that mark the base of the Nelway formation. It is almost equivalent to the Maitlen phyllite of the Metaline quadrangle (16), but excludes the basal quartzite member of that formation.

The Laib group is widely distributed in Salmo map-area, where it occupies the centres of the synclines on either side of the Sheep Creek anticline, and also the limbs of the plunging anticline that crosses Pend d'Oreille River.

No complete section of the Laib group has been found in Salmo map-area. Near the International Boundary, south of the South Fork of Salmo River, the lower part of the group, above the limestone band, consists largely of argillaceous quartzite with intercalated schist. At stratigraphically higher horizons, schist, which is locally calcareous, predominates over quartzite. In the Metaline quadrange (16, p. 15) the minimum thickness of the Maitlen phyllite, which is roughly equivalent to the Laib group, is estimated to be about 5,000 feet. Just beyond the north edge of Salmo map-area,

a section of the Laib group totalling 3,032 feet was measured. The lower members consist largely of quartzite, whereas the upper members are mainly schistose, arenaceous argillite, with a little limestone.

West of the Sheep Creek anticline, limestone is much more abundant at the base of the Laib group. On Reno Mountain there are at least two bands of limestone, and at the H.B. mine farther west the limestone has attained an apparent thickness of 3,200 feet. The overlying strata that occupy the synclinorium between the H.B. mine and Reno Mountain consist of argillaceous quartzite and slaty argillite.

These rocks can be traced southward to the South Fork of Salmo River, beyond which a rapid lithological change in the upper members takes place. The lower part consists mainly of limestone, and the upper part consists of carbonaceous slaty argillite and black limestone. These two parts of the Laib group form such distinctive lithological units in the vicinity of Pend d'Oreille River that Okulitch (13) regarded them as two formations. A section of the lower of these was measured by him near Reeves-Macdonald mine, and consists, from top to bottom, of the following:

	Thickness Feet
Grey and black limestone, in part siliceous, thin bedded	300
Phyllite and black micaceous and graphitic slates	75
Thin-bedded, platy, magnesian (?), buff to grey limestone	500
Grey to black, calcareous phyllite and black and rusty slate, variable in thickness	500
Grey, massive and banded limestone and dolomite, in beds $\frac{1}{2}$ to 1 inch (main Reeves-Macdonald limestone)	850

White to buff, platy quartzite and phyllite	1,000
Thin-bedded, grey limestone	300
Total thickness..	3,225

Of the upper formation, Okulitch gives the following description:

"The formation consists of black and dark grey slates, dark phyllites, and some thin bands of black limestone. This assemblage of rocks was very weak structurally and was intensely folded and cut by strike faults of undetermined displacement. Its true thickness is, therefore, impossible to determine. Estimates made in different parts of the area vary from 1,500 to 3,400 feet. It is likely that the lower figure is more nearly correct. The formation is more argillaceous in its lower part and becomes more calcareous in its upper portion."

Okulitch regarded the two formations as probably in part correlative with the lower part of the Metaline formation, which they most closely resemble. In view of their great thickness, and the fact that they appear to grade laterally into the Laib group, the present writer prefers to regard them as older than the Metaline formation and, therefore, of Lower Cambrian age. Without the aid of fossils, however, no exact correlation can be made, and a thorough search of these formations by Okulitch in the vicinity of Pend d'Oreille River failed to discover any definite fossils.

In 1948, the writer collected pleosponges in the eastern part of the map-area from the 200-foot band of limestone at the base of the Laib group, from a point 1,000 feet south of the International Boundary to a point nearly 5 miles to the north. Further collections were made in 1949 by Okulitch from the southern part of this band. He states (15) that the following species have been identified:

"Ajacicyathus osilinka Okulitch and Roots
A. nevadensis Okulitch
A. purcellensis Okulitch
A. undulatus Okulitch
A. sp.
Archaeocyathus atlanticus Billings
Archaeocyathellus sp.
Coscinocyathus cf. miniporosus Bedford
Coscinocyathus dentocanis Okulitch
C. sp.
Cambrocyathus amourensis Okulitch
Cambrocyathus cf. donaldi Okulitch
Cambrocyathus columbianus Okulitch
Cambrocyathus sp.
Copleicyathus laminosis Okulitch
Ethmophyllum whitneyi Meek
Ethmophyllum americanum Okulitch
Ethmophyllum sp.
Eucyathus cf. obliquus Okulitch
Paracoscinus sp.
Protopharetra sp.

"....the pleosponges are of Lower Cambrian age."

No fossils other than worm burrows have been found between this horizon and that from which fossils of Middle Cambrian age have been collected, nearly 6,000 feet above. The boundary between the Lower and Middle Cambrian has, therefore, been drawn arbitrarily at the top of the Laib group.

Because of the similarity of fauna, Okulitch correlates the pleosponge beds of the Laib group with the Donald formation of the Brisco-Dogtooth area of British Columbia, and the Old Dominion limestone of Stevens county, Washington.

