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BUREAU OF GEOLOGY AND TOPOGRAPHY

GEOLOGICAL SURVEY

PRELIMINARY REPORT

MINERAL DEPOSITS OF THE WEST HALF OF KETTLE RIVER AREA, BRITISH COLUMBIA

BY

C. E. Cairnes

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INTRODUCTION

Kettle River map-area (west half) occupies some 3,000 square miles in south-central British Columbia. It centres about Pentiction; is readily accessible by railway, steamer, and motor-bus services; and is traversed in various directions by highways and subsidiary roads.

The area includes a number of productive mining camps and prospecting at these, as well as at numerous other scattered localities, has revealed a variety of ore minerals and non-metallic deposits. The mining history of the area, like that of other parts of southern British Columbia, dates back seventy-five years or more, to the early days of placer mining. Records of early explorations within the area are scanty, but some discoveries were made, notably on Mission creek near Kelowna, and on Rock creek and its tributaries in the southeastern corner of the map-area. Though the discoveries were not as valuable as in some other districts they laid the foundations for later, intermittent discoveries and investigations that have persisted to the present, With the advance of settlement and resultant increased transportation facilities, interest in lode-prospecting and, in particular, lode-gold prospects, was aroused and resulted, in the early "nineties", in the establishment of important gold-mining camps at Fairview and Camp McKinney. Farther north, near the eastern border of the map-area, all the important claims of Beaverdell camp were staked in 1896 and 1897 and within the next four years numerous showings of the rich, silver-lead ores of this camp were opened up. At about this time developments commenced on the important gold ores of Hedley camp in Similkameen valley and led in 1900 to the location of the Golden Zone property lying just within the western border of the map-sheet. Other properties staked at about this time include the Dividend-Lakeview claims west of Osoyoos lake where substantial gold-bearing sulphide deposits were later developed; the Horn Silver mine on Similkameen river; and several claims on Oro Fino mountain, a few miles north-west of Fairview camp, where quartz veins carrying free gold were found.

These early discoveries have afforded the principal loci for mining developments and production up to the present. Numerous, other, widely scattered, mineral deposits have, however, been found; a few have proved of some commercial significance; and altogether they have provided a great variety of types, and are referred to more fully elsewhere in this report. Recent interest has, however, been largely concentrated on deposits carrying gold and has included active developments in both placer and lode mining.

The object of the present report is to correlate the various types of mineral deposits with respect to their geological environment; to outline the occurrences and characters of these deposits; and to draw such conclusions as seem warranted with respect to their probable origin and the geological conditions most suitable for their formation.

The report is based, partly, on a combined reconnaissance survey of the area, during the 1936 field season, by Mr. Carl Tolman and the writer. In the course of this work somewhat less than two-thirds of the area was geologically mapped and the results compiled on a topographic base-map with a scale of 2 miles to 1 inch. Remaining parts of the area had previously been mapped by different persons and on larger scales. This earlier mapping, together with related reports, has been of great assistance in correlating the geology across the map-area and in providing detailed information with respect to mineral deposits. Thanks are specially due to H.S. Bostock of the Geological Survey for valuable assistance in the compilation of the geological map.

SURFACE FEATURES

Most of the area lies within the Interior Plateaux of British Columbia, a region characterized by broad, rolling, upland areas deeply and steeply dissected by the main valleys and their principal tributaries. Within the map-area these uplands range from less than 5,000 to over 7,000 feet above the sea and the main valley bottoms lie 3,000 to 6,000 feet below them. The lowest level, 913 feet, is reached in Okanagan valley at Osoyoos lake and the highest point is Baldy mountain, north of Camp McKinney, which rises to an elevation of 7,575 feet. West of Similkameen river and for some miles north the plateau region merges with the Okanagan range of the Cascade Mountain system. Here the upland areas become more typically Cordilleran, being represented by relatively narrow inter-valley ridges rising, at Snowy mountain, to a maximum height of 8,507 feet.

Within the plateau region much of the upland area is drift covered and east of Okanagan valley is also thickly timbered. The main valley bottoms are floored with thick, unconsolidated glacial and stream deposits. These provide much of the rich agricultural lands of the district. Such unconsolidated deposits form conspicuous terraces at the lower elevations, and numerous smaller, bench remnants higher up the valley slopes to, in places, near plateau heights. Alluvial fans and deltas form large deposits at the mouths of tributary streams and extensive talus deposits have formed along the base of the steep valley slopes. A coalescence of alluvial fans from either side of Okanagan lake at Penticton has separated the water from Okanagan and Skaha lakes which, formerly, were one.

Rock outcrops are most continuously exposed along the steep valley walls, but are plentiful on some of the higher ridges and mountain tops. Within the area of the Okanagan range they are abundant. West of Okanagan valley, too, the relatively open character of the country, as contrasted with areas east of this valley, permits ready access to rock exposures.

GEOLOGY

Geological formations of the map-area range from late Palaeozoic, or older, to Recent and comprise a great variety of sedimentary, igneous, and metamorphic rocks. Sediments are in the minority, but have provided a few fossil collections on whose age determinations the entire sequence of formations and intrusive bodies has been very largely built. Fossils of Permian and of Triassic age were collected by Bostock from southwestern parts of the area; other collections, from various localities have been obtained from Tertiary sediments and have indicated that, mainly at least, these are of Late Eocene or (and) Oligocene age. Volcanic formations and related intrusives are correlated with the sediments according to their associations and structural relationships. No Jurassic or Cretaceous formations have been identified and, as a result, considerable uncertainty has arisen in dating the widespread intrusive bodies whose periods of intrusion probably span a long interval in post-Triassic time. Metamorphic rocks are also widespread; are mainly Triassic or pre-Triassic and are principally members of the Shuswap complex. Perhaps the most remarkable geological feature of the area is the contrast between the members of the Shuswap complex and those of all other formations and intrusive rocks. The contrast is not only in such matters as appearance, composition, structure, and origin, but is also significant from the point of view of mineral deposits, in which members of the Shuswap complex have proved notably deficient.

The following table presents a brief outline of the geology of the area and associated mineral deposits.

Table of Formations and Associated Mineral Deposits

Era	Period	Map Symbol	Formations and mineral deposits (Numbers refer to localities shown on map)
Cenozoic	Modern (glacial and Recent)		Chemical precipitations from lake waters Magnesium sulphate. 18
			Organic deposits in swamps Diatomite. 2
			Talus and slide debris Road metal.
			Stream deposits of gravel, sand, and clay Placer gold. Mission and rock creeks.
			Glacial and fluvioglacial deposits; (drift, boulder clay, silts, sand, and gravel) a. Clay. b. Placer gold - Mission and Rock creeks.
	Tertiary and Later (?)	C and A	Variously consolidated conglomerates, slide breccias, sandstones, shales, and tuffaceous sediments; contain plant and insect remains a. Placer gold - Mission and Rock creeks. b. Coal. 10
		B	Variously coloured, massive, to highly vesicular and amygdaloidal, and, in part, porphyritic, lavas, mainly dark green to black basalts and andesites. Agglomerates, breccias, and tuffs - in part waterlain.
			Medium-to coarse-grained, light grey to pink and reddish, granite, quartz syenite, and syenite, in part porphyritic; granite and syenite porphyry dykes and stocks with, in some places, associated flows.

Table of Formations and Associated Mineral Deposits (Cont'd)

Era	Period	Map Symbol	Formations and mineral deposits (Numbers refer to localities shown on map)
Mesozoic and Cenozoic (?)	Post-Triassic (OKANAGAN) (INTRUSIVES)	F	Coarse-grained, light grey to pink, mostly porphyritic, biotite-hornblende granite and granodiorite Quartz veins carrying irregularly distributed and mostly scanty sulphides, principally pyrite and galena, and containing variable, mostly low, values in gold. 14
		E	Undifferentiated, medium- to coarse-grained intrusives; chiefly biotite-hornblende granodiorite. Chiefly quartz veins, visibly mineralized with one or more of pyrite, galena, zinc blende, grey copper, chalcopyrite, hematite, etc., and carrying values in one or more of gold, silver, lead, and zinc. 6, 7, 9
		D	Medium- to very coarse-grained, in part highly porphyritic, alkaline intrusives of variable colour and composition; chiefly augite syenite a. Disseminated pyrite, chalcopyrite, and magnetite in massive alkaline intrusives (at north edge of area). b. Quartz veins, mineralized with pyrite, zincblende, hematite, chalcopyrite, galena, native silver, etc., with principal values in silver and lesser gold values. 19, 20 c. Quartz stringers, veins, and lenses, mineralized with pyrite, chalcopyrite, magnetite, and molybdenite; values in copper and molybdenum. 16
			Coarse-grained, hornblende-biotite intrusives, chiefly granodiorite and quartz diorite; foliated in places

Table of Formations and Associated Mineral Deposits (Cont'd)

Era	Period	Map Symbol	Formations and mineral deposits (Numbers refer to localities shown on map)
Mesozoic and Cenozoic(?)	Post-Triassic (OKANAGAN) (INTRUSIVES)	C	a. Mineralized shear zones containing high-grade galena, sphalerite, pyrite, silver-bearing ores. 31 b. Mineralized shear zones and quartz veins containing pyrite, galena, zinc blende, chalcopyrite, etc., with principal values in one or more of gold, copper, and, more rarely, silver; and, in some cases, with lesser values in lead and zinc. 8, 11, 13, 22, 24, 29 and 31
		B	Highly altered, coarse-grained, chiefly light greenish grey, in part gneissic, granodiorite and quartz diorite; bears some lithological resemblances to gneissic members of the Shuswap complex. Quartz veins with local heavy sulphide concentrations, chiefly pyrite, and containing variable gold values. 17
		A	Dark green to black, coarse-grained, ultrabasic intrusives including hornblendites, pyroxenites, and peridotites, the last mainly altered to serpentine. a. Mineralized shear zones and associated replacement deposits in pyroxenite, heavily mineralized with pyrite, chalcopyrite, and molybdenite; values in copper and molybdenum. 12 b. Segregations of chromite in serpentinized peridotite. 26 c. Asbestos in serpentinized peridotite. 30
Mesozoic	Triassic or (and) later		Highly metamorphosed, crystalline, dark amphibolitic rocks of uncertain origin associated with dioritic intrusives and highly metamorphosed sediments. Chiefly quartz veins, mineralized with pyrite, lesser galena, and free gold; values in gold. 11