Nelway Formation

The Nelway formation, which is named from Nelway in the south part of the map-area, is not widely distributed in Salmo map-area, being confined to a narrow belt extending from Stagleap Creek to Pend d'Oreille River except for a small area north of the river near the western edge of the map-area. It may be correlated with the 'Metaline limestone' of the Metaline quadrangle, Washington, which has been examined in detail, and, near Metaline Falls, provides

the following section measured by Park and Cannon (16, p. 18):

	Thickness Feet
Mottled dense grey limestone; few chert nodules	150
Mottled dense grey limestone; many chert nodules	450
Fine-grained, cream-coloured dolomite, particularly in upper part; alternating layers of black and white dolomite	1,200
Interbedded limestones and limy shales; locally dolomitic	1,200
Total thickness	3,000

In Salmo map-area the lower part of the Nelway formation is best exposed on the South Fork of Salmo River west of Stagleap Creek, and in the vicinity of Nelway. It is missing along Pend d'Oreille River, where the middle dolomite member is in fault contact with the upper part of the Laib group. The middle member, consisting largely of cream weathering dolomite, is the most widely distributed. The uppermost, 150-foot limestone member of the 'Metaline limestone' has not been recognized north of the International Boundary, but the down-faulted block of Nelway formation lying between Pend d'Oreille River and the Beaver Mountain volcanic rocks is regarded by Okulitch as consisting mainly of the 450-foot member of the 'Metaline limestone'.

The base of the Nelway formation is gradational into the underlying Laib group, and has been placed by Park and Cannon (16, p. 16) where limestone predominates over phyllite. For want of a better horizon marker, the present writer concurs in this definition. The top of the formation has been seen only in the Metaline quadrangle where it is sharply defined against the overlying Ordovician slates. No angular discordance has been observed, although

it seems probable, in view of the fact that Upper Cambrian strata are missing, that a disconformity exists.

The age of the Metaline formation, as determined from two collections of fossils made by Park and Cannon (16, p. 19) near Metaline Falls, Washington, was given as Middle Cambrian, and approximately equivalent to that of the Stephen formation of Field map-area, British Columbia. Howell (8, p. 1169) subsequently stated that the fauna was older than the Ogygopsis fauna of the Stephen formation, and correlated it with the Lakeview of Idaho, and Damnation and Pagoda formations of Montana, and with the lower part only of the Stephen formation.

In 1947, Okulitch collected fossils from the same locality across a vertical range of several hundred feet, and the following species were identified (13):

Brachiopods

Acrothele sp.

Trilobites

Elrathina cordillerae (Rominger)
E. fecunda Deiss
E. hybrida Deiss
E. erecta Deiss
E. oculineata (?) Deiss
E. lickensis Deiss
E. convexa Deiss
E. sp.
Elrathiella unisulcata Deiss
Elrathiella sp.
Ehmania sp.
Ogygopsis klotzi Rominger
Bathyuriscus formosus Deiss
Taxioura (?) sp.
Olenoides cf. *serratus* (Rominger)
Kootenia rugosa Deiss
K. subequalis Deiss
Pachyaspis typicalis Resser
Zachanthoides romingeri Resser

Two years later, Okulitch (15) revisited the fossil locality, and concerning it says: "the trilobites occur in two zones in the middle Metaline formation. The lower zone consists of thin-bedded shaly limestone, well exposed in lower Metaline Falls quarry. The dominant forms in this zone are Elrathia, Elrathiella, and Elrathina. This faunal zone is very similar to the Pagoda limestone described by Deiss in Montana. Some 200 feet above this zone, in the upper operating quarry, in dark blue to black limestone, is the second trilobite zone containing Ogygopsis, Neolenus, and Elrathia. This zone is similar in contents to the Stephen formation of British Columbia".

Two very poorly preserved trilobite pygidia, reported by Okulitch, and a fragment of Conulites are the only fossils known to have been found in the Nelway formation of Salmo map-area.

ORDOVICIAN

Active Formation

The Active formation is named from Active Creek in the north part of Salmo map-area. It is found in two, small, isolated localities within the map-area. The smaller of these crosses the International Boundary and the South Fork of Salmo River near the mouth of Stagleap Creek and forms a wedge-shaped fault block bounded on the west by strata of the Nelway formation and on the east by the upper part of the Laib group. It consists mainly of slate, in part arenaceous, and near the centre of the block is a wide band of white quartzite that may be the extension of a black quartzite band seen near Bunker Hill mine to the south (16, pp. 20, 63). The maximum thickness exposed is not more than 2,000 feet. No fossils were discovered in those parts within Salmo map-area, but the extension of these rocks south of the International Boundary

yielded graptolites (16, p. 21).

The larger area of Ordovician rocks is exposed at the north edge of the map-area, along Active Creek. There the base of the Active formation is not exposed, and the lowest members consist of three bands of grey crystalline limestone, each about 100 feet thick, separated by slaty argillite more than 100 feet thick. One of these limestone bands has been traced almost continuously around the southern periphery of the granite stock.

Above the limestone bands the formation consists largely of slate, which becomes more arenaceous near the top of the formation where bands of argillaceous quartzite appear.

It is impossible to obtain an accurate measurement of the thickness of the Active formation. The apparent thickness varies greatly to a maximum of 4,500 feet, but thickening by flowage and folding may have taken place. Park and Cannon (16, p. 20) have given a figure of 2,500 feet for the maximum thickness of the corresponding 'Ledbetter slate', and it seems probable that the Active formation is at least as thick.

In 1947, the writer (9) collected what appeared to be a poorly preserved gastropod from the slate talus east of Active Creek, 200 yards north of the north edge of Salmo map-area, at an elevation of 4,000 feet. A tentative examination of the fossil was made in the field by Okulitch, who expressed the opinion that it might be Hormotoma or a similar gastropod of probably Trenton (Middle Ordovician) age.

In view of the importance of obtaining more information the writer revisited the locality in 1949, accompanied by Dr. Okulitch, and a number of specimens of graptolites were collected. The following report was made upon this collection by Dr. Alice E. Wilson:

"Tetragraptus ? sp.
Didymograptus sp. A near D. hirundo occidentalis Ruedemann
D. sp. B.
Dicranograptus sp.
Climacograptus ? sp.

"The graptolites are not well enough preserved for specific determination, but the genera appear to correspond more to those of the upper horizon of the Ledbetter beds. It may also be significant that the better preserved species of Didymograptus resembles a Glenogle form."

From the above information, the Active formation is presumed, in part at least, to be representative of early Middle Ordovician time.

ORDOVICIAN(?) AND LATER

Seeman Group

The Seeman group is named from Seeman Creek north of Salmo map-area. It is exposed in the upper part of Hidden Creek Valley, and along the south slope of Porcupine Creek, which flows westward beyond the north border of Salmo map-area.

No accurate measurement of the thickness of the Seeman group is possible, but it appears to be about 5,000 feet thick. Near the base, white quartzite and limestone predominate, but at higher horizons schist and argillite become more abundant.

The contact between the underlying Active formation and the Seeman group is exposed along the ridge separating Active and Hidden Creeks. Here the slaty argillite and argillaceous quartzite of the upper part of the Active formation grade over a short distance into white quartzite, crystalline limestone, and schist of the Seeman group. The base of the group is defined as the base of a calcareous argillaceous quartzite of distinctive appearance. Owing

to leaching of the calcareous material, thin lenticular lamina stand out on the weathered surface. This horizon marker was traced from near the Hidden Creek granite stock eastward to beyond the small lake at the head of Active Creek.

The top of the Seeman group is exposed only in the valley of Porcupine Creek. Here, white quartzite and schist of the Seeman group grade into argillaceous quartzite and argillite of the overlying Ymir group.

The age of the Seeman group is not known. It overlies the Active formation of Ordovician age and underlies the Ymir group, which, for reasons to be presented later, is presumed to be of, or mainly of, Triassic age. Evidence of post-Ordovician sedimentation is found in the Metaline quadrangle, where fossiliferous limestone at least 700 feet thick yielded fossils of Devonian or Lower Mississippian age.

TRIASSIC AND(?) EARLIER

Ymir Group

The Ymir group derives its name from the town of Ymir, and only a small part of Salmo map-area along Salmo River is underlain by it. The group consists of a thick assemblage of slaty argillite and argillaceous quartzite within the map-area, but limestone bands appear farther north in the northern extension of this belt of rocks, near Nelson. In the Ymir area, the maximum apparent thickness of the group is about 7,000 feet, becoming thicker toward the north, but it is probable that isoclinal folding has repeated some of the beds.

The Ymir group is underlain conformably by white quartzite and schist of the Seeman group, and this contact is gradational.

The upper limit of the Ymir group is sharply defined where argillite gives way to thick flows and agglomerates of the Elise formation. This contact was observed in only one locality in Salmo map-area, near Salmo River. The exposures there are not good, and the relationship between the Ymir group and the Elise is not clear. To the north, however, excellent exposures are seen northeast of Ymir, and indicate that the basal flows of the Elise formation overlie the Ymir group with no angular discordance.

The age of the Ymir group is not known as no recognizable fossils have been found in it. The group has been traced northeastward to the 117th meridian, where it appears to link with the lithologically similar Slocan 'series', which has been traced southward from the Slocan area by Rice (17, Map 603A). The Ymir group, then is regarded as equivalent at least in part to the Slocan 'series', which is probably of Triassic age (2, pp. 60-61).

TRIASSIC(?)

Elise Formation

The 'Rossland volcanic group' as defined by McConnell and Brock (1904) consists of three formations. To the oldest of these the writer applies the name Elise formation, because it is well exposed on the western slopes of Elise Mountain in Ymir map-area.

In Salmo map-area, rocks of the Elise formation do not appear to be as widely distributed as was formerly thought, and only a few, relatively small, isolated areas underlain by these rocks were discovered.

The Elise formation consists of andesite and latite flows, and agglomerate, the latter being more abundant in the lower part of the formation. Bands of tuffaceous argillite up to 200 feet in thickness have been observed. Irregular bodies of

augite porphyry are common, being more numerous near the top of the formation. The minimum apparent thickness of the formation is about 9,000 feet.