Table of Formations and Associated Mineral Deposits (Cont'd)

Era	Period	Map Symbol	Formations and mineral deposits (Numbers refer to localities shown on map)
Mesozoic and Palaeozoic	Triassic and Permian(?)	D and C	Chert, cherty argillite, argillite, quartzite, and limestone; greenstone (lavas, breccias, tuffs, and associated intrusives); fossiliferous a. Replacement deposits near granitic contacts, containing chiefly pyrite and arsenopyrite and carrying gold values. 9, 12 b. Brecciated zones, partly cemented with quartz sparsely mineralized with pyrite, and carrying gold values. 12
	Permian	.	Limestone (fossiliferous); of no considerable areal extent and not mapped separately.
	Carboniferous(?)	B and A	Cherty and argillaceous sediments; limestone; greenstone and greenstone schist, mainly volcanic but with associated dioritic intrusives; strongly metamorphosed in much of the southern and eastern parts of the area. a. High-temperature replacement deposits in metamorphosed limestone and greenstone heavily charged with ore minerals including, chiefly, pyrite, pyrrhotite, arsenopyrite, chalcopyrite, and sphalerite; lesser molybdenite and galena; values in gold as well as in one or more other metals. 3, 4, 5, 21 b. Mainly quartz veins, with a variable but, in general, low sulphide content consisting of pyrite and, in most cases, one or more of galena, sphalerite, and chalcopyrite; carrying, also, occasional free gold; values in gold. 1, 14, 24 c. Shear zones with, generally, some vein quartz and mineralized with pyrite, galena, zinc blende, chalcopyrite, and, more locally, free gold; variable gold values. 23, 25 d. Shear zones containing some vein quartz and mineralized with pyrite, galena, zinc blende, grey copper, and chalcopyrite; values in silver, lead and zinc. 27, 28, 31 e. Limestone quarries.

Shuswap Complex

The following group of rocks is separated from those in the foregoing tabulation for the reason that its members cannot be arranged in a definite geological time sequence. Instead they represent, in the writer's opinion, different stages in the process of granitization of formations which, for the most part at least, are probably as old or older than any listed above. Final stages in the process are represented, over large areas, by biotite granite and granodiorite; initial stages by the least metamorphosed of the rocks included with the paragneisses and schists. No metallic mineral deposits of consequence have been found within the area of the Shuswap complex.

Era	Period	Map Symbol	Formations and mineral deposits (Numbers refer to localities shown on map)
Mesozoic and Pre-Mesozoic	Carboniferous (?) and later	B	Mostly medium-grained, massive, quartzose, biotite granite and granodiorite; in part porphyritic and in part gneissic; associated with abundant, white, coarse-grained, garnetiferous, pegmatitic granite.
		A	Medium- to coarse-grained, massive to gneissic, hornblende and hornblende-biotite intrusives of varying composition, but chiefly about granodiorite or quartz diorite; commonly conspicuously titaniferous.
		B	Chiefly medium-grained gneisses varying in appearance, composition, and origin; associated with abundant, white, pegmatitic and aplitic intrusives; showing many gradations into rocks like A and B above, and also into metamorphosed sediments and volcanics; containing red garnets and, more locally, abundant epidote as characteristic minerals.
		A	Banded paragneisses associated with amphibolitic and highly micaceous, garnetiferous schists with transitions into less metamorphosed formations.

ECONOMIC GEOLOGY

The mineral deposits of the area may be classified as follows:

A. Metalliferous Deposits

1. Gold placers
2. Lode deposits
   (a) Auriferous quartz veins
   (b) Miscellaneous quartz veins
   (c) Mineralized shear zones
   (d) Magmatic segregations

B. Non-metallic Deposits

1. Coal
2. Petroleum
3. Asbestos
4. Manganese
5. Magnesium sulphate
6. Silica
7. Limestone
8. Clay
9. Diatomite
10. Garnet

Metalliferous Deposits

Gold Placers

Placer mining in the area has been confined, mainly, to the vicinity of early discoveries along Rock creek and its tributaries and on Mission creek. Numerous other streams have been prospected and along some of these a little gold has been found, but not enough to encourage extended operations. From the principal localities, however, a production, amounting perhaps to several hundred thousand dollars, has been won. The gold has come, mostly, from present stream gravels and this source is nearing exhaustion. Much attention has, however, been paid, particularly in more recent years, to buried, old channel deposits occurring, in most cases, on one side or the other of present streams and at varying elevations above them. They are covered with glacial drift and evidently represent stream deposits of inter-glacial or pre-glacial age.

The placer deposits of Mission creek were examined by Dawson[1] in 1877 sixteen years after their discovery. Early recovery was made from the creek bed for a distance of ½ mile or so below a narrow, rocky gorge about 7 miles from the mouth of the creek. Good pay was won from the stream gravels, but they were soon worked over. Attention was then directed to low benches or flats on either side of the stream and mining there has revealed older, auriferous gravels underlying a varying thickness of, chiefly, glacial deposits. These gravels and the overlying drift are, in places, well cemented by calcareous material. Below the gorge they appear to form a fairly continuous bed, up to several feet thick, overlying Tertiary sediments, principally shale. Some work was done on these gravels in 1936. The gorge itself and the valley above the gorge have been cut into crystalline, gneissic rocks of the Shuswap complex. Gold-bearing gravels, very similar to those below the gorge, have also been found, in places resting on these Shuswap rocks but not in any quantity. Doubtless it is these deposits of older, auriferous gravels that supplied the gold won from the present bed of Mission creek. The source of the gold in the older gravels is less certain. The gravels themselves appear to be pre-glacial and to be composed of detritus from pre-Tertiary formations. It is not improbable that they represent reworked, basal Tertiary, gold-bearing stream gravels and that such deposits, rich in

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[1] Dawson, G.M.: Report on Exploration in the Southern Portion of British Columbia; Geol. Surv., Canada, Rept. of Prog. 1877-1878, pt. B, pp. 157-158.

gold, may occur in places at the base of the Tertiary sediments though not exposed at this particular locality. A few miles farther north, beyond the limits of the map-area, gold-bearing Tertiary gravels are exposed.[1] Investigations there have not, however, been successful in developing any important body of pay ground. Partly the difficulty is attributable to paucity of exposures; partly to what appears to be the great width of the old channel; partly to the faulted character of the Tertiary deposits, and partly to the fact that they are overlain (probably largely overlain) by later, Tertiary lavas and, as a result, are costly to explore. This latter feature is especially true of consolidated Tertiary gravels (conglomerates), such as occur at various places in the district. Their possibilities have been referred to by the writer in an earlier report.[2]

The buried, old channel deposits of the Rock Creek section have been referred to at some length in the Annual Reports of the Minister of Mines of British Columbia for 1931, pages 126-129; 1932, pages 131-133; 1933, pages 162-164; and 1934, page D12. The deposits, composed of stream gravel, sand, and clay, are, in most places, thickly covered with glacial drift. They may occur either beneath bench deposits flanking the present streams or may be separated from these streams by ridges of rock up to several hundred feet high. Lack of any great measure of success in exploring these old channels seems attributable rather to mechanical difficulties than to failure in finding gold. These difficulties have involved the means of removal and disposal of overlying drift and of the waste from the channel deposits themselves. Prospecting, too, from shafts to reach and explore the pay gravels resting,

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[1] Ann. Rept., Minister of Mines, British Columbia, 1935, pt.D., p.15.

[2] Cairnes, C.E., Mineral Resources of Northern Okanagan Valley, B.C.; Geol. Surv., Canada, Sum. Rept. 1931, pt. A, pp. 66-109.

generally, on bedrock, has commonly been handicapped by a rapid accumulation of water in the workings, necessitating efficient pumping machinery such as was not available in the early days of placer mining in this district. The pay gravels, too, where found, are commonly partly cemented with iron oxide and lime, and much of the associated, finer detrital gold may not be readily separable from the cement in the sluicing operations and may be lost with it. Such gold as has been recovered from these old channel deposits has been mostly coarse and rusty.

In the Rock Creek area placer gold has been found along Rock creek itself, particularly near its junction with Kettle river, and at intervals along its tributaries, Jolly and McKinney creeks; also along Rice creek which flows south into McKinney creek. The source of the gold is, presumably, gold-bearing quartz veins such as occur principally within the large area of pre-batholithic, Carboniferous (?) formations flanking the southeastern slopes of Baldy mountain and represented by the lode deposits at Camp McKinney and vicinity. Bullion from Camp McKinney ores is, however, stated to carry a much higher proportion of silver than the gold from the placer diggings. To what extent the information applies to all parts of the Rock Creek basin is not known, but there is the suggestion either that the source of the placer gold is other than as indicated above or that some chemical process (or processes) has intervened to change the composition of the lode gold either prior or subsequent to its separation from the lode deposits. It is well known that the fine gold of placer deposits may be leached of much of its silver content, but the process is doubtfully effective in the case of nuggets of any size. It is, however, possible that much of the placer gold in this area either occurs in or was obtained from Tertiary gravels; that this gold was derived from deeply oxidized outcrops in Tertiary time; that these oxidized outcrops contains gold that, mainly, had been concentrated, by solution and reprecipitation at or near the surface, from the primary gold of the lode deposits; and that this secondary gold was lower in silver than the primary gold. The fact that much of the placer gold recovered in the Rock Creek section is coarser than any free gold particles seen in the vein deposits suggests that some process of concentration was active in Tertiary time. Since glaciation there has been little opportunity for prolonged weathering, and gold-bearing lode deposits, though not uncommonly carrying concentrated free gold in their oxidized parts, have not been observed to contain gold as coarse as much of the detrital gold in the placer deposits. Auriferous stream gravels formed in periods preceding glacial erosion as a rule contain coarser gold than those formed in recent times, but the present-day placers may contain coarse gold that has been rederived from ancient placers. The occurrence, therefore, of any unusual concentrations of coarse gold in the present stream gravels may mean that these streams have cut across such old channels and that a search should be made for them.