The Elise formation is underlain conformably by the Ymir group and overlain conformably by strata of the Hall group. The age is, therefore, probably Triassic, but may in part be Lower Jurassic.

JURASSIC AND (?) CRETACEOUS

Hall Group

The Hall 'series' was defined by Drysdale (6, pp. 27-29) from Hall Creek in the Ymir area, where he estimated the thickness to be 7,000 feet. It is quite widely distributed in the northeast part of Salmo map-area. It consists of argillite, sandstone, and conglomerate, with minor interbedded flows, and bands of pyroclastic rocks, particularly in the upper part. Drysdale inferred that these sedimentary rocks are of continental origin, but although they have yielded plant fragments, marine fossils are present. It is probable that the sediments were laid down under near-shore conditions.

In 1948, a collection of fossils from the Hall group was made on the ridge south of Porto Rico Creek, to the north of Salmo map-area. An examination of this collection was made by H. Frebold of the Geological Survey, who makes the following statement concerning them:

> "Ammonites sp. indet. 1
> This ammonite is possibly a Stephanoceras.
> Ammonites sp. indet. 2
> Imprint of a whorl fragment with finer undivided ribs and keel. May be comparable to some Dumortieria forms from the Upper Lias.
> Age: Lower part of Middle Jurassic possible for Ammonite sp. indet. 1; upper part of Lower Jurassic possible for Ammonite sp. indet. 2. No exact determination can be made. Possibly the boundary between Lower and Middle Jurassic is represented at this locality".

In 1949, several collections from Salmo map-area were also reported on by Dr. Frebold:

"Fl 49A. West side of Archibald Creek between first and second tributaries.
Elev. 3,700'.
Ammonites sp. indet. 1
The form is similar to Arietites from the Lower Lias, but the type of the ribs (occasional presence of divided ribs) speaks more for Dumortieria from the Upper Lias. Unfortunately the state of preservation is so poor that an exact determination cannot be made.
Ammonites sp. indet. 2
Very poor and weak imprint of a smaller ammonite, very different from Ammonite sp. indet. 1, both in general shape and in the kind of ribs; apparently narrow umbilicus, higher whorls, very fine ribs. A keel is present, but it is not clear whether this keel lies between furrows or not. The form may belong to a fine ribbed type of the family Harpoceratidae from the Upper Lias, but an exact determination is impossible.
Ammonites sp. indet. 3
Weak and poor imprints of small ammonites. Perhaps young specimens of Ammonites sp. indet. 1
Age: Upper Lias?
"Fl 49B. West side of Archibald Creek between first and second tributaries.
Elev. 3,950'.
Ammonites sp. indet.
Weak and badly preserved imprints of ammonites, mostly similar to Ammonites sp. indet. 1 of Fl 49A (mentioned above).
Age: Upper Lias?
"Fl 49C. West side of Archibald Creek between first and second tributaries.
Elev. 4,000'.
Ammonites sp. indet.
Poor imprints of indeterminable ammonites, one of them showing similarities to Ammonites sp. indet. 1 of Fl 49A and A. sp. indet of Fl 49B.
Age: Upper Lias?
"Fl 49D. West side of Archibald Creek between first and second tributaries.
Elev. 4,100'.
Ammonites sp. indet. 1
Badly preserved. In shape and in the type of the ribs similar to Ammonite sp. indet. from Fl 49A and related forms from Fl 49B and C. May be same species.
Ammonites sp. indet. 2
Some very badly preserved indeterminable fragments of ammonites. One of them has apparently divided ribs, the other one shows a rib intercalated between two undivided ribs.
Age: Uper Lias?
F6 49. East side of Beaver Creek about 2 miles northeast of Fruitvale, west of Salmo map-area.
Elev. 2,700'.
Ammonites sp. indet.
Age: Indeterminable. May be Lias.
F10 49. East side of Archibald Creek, Salmo map-area.
Elev. 3,950'.

Imprints of small indeterminable ammonites.
Age: Indeterminable.

A plant fragment was collected about three-quarters of a mile northeast of Parks. W.A. Bell submitted the following report:

"This is a small fragment of a cycadooid, either a Pterophyllum or a Ptilophyllum. It certainly denotes a Mesozoic age and resembles species found in the Lower Cretaceous or Upper Jurassic".

From the top of the same ridge, about 7,200 feet at N.5°E. from Parks, two collections of marine fossils were made in 1949 by R. Mulligan and examined by Dr. Frebold:

"Cat. No. 17240
Ammonites sp. indet.
Badly preserved imprint of a whorl (Jurassic or Cretaceous form).
Many badly preserved pelecypods, among others Lima sp., Pecten sp., Pleuromya sp.
Corals
Age: Jurassic or Cretaceous
Cat. No. 17237
Belemnites sp. indet. (Jurassic or Cretaceous form).
Many badly preserved pelecypods, apparently same fauna as in No. 17240.
Corals
Age: Jurassic or Cretaceous".

From the above information, it can be tentatively inferred that the middle part of the Hall group, containing the ammonoids, is of Jurassic, possibly of late Lower and early Middle Jurassic, age. The exact age of the upper part, containing the pelecypods and a plant fragment, is uncertain, but may be Jurassic or Cretaceous.

JURASSIC OR CRETACEOUS

Beaver Mountain Formation

The Beaver Mountain formation was first described by McConnell and Brock (1904) as the Beaver Mountain volcanic group. Brock noted the fresher appearance of these rocks on Beaver (Kelly) Mountain in comparison with those of his 'Rossland Volcanic group', and concluded that they were younger. This feature was observed independently

by Daly (4, pp. 352-354), who included in the group sedimentary rocks of the 'Hall group'. The present writer refers to the volcanic rocks as the Beaver Mountain formation.

As Brock and Daly suspected, the Beaver Mountain formation is more extensive than as shown on their maps. Indeed, most of the volcanic rocks in Salmo map-area belong to this formation. In general they bear a close resemblance to the rocks of the Elise formation, and it is only when the fossiliferous sedimentary rocks of the Hall group are delineated that the volcanic rocks can be placed in their proper stratigraphic position with confidence. The term 'Rossland Volcanic group' might be retained for these rocks where such distinction cannot be made.

The Beaver Mountain formation consists of andesite and latite flows, agglomerate, augite porphyry, breccia, and tuff. Interbedded argillite, bearing plant remains, occurs in the upper part of the formation. The total thickness cannot be accurately measured, but must be several thousand feet.

The base of the formation has been placed at the top of the highest band of argillite of the underlying Hall group. The top of the formation has not been observed.

The age of the Beaver Mountain formation is not known with accuracy. A few obscure, longitudinally ribbed or striated stems were collected on the crest of the ridge west of Kelly Mountain, but are of no value for age determination. The formation overlies with conformity the Hall group, of which the upper part is believed to be of Jurassic or, possibly, Cretaceous age. The Beaver Mountain formation is, therefore, probably of Jurassic or Cretaceous age. It is, however, unlikely that it is of Upper Cretaceous age, because there exists a few miles to the west a conglomerate that rests with

great angular discordance upon the 'Rossland Volcanic group', and which yielded plant fragments of probable Upper Cretaceous age (W. A. Bell, personal communication).

Tertiary(?)

Conglomerate of possible Tertiary age was observed on the west side of Stagleap Creek, one-half mile from the mouth, at an elevation of 3,140 feet. About 10 feet of the conglomerate is exposed. The roundstones, which are up to 6 inches in diameter, consist of quartzite, black argillite, and fine-grained granite, and are moderately well rounded, but not well sorted. The matrix consists of a hard, limy cement. The conglomerate rests unconformably upon dolomite of the Nelway formation, with a northerly strike and a dip of 20 degrees east, and probably represents an erosion remnant of more extensive deposits formed in the valley.

INTRUSIVE ROCKS

NELSON INTRUSIONS

The Nelson intrusions consist of granite (mainly porphyritic), granodiorite, quartz diorite, syenite, and monzonite, together with numerous, related aplite and lamprophyre dykes. The similarity in the appearance of these rocks suggest consanguinity, and for want of evidence to the contrary the writer has followed Walker in relating them all to the Nelson batholith.

The Nelson intrusions have been fully described by Walker (20, pp. 13-18) and the writer has little to add to his descriptions. The intrusions cut the Beaver Mountain and all older formations, so that they are of post Lower Jurassic age. An accurate upper limit to the age has not been established, but in the Rossland area to the west conglomerate of probable Upper Cretaceous age rests with a large angular unconformity on the 'Rossland Volcanic group', and it

is probable that the Nelson intrusions were emplaced during the orogeny that preceded Upper Cretaceous sedimentation.

SHEPPARD INTRUSIONS

Along Pend d'Oreille River, near the west edge of the map-area, are two small stocks of medium-grained, rusty weathering, leucocratic granite. This granite closely resembles the Sheppard granite farther west in the Rossland area, where it intrudes conglomerate resembling that of Sophie Mountain, from which plant remains of probably Upper Cretaceous, or possibly Tertiary, age were collected. The age of the Sheppard intrusions is, therefore, probably Tertiary.

STRUCTURE

FAULTS

The largest fault in Salmo map-area is one of great complexity. It crosses the map-area from southwest to northeast, but changes strike along its course. Where it enters the map-area on the west, about a mile north of Pend d'Oreille River, it strikes about east. Thence it swings northeast and is obscured by a large granite stock, but appears again west of Salmo River, near the mouth of Sheep Creek. What is believed to be a continuation of the same fault truncates the folded rocks of the Sheep Creek camp on the north and then strikes north into Ymir map-area, where it can be traced for many miles.