Lode Deposits

Auriferous Quartz Veins

1.[1] Bluehawk. Annual Report of the Minister of Mines, British Columbia, 1933, pp. 196-197; 1935, pt. D, p. 13.

8. Torpedo. Annual Report of the Minister of Mines, British Columbia, 1918, p. 211; 1934, pt. D, pp. 33-34.

9. Golden Zone. Camsell, Chas.: The Geology and Ore Deposits of Hedley Mining District, British Columbia; Geol. Surv., Canada, Mem. 2, pp. 204-206. Annual Report of the Minister of Mines, British Columbia, 1930, pp. 216-217; 1931, p. 133, 1932, p.139.

11. Oro Fino Mountain Camp. Annual Report of the Minister of Mines, British Columbia, 1898, p. 1116; 1923, p. 186; 1929, p. 269; 1930, p. 218; 1931, pp. 134-135; 1932, pp. 136-137; 1933, pp. 168-169; 1934, pt. D., pp. 15-16; 1934, pt. D, p. 13.

13. Torres. Cockfield, W.E.: Lode Gold Deposits of Fairview Camp, Camp McKinney, and Vidette Lake Area, and the Dividend-Lakeview property near Osoyoos, B.C.; Geol. Surv., Canada, Mem. 179, p. 10. Annual Report of the Minister of Mines, British Columbia, 1933, pp. 167-168; 1934, pt. D., p. 15.

14. Fairview Camp. Cockfield, W.E.: Lode Gold Deposits of Fairview Camp, Camp McKinney, and Vidette Lake Area, and the Dividend-Lakeview property near Osoyoos, B.C.; Geol. Surv., Canada, Mem. 179, pp. 1-10. Annual Report of the Minister of Mines, British Columbia, 1897, pp. 599-600; 1920, p. 157; 1923, p. 185; 1926, p. 219; 1932, pp. 134-136; 1933, pp. 164-166; 1934, pt. D, pp. 13-14; 1935, pt. D, pp. 12-13.

15. Tinhorn. Annual Report of the Minister of Mines, British Columbia, 1897, pp. 601-602.

17. Mak Siccar. Annual Report of the Minister of Mines, British Columbia, 1927, pp. 238-239; 1928, p. 260; 1929, pp. 268-269; 1930, p. 214; 1931, p. 136; 1933, pp. 166-167; 1934, pt. D, p. 15; 1935, pt. D, p.13.

24. Camp McKinney. Cockfield, W.E.: Lode Gold Deposits of Fairview Camp, Camp McKinney, and Vidette Lake Area, and the Dividend-Lakeview property near Osoyoos, B.C.; Geol. Surv., Canada, Mem. 179, pp. 11-19. Annual Report of the Minister of Mines, British Columbia, 1897, pp. 604-605; 1928, pp. 255-256; 1932, pp. 130-131; 1933, pp. 156-158.

29. Boomerang. Annual Report of the Minister of Mines, British Columbia, 1913, pp. 157-158.

33. Dale. Annual Report of the Minister of Mines, British Columbia, 1925, p. 201; 1928, pp. 251-252.

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[1] The numbers in this column appear on the accompanying map and show the location of the properties.

Gold-bearing quartz veins constitute the most widely investigated type of deposits in the area. The largest producer, the Cariboo-Amelia mine at Camp McKinney, is recorded as having yielded over $1,000,000 worth of gold in the years 1895 to 1903 inclusive. A little gold was also won, in the early days, from one or more of the neighbouring properties in this camp. In recent years some attempts have been made to revive interest in Camp McKinney, but with little success. The old workings are mostly inaccessible and, though it seems probable that further discoveries of note will yet be made, there is but little information on the gold-bearing deposits to guide explorations. At the Fairview and Oro Fino Mountain camps development work has been actively carried on in recent years and both camps were producing in 1936. Ore from these camps has been valued at a few dollars to over $20 a ton, the Oro Fino ores being, on the whole, the richer. Other properties, from which small quantities of gold-bearing ores have been produced, include the Torpedo, Tinhorn, and Mak Siccar mines. There are, in addition, many widely scattered claims and groups of claims within which sizable quartz veins carrying low gold values occur and on which more or less work has been done, in most cases, many years ago, though quite recently in the cases of the Bluehawk and Torres groups. A few of these are included in the list of lode deposits.

Sizable, auriferous, quartz veins occur in all types of the Okanagan intrusives, except the ultrabasic rocks, and in both sedimentary and igneous members of the pre-batholithic formations. Production, to date, has come almost entirely from veins in these older rocks, but ore-bodies of some importance have also been found in the granitic intrusives and, in the case of the Torpedo property, have provided small shipments. The quartz veins vary greatly in their dimensions from less than 2 feet wide and 100 feet long to as much as 30 feet wide, and, perhaps, several thousand feet in length. In general the wider veins are the longer, but short veins may, in places, widen to form large, lenticular masses of quartz and long veins may pinch at intervals along their strike to mere stringers or may split to form several such stringers. The Cariboo-Amelia vein (or veins) is stated to have been mined over a length of 1,740 feet and to a depth of 540 feet. At Fairview camp the principal veins of the Morning Star, Stemwinder, and Fairview mines have been followed for distances of several hundred to 2,000 feet and as the properties adjoin along the strike of these veins it is not improbable that one or more of the veins are continuous through the three properties, except as disrupted by faults. In none of the workings, however, has developments been carried to depths of more than a few hundred feet. At the Oro Fino Mountain camp the workings are comparatively shallow and short. Among the hitherto unproductive veins those of Fairview camp occurring in the granitic intrusives (locally referred to as the Oliver granite), as explored on the Standard, Empire, and Susie claims, average several feet wide and have been traced for hundreds of feet. From the Oliver (Victoria) claim, adjoining the Susie, a few tons of ore were shipped in 1932 and 1933. The ore carried some free gold.

In the pre-batholithic formations many of the principal quartz veins conform with the schistosity of the enclosing formations and have formed partly as a result of fissure filling and partly by replacement processes. Inclusions of wall-rock are common and in places show as relatively long, narrow bands of partly silicified rock alternating with bands of pure quartz and conforming, roughly, with the strike and dip of the veins. The principal veins at Camp McKinney and Fairview camp have a general westerly to northwesterly strike; those on Oro Fino mountain northerly to northeasterly. Dips may be in either direction and vary from flat to vertical. The Cariboo-Amelia vein dipped steeply south, the Morning Star, Stemwinder, and Fairview veins dip northeasterly at low to intermediate angles; and the Twin Lakes main vein rolls gently to reappear at different surface workings. Other veins in the Oro Fino camp have quite steep dips.

Veins in the batholithic rocks may strike in any direction, though the larger veins seem to favour a northerly or a westerly to northwesterly course. Thus, the Empire, Standard, and Susie veins of Fairview camp strike northerly; the Torres and Golden Zone veins, about east and west. Replacement of the wall-rock by vein quartz is pronounced in Fairview camp.

The quartz veins are intersected by faults and the quartz itself is commonly much fractured and, in places, badly crushed. Most of the faults have a small throw and are principally normal faults. More important faults, marked by heavy gouge, are also encountered and have presented more difficult structural problems. The ore at the Cariboo-Amelia mine is stated to have been lost on such a fault.

The veins are composed, very largely, of quartz, but in places may contain abundant inclusions of the wall-rocks. Other gangue minerals are scarce, but may include a little calcite and, in rare cases, as at Mak Siccar mine, black tourmaline. The quartz is mostly white and vitreous and in some veins is distinctly glassy. Dark, rather bluish quartz composes parts of the Camp McKinney veins. Most of the quartz veins contain abundant, small, drusy cavities lined with clear quartz crystals.

The quartz veins are mineralized with one or more of a variety of sulphides of which pyrite is most common. It occurs irregularly disseminated through the quartz both in fine grains and as masses of coarse crystals. Inclusions of wall-rock in the quartz or the wall-rocks themselves may contain disseminated pyrite. Decomposition products of the pyrite, chiefly sulphur, have added a conspicuous black film to the quartz both of the veins and of the granitic wall-rocks in the Standard and Empire veins of Fairview camp. Other, commonly associated sulphides are galena and sphalerite. These occur both finely disseminated and in nests of coarse crystals. A little, red sphalerite was observed in an ore specimen from Fairview mine. Chalcopyrite and molybdenite occur mostly as specks and flakes respectively. Striated surfaces of the quartz may be smeared by a thin film of molybdenite giving a bluish tarnish or iridescence to the quartz.

Aside from the sulphide minerals the quartz veins may carry visible free gold. It occurs mainly as sparsely disseminated specks through the quartz and up to a millimetre or so in diameter. The gold is in part primary, but concentrations of fine gold have formed in the oxidized outcrops of some of the veins.