Along this fault the vertical displacement is great, as the Beaver Mountain formation is brought into contact with strata of Lower Cambrian age in the southwest part of Salmo map-area. Wherever this contact has been observed, particularly west of the map-area in the lower reaches of Pend d'Oreille River, the rocks are highly sheared. This contact has long been regarded as unconformable, but support

for the writer's view that it is a fault is derived from the fact that no evidence of a structural unconformity in strata ranging in age from Late Precambrian to Jurassic has been observed in Ymir map-area a few miles to the north. This fault dips steeply at all points examined, and the rocks on its northwest side have moved downward relative to those to the southeast. The fault displaces all rocks of Beaver Mountain age or older, but is pre-batholithic in age, and appears to control to some degree the shape of some of the intrusive bodies along it, particularly in Ymir map-area.

The second most prominent fault in the map-area is the Ripple Creek fault, first observed by Daly (4, Sheet 7), and independently noted by Calkins and MacDonald (3). Walker confirmed the presence of this fault, but Park and Cannon (16, pp. 33-34) expressed doubt concerning its existence. The present writer, however, agrees with the earlier writers. It is a tear fault, as it was formed at the time of folding. The stress that developed it was concentrated largely to the north of the fault in an easterly direction, and resulted in overturned isoclinal folds on that side and comparatively open folds to the south. This differential movement caused rotation of the strata in the vicinity of the fault, and widening between the Ripple Creek fault and the branch fault that extends up the South Fork of Salmo River. As a result, the wedge-shaped block south of Lost Mountain moved westward relative to the surrounding rocks, thereby accounting for the opposite directions of movement on the two faults that mark its flanks.

A second branch of the Ripple Creek fault truncates an anticline exposed near the United Verde property.

The Ripple Creek faults dips vertically. South of Lost Mountain, the Quartzite Range formation, which forms the core of the Sheep Creek anticline, terminates abruptly against the fault,

beyond which the anticline plunges 30 degrees southwest. This suggests a downward movement on the south side, but it may be that the Quartzite Range formation has been squeezed up at this point owing to the tight folding on the north side of the fault.

The average horizontal displacement of the Ripple Creek fault, from the southeast corner of the map-area to the point where it enters the valley of the South Fork of Salmo River, is about 4,000 feet, the north side having moved eastward. Farther west, however, the horizontal displacement decreased to where, at the mouth of the South Fork, the movement caused only warping of the strata of the Laib group.

A third prominent fault is that which extends from Pend d'Oreille River northward beyond Parks. The southern part of this fault appears to have displaced the larger, easterly trending fault first described. Near Parks, the fault is more evident where strata of the Hall group have been faulted against volcanic rocks of the Beaverton Mountain or Elise formations. The dip of this fault is nearly vertical, and the west side has moved upward relative to the east side. Along the south part of the fault there seems to have been also a movement of the west side northward. The displacements resulting from these movements are unknown, but are apparently in excess of 1,000 feet.

Normal faults of lesser displacement were observed in several localities. One such fault separates the upper part of the Laib group from dolomite and limestone of the Nelway formation north of Pend d'Oreille River. The wedge of Active formation at the International Boundary forms a graben bounded by normal faults. Reverse faults are also represented in Salmo map-area, and some of those appear to have formed channelways for mineralizing solutions. The fault on the

east limb of the Sheep Creek anticline, and those east of the Emerald and Jersey mines and the Truman property are of this type, and displacement along them has amounted to at least several hundreds of feet.

About 6 miles northeast of Salmo the summit of the ridge consists of gently folded argillite and limestone. These strata differ greatly in structure and lithology from the rocks below and to the north, and their occurrence at this locality is probably due to overthrusting. The fault that crosses the International Boundary 3 miles east of Nelway is poorly exposed, but may also be of the overthrust type.

No tectonic pattern governing the faults of Salmo map-area has yet been discerned, but such a pattern may be apparent when the study of the adjoining areas to the west and north are completed.

FOLDS

The structure of the eastern part of Salmo map-area is, broadly considered, monoclinal, but reversals of dip in the Three Sisters formation suggest that open folding has taken place within that part of the monocline between Monk and Panther Creeks. This monoclinal structure is terminated by the syncline that transgresses the map-area from north to south, and that is succeeded on the west by the Sheep Creek anticline (See map and structure-section D-E). This anticline is isoclinal and overturned, most of the dips being to the east. It is terminated on the north by a fault, and to the south it plunges southwestward and is lost in the open folds near the International Boundary. On the west limb of the Sheep Creek anticline is a small isoclinal fold on which lie most of the productive mines of the Sheep Creek camp. Farther west, a more open syncline is underlain by strata of the Laib group, and beyond this to the west is an anticline that plunges southwest in the vicinity of Pend d'Oreille River.

In most of the localities where detailed mapping has been done within these broad structures in the Palaeozoic rocks, smaller folds have indicated a complexity of structure beyond the limits of adequate representation on the scale of the writer's investigations.

Folds in the Mesozoic rocks appear to be more open than those in the older formations. On Mount Kelly, a syncline plunging southwest is probably terminated by a fault. To the east, lies a broad anticline in the valley of Archibald Creek. Farther north, across the Great Northern railway, the folds are even more open, and plunge gently south-southeast. Synclines occupy the west side of Keystone Mountain, Erie Mountain, and the crests of the two ridges to the west.