Gold assays are not uniform for any one vein or group of veins. Those sufficiently high to encourage mining are confined mainly to parts of a vein which, as developed by the mine workings, constitute ore shoots and, in the principal discoveries to date, form relatively small parts of the vein as a whole. Enrichment of gold in the oxidized vein outcrops has provided shallow ore shoots from which a considerable aggregate tonnage of high-grade ore was obtained at the Morning Star mine at Fairview and at different properties on Oro Fino mountain. In such ore shoots the gold occurs almost entirely free. In the primary ore shoots, however, a variable proportion of the gold may, depending upon the particular type of deposit or even the particular ore shoot, be combined with the sulphides and high values obtained from ore in which visible gold is rarely seen. The boundaries of ore shoots are determined, largely, by assay values and operations on an appreciably larger scale than at present would, undoubtedly, enable operators to extend the boundaries of their ore-bodies. Old records indicate that 75 per cent or more of the gold content of the Cariboo-Amelia ores was free and caught on amalgamation plates in the milling process.

About the same percentage of the gold recovered, in 1936, from the milled ore of the Twin Lakes mine, was caught on the plates. At Fairview camp it is reported that some 2,700 tons milled in the winters of 1892-1893 and 1893-1894 yielded $11 a ton by amalgamation and 92 cents a ton in the concentrates. These figures are based on the old price of gold and the tonnage was drawn from or near the surface where there was considerable enrichment in free gold. In the deeper workings free gold is rarely seen in the ore and the gold is believed to be combined mainly with the sulphides.

The principal ore shoots at Camp McKinney, Fairview, and Oro Fino Mountain contain more sulphide than the other parts of the veins. Though pyrite is, in general, the abundant sulphide, values in many places have seemed best where galena and sphalerite were also present, though not always where they were most abundant. Specimens stated to be of high-grade ore assaying, in each case, up to several ounces of gold a ton, were taken from the Twin Lakes, Fairview, and Morning Star mines and were polished for microscopic study. In each specimen the abundant sulphide was coarsely crystallized pyrite and under the microscope it was observed to be more or less severely fractured and was veined, in places, by galena, zincblende, chalcopyrite, and quartz. On the other hand, small, irregular, mostly rounded bodies of the same sulphides are common in the pyrite crystals and these bodies have the appearance of being replaced by, rather than of replacing, the pyrite. A specimen from the Twin Lakes mine showed free gold as microscopic, irregular, bodies, some in the pyrite, some forming parts of the small bodies of galena in the pyrite crystals, and some in the quartz gangue following the borders of the pyrite crystals and, in places, definitely veining the pyrite. A very little, microscopic gold was also observed in a specimen from Fairview mine. No conclusions could be drawn from these few specimens as to any special predilection of gold for particular sulphide or gangue minerals; nor as to the paragenetic relations of the vein minerals. From the microscopic size of the free gold particles it did, however, appear that much of such gold would escape amalgamation in the milling process, but could be saved in the concentrates. It also appeared probable that the gold was partly in solid solution with the sulphides, as specimens presumably carrying high values, as at the Morning Star mine, showed no free gold under the microscope.

At the Mak Siccar mine, on Manory creek, a lot of exploratory work has been done in an area occupied in part by greenstones and in part by an intrusive, hornblende quartz-diorite stock. The deposits consist mainly of veins of vitreous, drusy quartz, carrying some black tourmaline, and mineralized with pyrite and some chalcopyrite. The quartz veins are partly replacements of the wall-rocks, and the associated pyritic mineralization may extend into these rocks beyond the vein boundaries. The veins occur along shears in both the greenstone and the quartz-diorite; they are very irregular in width, discontinuous in strike, and where observed are fractured and sheared as a result of post-mineral movements. Small ore shipments have been made. Samples from different parts of the workings are reported to have shown high gold assays, especially where chalcopyrite occurs. A company report is quoted[1] as stating that at the top of the shaft in No. 1 level a width of 4½ feet of ore consisted of 2½ feet of solid sulphides on the hanging-wall and 2 feet of a mixture of sulphides, carbonates, and quartz on the foot-wall side and across the full width of 4½ feet gave assays of 1.66 ounces gold and 0.84 ounce of silver a ton. A shipment of 2 tons made from this shoot, in 1934, gave 1.83 ounces of gold and 1 ounce of silver a ton.

The principal workings include two main adit-levels and one sub-level below each adit-level. Only the adit-levels were examined by the writer who visited the property, unaccompanied, on October 6, 1937. The adits are about 365 feet apart, vertically

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[1] Ann. Rept., Minister of Mines, British Columbia, 1933.

(barometric readings), the portal of the upper (No. 1) adit lying about 600 feet north 55 to 60 degrees east of the portal of the lower adit (No. 2). A rough, pace-compass survey was made of these two levels. Just to the east of the portal of the upper adit is a vein, several feet wide, of vitreous, drusy quartz, containing black tourmaline, scattered pyrite cubes, and stained with brownish black manganese (?) oxide. The quartz is somewhat sheared and is along a shear striking about north 30 degrees east which is followed by the adit for 170 feet or more. The shear is in quartz diorite, dips westerly at 50 to 60 degrees, and contains irregular, mostly small, bodies of quartz. At about 150 feet from the portal a crosscut driven easterly for 45 feet encounters another shear about 6 feet wide containing considerable quartz. This shear is apparently about parallel with the other, but seems to dip more steeply. North of the crosscut intersection it is evident that considerable work has been done both above and below the level, but little mineral can now be seen. The foot-wall rocks are greenstone, the hanging-wall rocks, quartz diorite.

The lower, main adit is driven north-northeasterly, mainly in quartz diorite and along a very irregular course for about 600 feet, and then swings sharply to the east and, 120 feet farther, encounters a heavy shear in greenstone. The shear is parallel with those in the upper adit and dips about 48 degrees westerly. North of the crosscut intersection there is, again, evidence of considerable work above and below the level. South of the intersection the shear has been followed for 100 feet, in which distance there is little mineral in evidence. At about 450 feet from the adit portal, a second crosscut, to the east, 110 feet long, encounters a shear in quartz diorite. The shear is about a foot wide, strikes parallel to the others mentioned, dips 45 degrees westerly, is not noticeably mineralized, and has been followed for only a few feet. According to a plot of the writer's rough survey this shear is directly in line with the other on this level, on which work has been done, and about 300 feet from the south end of the south drift in those workings. From the plot, however, it was not certain with which of the two shears encountered in the upper adit level this shear explored at the lower level corresponded. An interesting feature, however, was the apparent regularity and persistence of these shears in an area of rocks which otherwise, as explored along most of the lower adit-level, is intersected by shears and fault-fractures striking and dipping in different directions and giving the appearance of great irregularity to the rock structures. On the other hand, the shattered character, irregular form, and apparent lack of persistence of the quartz vein deposits, as exposed in these workings, with which the mineral deposits seem definitely associated, suggests that such ore-bodies as are encountered are apt to be small.

On the Bluehawk property lying west of Okanagan lake north of Lambly (Bear) creek, a number of small workings investigate scattered vein deposits of shattered, vitreous quartz. The veins vary from a few inches to several feet wide and have not been traced far. They are mineralized, in places, with pyrite, a little galena, and dark, oxidation products. Picked samples are reported to have assayed from 0.20 ounce to nearly an ounce in gold, but such assays appear to be spotty and the average tenor of the veins quite low. The deposits occur in an area of old sediments and greenstones, the latter including bodies of related, dioritic intrusives. To the north they are close to a large mass of younger granodiorite.

Miscellaneous Quartz Veins

9. Golden Zone. Camsell, Chas.: The Geology and Ore Deposits of Hedley Mining District; Geol. Surv., Canada, Mem. 2, pp. 204-206.
Annual Report of the Minister of Mines, British Columbia, 1930, pp. 216-217; 1931, p. 113; 1932, p. 139.

16. King Edward. Annual Report of the Minister of Mines, British Columbia, 1921, pp. 178-179.

20. Horn Silver. Bostock, H.S.: Horn Silver Mine, Similkameen, B.C.; Geol. Surv., Canada, Sum. Rept. 1927, pt. A, pp. 47-52.
Annual Report of the Minister of Mines, British Columbia, 1925, p. 209; 1926, pp. 215-217; 1927, p. 237; 1928, pp. 258-259; 1929, p. 268.

Under this heading are included a number of widely separate vein deposits in which, though gold may be present, the values in one or more other metals are equally or more important. Among them may be included the properties referred to above, as well as the Bathfield Silver Lode claim in Trout Creek valley and the Silver Star group in Similkameen valley. The Golden Zone quartz veins, already classified among the gold-bearing veins, might equally well be included here as their gold content is low, whereas their appreciable content of sphalerite lends them some interest as zinc-bearing deposits.

The veins of this group carry a greater proportion and, in part, a greater variety of ore minerals than those of the preceding group. The principal metal or metals in the different deposits may be indicated as follows:

6	Bathfield Silver Lode	- silver, lead
9	Golden Zone	- zinc, gold
16	King Edward	- copper, molybdenum
19	Silver Star	- silver
20	Horn Silver	- silver, gold

On the Bathfield Silver Lode claim a number of narrow quartz veins and stringers striking in different directions occur in a large body of granodiorite. The quartz is drusy and crystalline and contains considerable galena, grey copper, pyrite, hematite, copper carbonates, and probably some sphalerite and chalcopyrite. The deposit, as developed, is not economic, but is of interest as indicating the type of mineralized quartz veins characteristic of a large area of granitic rocks in Trout Creek valley and neighbouring areas. The nearby deposits of the old Kelly mine contain very similar quartz veins, but as a whole the occurrences there belong rather to the type of mineralized shear zones and will be referred to later under that heading.

The Golden Zone quartz veins have already been referred to. The principal vein (or veins) has been traced easterly for several hundred feet, averages about 2 feet wide, dips very steeply south, and is composed of vitreous, drusy quartz conspicuously mineralized with coarsely crystalline, black sphalerite as well as pyrite and chalcopyrite. The vein is faulted in places and cuts across granite and metamorphosed sediments, but the value of the zinc has not been estimated. Gold up to $2 or $3 a ton is reported.

Most of the work on the King Edward group was done many years ago, but in 1918 it is reported that the King Edward claim of the group was further explored as a molybdenum prospect. There is no record of any production, but picked samples give high assays in copper and molybdenum and at one point samples across 4 feet of quartz are reported to have assayed 1.60 per cent copper. The principal deposit occurs in and near the southern edge of a small body of alkaline intrusives surrounded and invaded by granodiorite. The deposit consists of stringers, veins, and irregular masses of quartz mineralized with magnetite, chalcopyrite, and molybdenite. Molybdenite occurs also along small fractures in the adjoining wall-rocks. Mineralization evidently took place under rather high-temperature conditions and was probably introduced into the alkaline rocks from the surrounding granodiorite.

The deposits at the Silver Star and Horn Silver properties are of essentially similar types. Both consist of mineralized quartz veins in alkaline intrusives and in both the principal values are in silver. A few tons only have been shipped from the Silver Star, one shipment of 12 tons averaging $18 a ton in silver and another shipment of 1 ton $38. The deposit is a quartz vein following a shear and mineralized with grey copper, galena, chalcopyrite, sphalerite, and molybdenite.

The Horn Silver mine has produced several thousand tons of ore. This has varied in its silver content from about 25 to 700 ounces a ton, the richest ore being obtained near the surface where there was an important concentration of native silver. Values in gold have been mostly low, but have run up to over an ounce a ton. The principal deposit is a low-dipping, much-faulted quartz vein about 3 feet wide and several hundred feet long. The quartz is milky white and crystalline; is drusy in places, and carries some calcite. It is associated, in most places, with fragments, streaks, and bands of brecciated and altered wall-rock in which pyrite may generally be observed. The quartz is mineralized with pyrite, sphalerite, chalcopyrite, galena, grey copper, hematite, and native silver. Argentite and pyrargyrite are also reported. According to Bostock[1] the ore consists of sections of the vein richer in sulphides in general and native silver in particular.

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[1] Bostock, H.S.: Horn Silver Mine, Similkameen, B.C.; Geol. Surv., Canada, Sum. Rept. 1927, pt. A, pp. 47-52.

Mineralized Shear Zones

7. Kelly. Annual Report of the Minister of Mines, British Columbia, 1906, p. 172; 1926, p. 200; 1927, p.476.

12. Olalla Camp; Golconda. Annual Report of the Minister of Mines, British Columbia, 1917, p. 206; 1922, pp. 162-163; 1927, p. 239; 1930, p. 218.

Gold Valley. Annual Report of the Minister of Mines, British Columbia, 1932, p. 138.

Dolphin. Annual Report of the Minister of Mines, British Columbia, 1916, p. 260; 1917, p. 215; 1918, p. 211; 1922, p. 162.

23. Dayton Camp. Cockfield, W.E.: "Lode Gold Deposits of Fairview Camp, Camp McKinney, and Vidette Lake Area, and the Dividend-Lakeview Property near Osoyoos, B.C."; Geol. Surv., Canada, Mem. 179, p.19. Annual Report of the Minister of Mines, British Columbia, 1926, p. 211; 1928, p. 256; 1929, p. 259; 1930, p. 221.

25. Lemon Camp. Annual Report of the Minister of Mines, British Columbia, 1897, p. 607; 1930, p. 221.

28. Jo Dandy. Annual Report of the Minister of Mines, British Columbia, 1927, p. 234.

31. Beaverdell Camp. Reinecke, L.: "Ore Deposits of the Beaverdell Map-area"; Geol. Surv., Canada, Mem.79 (throughout).

Nepanee. Annual Report of the Minister of Mines, British Columbia, 1925, pp. 207-208; 1928, p. 253.

Rambler Fraction, etc. Annual Report of the Minister of Mines, British Columbia, 1925, p. 206; 1926, p. 209; 1927, p. 233.

Bounty. Annual Report of the Minister of Mines, British Columbia, 1925, p. 205; 1926, p. 209; 1927, p. 233; 1928, p. 253.

Wellington. Annual Report of the Minister of Mines, British Columbia, 1925, p. 206; 1926, p. 209; 1927, p. 233; 1928, p. 254; 1929, p. 262; 1930, p. 220; 1931, p.123; 1935, pt. D, p. 14.

Sally. Annual Report of the Minister of Mines, British Columbia, 1925, pp. 204-205; 1926, p. 209; 1927, p. 233; 1928, p. 254; 1929, p. 261; 1930, p. 214; 1934, pt. D, pp. 9-10.

Beaver. Annual Report of the Minister of Mines, British Columbia, 1926, pp. 206-208; 1927, p. 232; 1928, pp. 253-254; 1929, p. 262.

Bell (And Highland Lass). Annual Report of the Minister of Mines, British Columbia, 1925, p. 204; 1926, p. 208; 1927, p. 233; 1928, p. 252; 1929, pp. 260-262; 1930, p. 214; 1931, p. 123.

32. Dollar Camp. Annual Report of the Minister of Mines, British Columbia, 1923, p. 184; 1925, pp. 199-200; 1928, p. 252; 1930, p. 220; 1931, p. 24; 1933, p.154.

34. Carmi Camp. Annual Report of the Minister of Mines, British Columbia, 1930, p. 220; 1931, pp. 123-124; 1933, p. 154; 1934, pt. D., pp. 10-11.

Many of the mineral deposits in the map-area occur along shear zones and several of them have proved economically important. The shear zones occur in both the Okanagan intrusives and in pre-batholithic formations. They vary from such as are simple fault-fissures, along which more or less shearing and brecciation of the wall-rocks have occurred, to wide belts of sheared ground within which there may be several significant fissures. Mineralization occurs both as vein deposits along the fissures and as sulphide impregnations in the adjoining wall-rocks. In general the veins have proved the more important economically, as at Beaverdell camp, and, on the whole, those in the intrusive rocks are more valuable than those in the older formations. Among the older rocks the greenstone bodies are the most common host rocks of the shear zones and are the rocks most susceptible to alteration and replacement by the mineralizing solutions. The principal gangue mineral of the veins is quartz, but it is commonly in minor proportion to the ore minerals in at least those parts of the veins that constitute the ore deposits. Individually, too, the veins are smaller and less continuous than those included with the preceding groups, but may make up for this deficiency by occurring in numbers so closely spaced as to be developed together. In the associated, replacement deposits, the wall-rocks are usually highly altered. Ankerite, chlorite, and sericite are common alteration products, the first particularly characteristic in greenstone formations where it is not uncommonly associated with a disseminated, bright green, flaky mineral resembling mariposite.

Collectively, these deposits contain a great variety of ore minerals and any one deposit may contain most of them, the value or values depending on their proportions. Based on these values the various deposits of this group may be classified as follows:

A. Silver-lead-zinc deposits

B. Gold-silver-lead-zinc-copper deposits

C. Gold and copper deposits

D. Copper-molybdenum deposits

A. Silver-Lead-Zinc Deposits. Deposits of this type have proved most important. They are represented by most of the properties in the Beaverdell camp, to which references have already been made. The geology and mineral deposits of this camp have been described in some detail by Reinecke[1] who states that to the end of the year 1911 ore to the value of nearly $100,000 had been shipped. Since that time the production has been valued at many times this amount. The chief productive area, less than a mile long, has included, from west to east, the adjoining Wellington, Sally, Rob Roy, Bell, and Highland Lass properties. From the Bell mine, the largest producer, the gross value of production, mainly from about 1918 to 1929, has been estimated at over $1,000,000. The Sally property was the principal producer prior to 1911 and has continued shipments up to recent years; from 1918 to 1928 records indicate that these have exceeded 4,000 tons of ore averaging 290.5 ounces of silver a ton. Other important producers have been the Wellington and Rob Roy (and Pueblo fraction). From 1919 to 1925 the latter produced some sixty-four cars of ore averaging about 300 ounces of silver a ton; included in this was one car of fifty tons representing the richest ore mined at this camp in recent years, averaging 608 ounces in silver a ton and 10 per cent lead. In 1935, 510 tons of rich ore shipped from the Wellington afforded

[1]Reinecke, L.: Ore Deposits of the Beaverdell Map-area; Geol. Surv., Canada, Mem. 179.

profits from which 100 per cent dividends were declared. Other productive properties have included the Rambler, Bounty, Tiger, and Beaver.

The mineralized shear zones at this camp strike mainly about east to northeast, dip south, and vary from about 1 to 10 feet wide. They are composed of sheared and brecciated rock, partly altered and replaced, and vein filling. The filling may form distinct, single, parallel or linked veins or an irregular matrix to the rock fragments; it consists of ore and gangue minerals, the latter chiefly quartz but including some carbonates, generally calcite, and, rarely, a little fluorite. The ore minerals are partly distributed through the gangue and partly form masses of mixed sulphides; the latter constitute the bulk of the ore-bodies and form much of the principal ore shoots. The abundant sulphides are galena, sphalerite, pyrite, and grey copper, but one or more of the following may be present - ruby silver, polybasite, and argentite. Native silver is also present in the richer ore-bodies. Where quartz predominates pyrite commonly increases in comparison with other ore minerals and silver values drop. The lead and zinc content of the ores may run up to 10 per cent, each, of the ore shipped, but have this distinction that whereas the lead content is paid for by the smelters a penalty has been exacted for the zinc content. Values have been principally in silver and for the deposits as a whole have averaged 150 to 200 ounces a ton.