ECONOMIC GEOLOGY

PLACER DEPOSITS

The earliest recorded discovery of placer gold in British Columbia was made at the mouth of Pend d'Oreille River in 1855. Since that time activity on placer workings on Pend d'Oreille and lower Salmo Rivers has been reported, and small operations are now in progress.

LODE DEPOSITS

Salmo map-area has long been recognized as a leading producer of metals, particularly the Sheep Creek camp, which ranks fifth in the province in total production of gold. In addition to gold and silver, lead and zinc have been produced from mines of Salmo area, either as a by-product of silver and gold mining, as in the case of the Hunter V and Arlington mines, or as the principal metals, as at the H.B., old Emerald, Howard (Durango), Reeves-Macdonald, and others. Of the other metals, only tungsten and iron oxides have been

shipped, the former from the new Emerald mine, and the latter from the Lomond (International Lead and Iron) mine.

GOLD

Between 1934, when the price of gold was substantially increased, and the early years of World War II, the gold-producing mines within Salmo map-area were active. During the later years of the war, difficulties in obtaining labour and materials forced many mines to close, and subsequent to the war the high cost of labour and materials forced the closing of many more gold-producing mines. At present only the Arlington and Sheep Creek gold mines are operating.

Most of the productive gold mines lie within the Sheep Creek camp, and a report on these, by W.H. Mathews of the British Columbia Department of Mines, is in preparation.

ZINC-LEAD

The most active development and mining is at present centred in mines that contain lead and zinc orebodies, all of which are replacement deposits in limestone. Most of the orebodies are confined to those parts of the limestone strata that have been hydrothermally altered to dolomite and, more rarely, to skarn. In the Reeves-Macdonald mine, the orebodies are contained within an envelope of dolomitized limestone, which extends up to 40 feet from the orebodies. The same conditions were observed in the H.B. mine where the dolomite envelope extends from 5 to 50 feet beyond the orebodies. In the Jack Pot property, the ore is likewise contained within a dolomite envelope, but patches of calcite, which may be later than the ore, are said to occur with it. At the Truman property, no relationship between dolomitization and ore could be found. In the Jersey mine, ore occurs only where dolomitization or the development of skarn has taken place.

Reeves-Macdonald

The Reeves-Macdonald mine is on the north shore of Pend d'Oreille River, about a mile upstream from the mouth of the Salmo, and is reached by road from either Nelway or Waneta. It is a subsidiary of Pend Oreille Mines and Metals Company, of Metaline Falls, Washington, which has directed development work in recent years. In 1949, a 500-ton mill was constructed and put into operation in August. Further expansion is planned.

The rocks at the mine are limestone, quartzite, schist, and argillite of the lower part of the Laib group, and the orebodies are replacement deposits within the main limestone members. The principal ore mineral is sphalerite, but much pyrite and a little galena are present.

The strata form the southeast limb of an anticline that plunges southwest. Small sigmoid folds within the limestone members also plunge southwest and perhaps exert a structural control over the orebodies, which plunge in the same direction. Cross-faults with displacements up to several hundred feet were described by Walker, and several smaller faults are present. These faults may also have served to localize dolomitization or ore deposition.

Three orebodies have been discovered but only one of these is now being developed and mined. This is the Reeves orebody, which has been trenched on the surface and intersected in the River adit, 800 feet below. An inclined raise was completed, and stoping in the upper levels has been in progress.

A second orebody, known as the B.L., is exposed in surface trenches several hundred feet northeast of the outcrop of the Reeves orebody. The heavy overburden in its vicinity makes it difficult to determine the structural relationship of this orebody to the Reeves.

A third orebody, several thousands of feet southeast of the Reeves orebody, may be seen at low water on the bank of Pend d'Oreille River.

Michaely (Red Rock)

The Michaely property, owned by M. Michaely of Trail, is on the north side of Salmo River about 2 miles northeast of its mouth, and is connected by a branch road with the Nelway-Waneta road.

The rocks on the property consist of limestone of the lower part of the Laib group, which forms a smaller syncline whose axis is parallel with that of the major anticline to the northwest. The orebody is a lenticular mass of high-grade galena and sphalerite, with some pyrite. It is exposed in an open-cut, and has been intersected below by two short adits, the lower about 60 feet below the outcrop. The dimensions of the orebody on the surface, as given by Walker, are 65 feet by 6 to 8 feet.

Several hundred tons of hand-sorted ore have been shipped to Trail by Mr. Michaely and his associates.

Truman (Mona)

The Truman property lies between Lost Creek and the South Fork of Salmo River. It is owned by L.R. Clubine of Salmo, from whom it was optioned by the Valley Mining Company, a subsidiary of New Jersey Zinc Explorations Limited, in 1947. After some diamond drilling had been done, the option was dropped.

Disseminated sphalerite and pyrite occur in limestone overlying an anticline of Reno argillite and quartzite. The deposit is exposed in open-cuts on the east limb of the anticline, and on the west limb by an adit driven in from Lost Creek.