The mineralized shear zones are mainly in batholithic intrusives, referred to locally as the Westkettle quartz diorite. None has been found in nearby intrusive masses of the Tertiary, Beaverdell batholith and few of consequence in the pre-batholithic rocks. In a number of places, however, fine-grained, grey to greenish grey, andesitic dykes are intruded along the shear zones and, in places, ore is developed in them. According to Reinecke[1]

[1] Op. cit., pp. 89-90.

these dykes are not found intruding the Tertiary batholithic rocks and are believed to be older.

The shear zones and their contained ore-bodies are intersected by abundant post-mineral faults. These may strike or dip in any direction, but a principal set strikes northerly and dips in most cases westerly at angles of 30 to 50 degrees. These faults are commonly spaced at intervals of 10 to 50 or 60 feet; are normal faults; and displacements along them amount, generally, to only a few feet. Stronger faults have been encountered and in some places the ore-bodies displaced have not been picked up. The numerous faults and the irregular disposition of the ore-bodies within the shear zones are features that have resulted in a great deal of "dead" work in mining the deposits. This and the fact that the ore is hand-sorted for shipment and may be handled several times before shipment, have meant that mining costs are high and it is a tribute to the rich character of the ores that in spite of such handicaps handsome profits have been made from mines in this camp.

Underground workings are extensive at the principal productive properties, but in no case have been carried to a depth of more than a few hundred feet. Little definite information is available as to changes in the character of the ores at depth, but there is the suggestion, as pointed out by Reinecke,[1] that at greater depths they may change in type to ores more resembling those of Carmi in which quartz is an abundant gangue mineral, pyrite and chalcopyrite the conspicuous sulphides, and values principally in gold.

Other properties than those of Beaverdell camp on which silver-lead deposits have been found include the Kelly mine on Trout creek near Summerland; and the Sunrise and Donkey and Jo Dandy groups of claims near Westbridge.

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[1] Op. cit., pp. 108-109.

The workings at the Kelly mine are inaccessible, but the deposits, from which small shipments of ore were made in 1926 and 1927, occur along a shear zone in granodiorite. A little mineralization seen at the surface consisted of stringers of mineralized quartz and a little disseminated sulphides through the sheared and altered rock. The ore minerals noted are grey copper, galena, sphalerite, and copper carbonates. The shear zone strikes north to northwesterly, dips to the northeast at about 30 degrees, and, where best seen, is about 2 feet wide.

A lot of exploratory work has been done on the Sunrise and Donkey groups, that on the former mainly in greenstone and on the latter principally in sediments. One of the Sunrise workings encountered a small ore-body in a shear zone striking northwesterly. A shipment in 1916 is reported to have carried silver values averaging $200 a ton. The ore consisted of a mixture of galena, sphalerite, pyrite, grey copper, and chalcopyrite in a gangue consisting mainly of quartz.

On the Jo Dandy group a silicified shear zone containing both massive and banded quartz strikes northerly across quartzitic sediments and dips about 35 degrees west. It is mineralized with pyrite and galena and is reported to carry low gold values. Elsewhere on the property veins, stringers, and lenses of quartz occur along shears parallel to the schistosity of the enclosing rocks and are mineralized with galena, sphalerite, and pyrite. The veins vary from less than 1 inch to 2 feet wide. Samples of the vein matter are reported to have assayed from a trace to 0.05 ounce in gold and from 1.4 to 19 ounces in silver a ton, 4 to 10 per cent lead, and 2 to 11 per cent zinc.

<u>B. Gold (Silver-lead-zinc-copper) Deposits</u>. The mineral deposits of the Carmi and Butcher Boy properties at Carmi occur in the same intrusive body and under structural conditions very similar

to those of the neighbouring Beaverdell camp. The Carmi deposits, however, contain more quartz and the chief ore mineral is pyrite. Other minerals include sphalerite, chalcopyrite, galena, and some molybdenite. Both are old properties and the principal production was from the Carmi mine in 1901 when 885 tons shipped to the smelter at Greenwood averaged over an ounce in gold and about 4 ounces in silver a ton. Shipments of 270 tons are also recorded in 1933 and 55½ tons in 1935, the latter averaging about 0.33 ounce in gold and 2 ounces in silver a ton. From the adjoining Butcher Boy property, a car-load shipment in 1931 was valued at $28 a ton; in 1934, 110 tons were shipped and averaged about 0.62 ounce in gold and 2 ounces in silver a ton. Reinecke believed that upper, eroded parts of the mineral deposits on these properties may have been similar to the rich, silver-lead ores of Beaverdell camp.

Other properties that may be included here are the Nepanee, Inyo and Ackworth, Lucky Boy (Titanic), and perhaps, also, certain showings on Arlington mountain.

The Nepanee group of claims lies near the southeastern border of the Beaverdell camp, but unlike the principal deposits of that camp is in an area of the Wallace group of pre-batholithic rocks. The mineral deposits occur in a highly-fractured body of hornblende diorite porphyry and consist of a network of irregular veins and veinlets of mineralized quartz and of sulphides following the fractures, and, to some extent, replacing the wall-rock. Picked samples of the quartz veins have carried gold and silver and an important content of lead and zinc. The sulphide deposits contain gold and silver as well as considerable copper. They consist, mainly, of pyrite, chalcopyrite, and arsenopyrite in disseminated and vein-like form through the broken wall-rocks.

The Inyo and Ackworth, and Lucky Boy properties of the Dollar camp are on Cranberry ridge, west to northwest of Beaverdell camp and in the same body of granitic rocks. Here are shear zones carrying considerable vein quartz and mineralized with pyrite, galena, sphalerite, and chalcopyrite. From the Inyo and Ackworth small shipments were made in 1925 and 1927, the latter reported to carry about half an ounce in gold a ton, a few ounces in silver, and fair percentages of zinc and lead. On the Lucky Boy property values, as indicated by samples, have been principally in silver and copper.

C. Gold and Copper Deposits. Mineralized shear zones in which one or both of gold and copper are of principal importance occur at the Dayton and Lemon camps near Camp McKinney, the Golden Gate prospect near Rock creek, the Gold Valley and Dolphin properties near Olalla, the Crater Lake property near Beaverdell, and certain prospects on Arlington mountain northeast of Carmi.

At the Dayton camp considerable work, in the aggregate, was done years ago on the Jim Crow, Le Roi, War Eagle, and Dayton claims. Underground workings are now mostly inaccessible. Here shear zones, 3 to 4 feet wide, strike northwesterly across greenstone rocks near the northeast contact of a body of quartz diorite. The shear zones carry very little vein quartz and the sheared greenstone and more massive wall-rocks are partly altered to ankeritic carbonate. The sulphides are mainly pyrite and some chalcopyrite. A shipment of about 40 tons from the Dayton in 1916 is reported to have carried 2 ounces of gold and 5 ounces of silver to the ton and 5 per cent copper.

At the Lemon camp to the northeast of Camp McKinney some work was done about forty years ago on the old Victoria, Old England, and Snowdon claims and it is reported that several car-loads of high-grade gold ore were shipped. The workings are not accessible, but apparently explored a shear zone 2 to 12 feet wide containing veins and stringers of mineralized vein quartz from which, it is believed, most of the ore was derived. The principal ore mineral is pyrite, but chalcopyrite and galena are present and some free gold. More recently work has been done on the Gold Standard group of claims to the west and, principally, on the Ogofan claim. Here a shear zone, 4 feet wide, in greenstone, carries stringers of quartz and is mineralized with pyrite, chalcopyrite, galena, and sphalerite. A little free gold is also reported. The shear zone strikes north 35 degrees east and dips 60 degrees southeast. The wall-rock is partly altered to ankeritic carbonates and a bright green mineral resembling mariposite.

The Golden Gate prospect is in sheared greenstone containing narrow quartz stringers striking northwesterly and dipping northeast. The quartz is sparsely mineralized with pyrite, galena, and sphalerite. No assays have been recorded.

At the Gold Valley Mines property near Olalla a wide belt of brecciated and sheared sediments follows westerly up the valley slope near the south contact of a body of pyroxenite. The breccia is partly cemented and irregularly veined with quartz and sparsely mineralized with pyrite. A lot of exploratory work has been done and high assays in gold reported from samples of the quartz and cemented rock breccia.

The Dolphin property, including the Dolphin and Spar Fraction claims, lies east of Olalla within, but near, the south-eastern border of a body of pyroxenite. The rocks have been crushed and sheared and mineralization has followed some of the fractures and been displaced by others. The principal ore minerals are chalcopyrite and pyrite and values are principally in copper with some silver and gold (?). Shipments are recorded in 1916, 1917, and 1918. In 1916 a car of ore (about 40 tons) yielded a net return of $837.56. In 1917, 80 tons were shipped and had a gross value of $35 a ton. In 1918, 46 tons were shipped and carried 1.50 ounces in silver to the ton and 6.2 per cent copper.

The Crater Lake property is a new prospect. On the Balaclava claim, the principal work has been done on a mineralized fracture zone striking northwesterly across quartz diorite and a dark, fine-grained, low-dipping, narrow dyke. Both the quartz diorite and dyke carry irregular, small lenses and veins of ore consisting of mixed sphalerite, pyrite, chalcopyrite, and magnetite (?). Samples of this material are stated to have yielded high gold assays--the maximum reaching to 6 to 8 ounces a ton and as much as 5 per cent copper.

Showings on Arlington mountain are said to occur in somewhat the same type of shear zones as those at Carmi.[1] On the Arlington claim an east-west shear zone carrying quartz and mineralized with chalcopyrite and pyrite intersects a body of pyroxenite. Silver and copper have been reported. Other, mineralized shear zones are in quartz diorite.

D. Copper-Molybdenum Deposits. The principal deposits of this type are on the Golconda claim about a mile northwest of Olalla. They occur within a shear zone in a body of pyroxenite near its northwest contact with a body of granodiorite. The shear zone strikes northwesterly, dips vertically, varies from about 2 to 10 feet wide (averaging about 4 feet) and is marked on either wall by 2 to 3 inches of gouge. The shear zone is partly occupied by a quartz ledge, perhaps of pegmatitic origin, carrying considerable feldspar[2] and mineralized with pyrite, chalcopyrite, and molybdenite. The ore minerals are partly disseminated through the ledge and associated rocks of the shear zone and occur partly as veins and lenses of nearly solid sulphide, mainly chalcopyrite. Small shipments are recorded in 1917 and 1918. In 1917, 3,390 pounds of

[1] Reinecke, L.: Ore Deposits of the Beaverdell Map-area; Geol. Surv., Canada, Mem.79, p. 129.

[2] Bostock, H.S.: Personal communication.

molybdenite ore contained 17.1 per cent molybdenum and 2 tons of copper ore carried 19 per cent copper. In 1918, a shipment of 10 tons of copper ore yielded 1.7 ounces of silver a ton and 18.6 per cent copper.

Replacement Deposits

Golden Zone. Camsell, Chas.: The Geology and Ore Deposits of Hedley Mining District, British Columbia; Geol. Surv., Canada, Mem. No. 2, pp. 204-206.
Annual Report of the Minister of Mines, British Columbia, 1930, pp. 216-217; 1931, p. 133; 1932, p. 139.

Olalla Camp; Copper King. Annual Report of the Minister of Mines, British Columbia, 1917, p. 206.
Bullion. Annual Report of the Minister of Mines, British Columbia, 1910, p. 124; 1928, p. 261.

Osoyoos Camp. Cockfield, W.E.: Lode Gold Deposits of Fairview Camp, Camp McKinney, and Vidette Lake Area, and the Dividend-Lakeview Property near Osoyoos, B.C.; Geol. Surv., Canada, Mem. 179, pp. 20-26.
Annual Report of the Minister of Mines, British Columbia, 1913, pp. 172-174; 1927, pp. 237-238; 1930, p. 218; 1931, p. 135; 1932, p. 134; 1933, p. 164; 1934, pt. D, p. 13; 1935, pt. D, p. 12.

Under this heading are included a number of widely separate deposits, some of which have proved economically important and all of which owe their occurrence mainly to replacement processes. They differ from other deposits in the area in which replacement has been a contributory, and perhaps important, factor in mineralization, in that (1) their occurrence is attributable only in a small way to vein formation or to deposition along fractures or shear zones; (2) they consist mainly of either solid or nearly solid masses of ore minerals or of highly altered rock heavily charged with such minerals; (3) their shape and size are determined by that of the rock body replaced or by structures within such a body rather than by the extent to which this body has been fractured prior to mineralization; (4) by the fact that the most common replaced rock is limestone; and (5) by a somewhat distinctive suite of both ore and gangue minerals including among the former arsenopyrite, pyrrhotite, and magnetite and, among the latter, an abundance of lime-silicates such as garnet (chiefly andradite), epidote, diopside, and less commonly, vesuvianite, wollastonite, and others. Other ore minerals include abundant pyrite and, in places, sphalerite and chalcopyrite with lesser galena, molybdenite, and, rarely, free gold. In general, gold values have proved most important, as at the Golden Zone and Osoyoos camp, but to some extent, one or more of zinc, copper and arsenic may provide contributory values or, locally, be the most important. At all the properties the deposits lie near or at the contacts of granitic intrusives and these, presumably, represent the source of mineralization.

To date the most important deposits of this type are those at Osoyoos camp as developed on the Dividend, Lakeview, and Manx claims. They have been described at some length in the references listed above. Quite an amount of surface and underground work has been done in the aggregate, but only to maximum depths of a few hundred feet. Most of this work has been done on the Dividend and Lakeview claims. Production has been mainly in the years 1911 to 1913 and since 1934 and has been principally from the Dividend claim. Records indicate that in 1911 two cars of ore were shipped from the Lakeview dump and averaged $8 a ton in gold and copper; in the same year eight cars from the Dividend claim ran $15 a ton in gold. In 1911 or 1912, eight cars from the Dividend averaged $17.14 and eight cars, in 1913, averaged $24.34 a ton. Recently an old 10-stamp on the property was rebuilt as a pilot mill to handle about 45 tons a day. It ran for a short period in 1935 and was operating again in 1936. In the interim about 2,300 tons of ore from the Dividend was treated on a custom basis at the Morning Star mill at Fairview.

The ore deposits on the Dividend claim are partly in limestone and partly in greenstone, the latter including both fine-grained types and related crystalline, dioritic intrusives. The structures controlling the formation of the deposits have not been worked out, but the deposits themselves have been partly outlined by underground workings and diamond drilling. The principal deposit extends to the surface and was mined from a glory hole connected, later, with a level 40 feet below from which considerable stoping was done. Three other levels, the lowest 190 feet below the outcrop, have partly investigated the continuity of this deposit and the occurrence of others. At the lowest level a marked change from comparatively massive to, in part, highly sheared and schistose rocks has proved a structural problem the significance of which is not yet known.

The ore minerals in the Dividend deposits are pyrrhotite, pyrite, chalcopyrite, arsenopyrite, and magnetite. These occur in varying proportions with pyrrhotite, in general, most abundant. Nearly solid masses of pyrrhotite, up to several feet thick, were observed, but carry only a little gold. Best gold values are associated with chalcopyrite and arsenopyrite, and with pyrite where the gangue is mainly coarsely crystalline calcite. Assays up to 3 ounces in gold are obtained locally. The principal ore shown[1] is on the walls of the long, east-west stope above the 40-foot level and in No. 1 level 20 feet below. Sampling of the walls of No. 1 level is reported to show an average value of nearly 0.67 ounce of gold across an average width of 5 feet and for a length of 120 feet. This ore-body is picked up on No. 2 level, 30 feet below No. 1, but has not been encountered in workings on the lowest level, 100 feet below No. 2 level.

On the Lakeview claim the rock formations, as seen at the surface and as encountered in the upper of two adit-levels,

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[1]Cockfield, W.E.: Lode Gold Deposits of Fairview Camp, Camp McKinney, and Vidette Lake Area, and the Dividend Lakeview Property, near Osoyoos, B.C.; Geol. Surv., Canada, Mem. 179, p. 23.

are mainly massive greenstones and altered limestone rocks, whereas in the lower adit-level the formations are principally sheared, schistose rocks and, in part at least, are of doubtful origin. The change is analogous to that observed in the lowermost, Dividend workings and similarly in these workings the downward continuation of the ore developed in the more massive rocks has not been picked up. The upper level of the Lakeview mine has exposed a substantial ore-body striking about east and, apparently, dipping southerly at a low angle. The ore consists of highly altered rocks heavily charged with ore-minerals, principally pyrite, with some chalcopyrite. In the main drift, for a length of 60 feet or more, sampling has indicated gold values ranging from 0.09 to 0.66 ounce over widths of 3 to 6 feet. In places widths of as much as 25 feet are stated to have shown values of $14.50 a ton in gold, at $35 an ounce.

On the Manx claim a large body of limestone is altered to lime-silicate minerals consisting, mainly, of garnet. Locally within this mass and surrounding greenstone are concentrations of ore minerals, attended by some quartz gangue, in which assays in gold, ranging from 0.05 to 0.33 ounce a ton across average widths of about 5 feet, have been obtained.

Other properties containing deposits of similar origin to those at Osoyoos include the Golden Zone, northwest of Nickel Plate lake, the Copper King and Bullion properties near Olalla, and the Iron Horse and Bluebell properties in the valley of Peachland creek.

The Golden Zone has already been referred to in connexion with its mineralized quartz veins, but its principal deposits are replacement ores in highly altered sediments, chiefly limestone, near the contact of a large body of granite. The deposits occur in a mineralized zone, 300 feet long and, probably, several feet in average width. The belt strikes east and dips south at about

70 degrees. It has been explored by shafts, open-cuts, and diamond drilling. The ore consists of highly altered rock heavily charged with pyrite and arsenopyrite and lesser chalcopyrite and contains some free quartz. The two principal sulphides occur both coarse- and fine-grained, both massive and disseminated, and both are stated to carry good values in gold. No free gold has been reported and none was seen in a specimen of the ore studied under the microscope. Average assays are not known. An open-cut near the west end of the belt exposes a width of 12 to 13 feet of ore which was stated to average half an ounce in gold a ton. This showing was intersected by diamond drilling at 145 feet below the surface where it was stated to have an indicated width of 10 feet and to average about 0.30 ounce in gold a ton.

The Copper King property, west of Olalla, is reported to have good surface showings of chalcopyrite-magnetite ore in a limestone body close to the contact of intrusive granodiorite. Four tons shipped to the smelter at Grand Forks about 1917 averaged $24 a ton in silver and copper. On the Bullion property, one-half mile east of Olalla, limestone remnants in contact with pyroxenite were reported to carry an emerald-green mineral identified as the hydrous, nickel carbonate, zaratite. It is reported that 10 tons of ore were shipped from this property in 1910. Returns were not given.

The Peachland Creek deposits are mainly the result of limestone replacement near the contact of a large body of quartz diorite. Within the Iron Horse group of six claims, large bodies of crystalline limestone occur on the summit and for some hundreds of feet down the slopes of the ridge between Greata and Peachland creeks. Several showings of heavy sulphide deposits have been exposed by surface workings. An open-cut on the south slope of the ridge, about 1,000 feet above Greata creek, exposes a band of nearly solid sulphide, 10 feet wide, striking westerly and dipping northerly, into the hill, at about 70 degrees. It is composed, mainly, of mixed pyrite and arsenopyrite with some chalcopyrite. Other showings of somewhat similar deposits were observed higher up the ridge and on the summit. It is reported, also, that a considerable body of heavy, sphalerite ore is exposed on the north slope within a few hundred feet of the summit of the ridge. Samples from these deposits are stated to give low assays in gold.