Jersey

The Jersey mine, at an elevation of 4,500 feet on the

north slope of Lost Creek, is served by the Emerald road from Sheep Creek. It is part of the Emerald property, which is owned by Canadian Exploration Limited.

With the post-war fall in prices of tungsten concentrates, the company diverted exploration to the base metal deposits on their holdings and succeeded in blocking our large bodies of good grade lead-zinc ore.

The rock on the Jersey property is largely limestone of the lower part of the Laib group. It has been compressed into open folds, plunging gently southward, on the crests of which the mineral deposits of the property are found. These orebodies are replacements of limestone by galena, sphalerite, and pyrite, mainly along bedding planes, but where brecciation of the limestone has occurred they form small, irregular, branching veins.

H.B.

The H.B. mine lies on the north side of Sheep Creek about a mile by branch road from the Sheep Creek highway. It is controlled by the Consolidated Mining and Smelting Company of Canada Limited, which has carried out an extensive development program during the last 2 years. Drifting was extended southward on the 400 level and much diamond drilling was done.

The rock is mainly limestone and intercalated schist of the lower part of the Laib group. The strata strike approximately north and dip steeply eastward.

The orebodies consist of sphalerite, with pyrite and some galena, and form replacements in limestone. The mineralization appears to be closely associated with strike faults, which apparently formed the channelways for the hydrothermal solutions from which the ore was deposited.

Jack Pot

The Jack Pot property is on the south slope of Porcupine Creek, near the north edge of the map-area, at an elevation of about 5,500 feet. It is owned by E.I. Haukedahl and associates of Ymir. The property was optioned in 1948 by New Jersey Zinc Explorations Limited and exploration was carried out during 1949. A road was constructed to the property from the Porcupine Creek road near the mouth of Active Creek, and extensive trenching was done, much of it with the aid of a bulldozer.

The rock on the crest of the ridge consists of an assemblage of limestone, argillite, and argillaceous quartzite, which most closely resembles the strata of the lower part of the Laib group. These rocks form open folds, and contrast sharply in lithology with those to the north, which are white quartzite, schist, and limestone of the Seeman group. The latter strike north, and their dip is nearly vertical. It is probable that a thrust-fault separates the rocks of these two groups. To the south is the Hidden Creek granite stock, and a few small bodies of fine-grained granite and monzonite occur within the Jack Pot property.

The limestone members are coarsely crystalline and contain many radiating clusters of tremolite crystals. Pyrite and sphalerite are widely disseminated, and are commonly associated with pyrrhotite and a little galena. In one place a little chalcopyrite was noted.

Ore minerals occur in limestone of both the Laib and Seeman groups, and appear to be localized in general near the fault contact. It is probable that this fault formed a channelway for the mineralizing solutions.

TUNGSTEN

Emerald

Prior to 1941 the Emerald mine was known as a producer of lead and zinc. In that year the British Columbia Department of Mines found scheelite in skarn, which was submitted for molybdenum assay. Further investigation revealed a large scheelite orebody a few hundred feet below and southwest of the old workings. The property was acquired by Wartime Metals Corporation and production of tungsten concentrates was begun in 1942. At the conclusion of the war, the property was purchased by Canadian Exploration Limited, which operated the mine until 1949, when the mill was converted to treat lead-zinc ore from the Jersey workings.

The rock consists of limestone and argillite of the lower part of the Laib group. Much of the limestone has been altered to skarn, and it is within this altered limestone that the scheelite occurs.

The orebodies lie in a trough that plunges gently southward, flanked on the east by a fine-grained granite stock and on the west by a band of argillite dipping eastward. For a complete description of the property, together with a detailed map and cross-sections, the reader is referred to a report by M.S. Hedley (18) in Bulletin 10 of the British Columbia Department of Mines.

IRON OXIDES

Lomond (International Lead and Iron)

The Lomond property, owned by G. Shallenberger, is situated along Lomond Creek, which flows westward into Pend d'Oreille River near the International Boundary. It is served by a short branch road from the Nelway-Waneta road.

The workings that were described by Walker (20, pp. 62-63) are for the most part inaccessible due to slumping, and present activity is centred in open-cut mining on the banks of Lomond Creek,

near three short adits.

The rock consists of alternate bands of creamy dolomite and black and white mottled dolomite, which is typical of the lower part of the middle member of the Nelway formation. The general strike of the beds at this locality is east to southeast, and the dip is 25 to 35 degrees southerly. The orebodies appear to be largely confined to the creamy dolomite strata. They consist of limonite and hematite, which form irregular masses in the dolomite. Some of the orebodies contain galena and cerussite (lead carbonate). It is presumed that the original bodies consisted of pyrite, which has been completely altered to limonite and hematite, and galena, which is partly altered to crystalline cerussite.

In some localities the orebodies are numerous and as much as 15 or 20 feet in diameter, but elsewhere they are small and sparsely distributed.

Galena and cerussite are hand-sorted and shipped to Trail. The limonite and hematite are shipped to Metaline Falls, Washington, where they are used in the manufacture of certain types of cement.

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