On a property (No. 4) near Greata creek, large bodies of limestone have been altered to rock composed mainly of reddish brown garnet associated with some calcite and epidote and containing sparsely disseminated pyrite and molybdenite.

Scattered occurrences of sulphide-rich deposits of indefinite form, occurring partly in limestone and partly in greenstone rocks, have been investigated on the Bluebell group of four claims east of Peachland creek by a number of open-cuts, short adits, and diamond drill holes. The showings have a vertical range of several hundred feet. Mineralization is chiefly by pyrite and pyrrhotite with lesser sphalerite and chalcopyrite and a little galena. A little native copper, probably of secondary origin, has also been reported. It is stated that samples from the different showings have given low assays in gold and that selected material has run from $9 to $18 a ton in combined metals, chiefly zinc and gold. The aggregate amount of sulphide on this property is undoubtedly great, but there is no evident system to the several occurrences and no single deposit seems to be large.

Elsewhere in the area, as in the valley of Trepanege creek and on the divide between Trepanege and Peachland creeks, a little pyrite has been observed in roof pendants of pre-batholithic formations near their contacts with granitic intrusives.

Magmatic Segregations

Annual Report of the Minister of Mines, British Columbia, 1928, p. 251.

The only known mineral occurrence of this type in the area is a chromite deposit on the west side of the main Kettle river about 4 miles north of Rock creek. Here, chromite occurs disseminated through a body of serpentine and is more concentrated in one small area where a little work has been done. The deposit is of doubtful economic importance. A very similar type of deposit occurs just beyond the northern boundary of the area on the continuation of a narrow band of ultrabasic rock (partly serpentinized peridotite) shown on the map in the vicinity of Cameo (Cameron) lake. This deposit is described in some detail in the Summary Report of the Geological Survey for 1931, part A, pages 94-95.

Non-metallic Deposits

A number of non-metallic deposits have been found within the area. A few occurrences have proved valuable; others have some prospective value; and still others, of little or no value in themselves, are of interest in directing attention to their mode of formation and to the geological associations favourable to their occurrence.

Coal

Cairnes, C.E.: Mineral Resources of Northern Okanagan Valley, B.C.; Geol. Surv., Canada, Sum. Rept. 1931, pt. A, pp. 100-108.

Camsell, Charles: The Geology of Certain Portions of Yale District, British Columbia. Geol. Surv., Canada, Sum. Rept. 1912, pp. 213-216.

Annual Report of the Minister of Mines, British Columbia, 1920, pp. 158-159; 1922, pp. 165-166; 1926, p. 219; 1931, p. 136; 1933, p. 172.

Coal has been found in Tertiary sediments in different parts of the area, but except at one locality the discoveries have no commercial attraction. Farther north, in northern Okanagan valley, coal deposits of similar origin are described in some detail in the first reference listed above. In the present area the significant deposits are those of White Lake Collieries at White lake. No work has been done on them, to the writer's knowledge, since about 1933 and no attempt was made to examine the workings. The occurrences have been described, in some detail, in earlier reports and indicate that several seams of coal, the widest about 5 feet, have been discovered in a local basin of Tertiary sediments which appears to correspond, stratigraphically, with the Shorts Creek coal measures of northern Okanagan valley. Analyses indicate a high-volatile, bituminous coal with high ash and moisture content. Clay partings are common in the wider seams and, locally, the coal contains considerable pyrite. Work in 1933 is reported to have encountered a new, 4-foot seam of cleaner coal than the others. A few shipments have been made to local points, with, it is stated, satisfactory results. The field was first opened up about 1900 and most of the development work was done prior to 1927.

Petroleum

Cairnes, C.E.: Mineral Resources of Northern Okanagan Valley, B.C.; Geol. Surv., Canada, Sum. Rept. 1931, pt. A, pp. 108-109.

Annual Report of the Minister of Mines, British Columbia, 1932, p. 144.

On the south bank of Mission creek, about 6 miles southeast of Kelowna, a well has been drilled to a depth of over 2,700 feet (July 1936) in search for oil and gas. Geological conditions, as pointed out in earlier reports, are quite unfavourable. The well has passed through Tertiary sediments into, apparently, hornblende granite gneiss of the adjacent Shuswap complex. An analysis (A) of drill sludge[1] taken between 2,530 and 2,538 feet is compared below with an analysis (B) of hornblende gneiss from Guilford quadrangle, Connecticut.[2]

	A	B
SiO_2	66.88	66.91
Al_2O_3	16.42	15.47
FeO) (?)	5.22[1]	3.74
Fe_2O_3)		1.57
MgO	1.33	1.80
CaO	4.24	4.78
K_2O)	3.57	1.29
Na_2O)		1.70
H_2O -) (?)	2.34[2]	0.03
H_2O +)		1.16
Minor constituents	---	1.09
	100.00	99.54

1. Recorded as "FeO_3"

2. Recorded as "ignition loss".

The analyses are of interest as indicating not only support for the belief that the sludge sample came from Shuswap gneiss, for which no other analysis is available, but, also, a remarkable similarity in the composition of gneisses from two such widely separate parts of the continent.

[1] Annual Report of the Minister of Mines, British Columbia.

[2] U.S. Dept. of the Interior, Geol. Surv., Bull. 878, "Analyses of Rocks and Minerals", p. 24.

Asbestos

Camsell, Charles: Parts of the Similkameen and Tulameen Districts; Geol. Surv., Canada, Sum. Rept. 1910, pp. 117-118.

Reinecke, L.: Ore Deposits of the Beaverdell Map-area; Geol. Surv., Canada, Mem. 79, pp. 143-144.

No commercial deposits of asbestos have been found in the area, but different occurrences have been noted and these have indicated the type of rock and, partly, the conditions under which asbestos may be expected to occur. The occurrences to which the above references apply are, respectively, deposits on the south slope of Shuttleworth Creek valley about 2,000 feet above Okanagan valley (Location No. 30 on accompanying map) and deposits on the west side of Hall Creek canyon about 6 miles north-northeast of Carmi in Beaverdell map-area. In both localities the asbestos occurs as veinlets in serpentine of partly serpentinized, ultrabasic, peridotitic intrusives. Distance from convenient transportation and the apparent, limited quantities of serpentine in which asbestos could form render these deposits of little other than technical interest, but do suggest that larger masses of serpentine, in this or neighbouring areas, might be prospected for more substantial deposits.

Manganese

No manganese ore has been found in the area, but a conspicuous deposit of rhodonite (manganese silicate) was observed on the King claim, on Oro Fino mountain. No work has been done on the deposit which, as indicated by outcrops, is irregular in outline and probably lenticular in general form. More than one lens may be present. Exposed parts are altered to black oxide of manganese, but where broken into reveal the typical pink colour of rhodonite. This mineral, when pure, contains 41.9 per cent manganese. It has not been used as an ore of manganese but has been used for ornamental purposes.[1]

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[1]Hanson, G.: Geol. Surv., Canada, Econ. Geol. Series No. 12. Manganese Deposits of Canada, p. 3.

Magnesium Sulphate

Annual Report of the Minister of Mines, British Columbia, 1915, p. 202; 1916, p. 260; 1917, p. 206; 1918, p. 213; 1919, p. 169.

Over 2,000 tons of magnesium salts have been shipped from Spotted lake, 2 miles west of the north end of Osoyoos lake. The deposit has resulted from the evaporation of saline, lake water; covers about half the area of two adjoining mineral claims; and has an apparent average thickness of several feet. The crude product, consisting mainly of magnesium sulphate but including some sodium salts, was trucked south to Oroville, Washington, where it was refined to produce two grades of magnesium sulphate--finer crystals that were used for medicinal purposes and coarser, crystalline material for tanning leather. It is understood that most of the refined, magnesium sulphate was shipped to eastern United States and that the discovery of other deposits in Okanagan valley, in Washington, has destroyed this market for the Spotted Lake deposit. The period of production included the years 1915 to 1920.

An abundance of crystalline epsomite (magnesium sulphate) was observed on the walls of the main adit of Fairview mine, near the portal.

Silica

Annual Report of the Minister of Mines, British Columbia, 1926, p. 219.

From a large deposit of quartz outcropping on the Gypo claim, north of Oliver, shipments of 254 tons are reported to have been made to the Trail smelter for fluxing purposes. This and other uses for large, conveniently situated deposits of quartz are discussed in Report 555, Mines Branch, Dept. of Mines, Canada, by L. Heber Cole in "Silica in Canada, Its Occurrence, Exploitation, and Uses", published 1923.

Limestone

Cairnes, C.E.: Mineral Resources of Northern Okanagan Valley, B.C.; Geol. Surv., Canada, Sum. Rept. 1931, pt.A, p. 99.

The pre-batholithic, sedimentary formations of the area contain many large deposits of limestone. Most of these consist of white or grey, crystalline rocks in deposits ranging from a few feet, or less, to several hundred feet thick and composed of nearly pure, calcium carbonate. Conveniently situated deposits have, in a few places, been used locally, chiefly in the manufacture of lime. Large deposits of limestone occur on either side of Okanagan lake near the north edge of the map-area; in the valleys of Peachland and MacDonald creeks; on the southern slopes of Mission Creek valley; in the valley of Keremeos creek, north-east of Olalla; and in Blind Creek valley, northeast of Cawston. Aside from its peculiar, economic interest in connexion with replacement mineral deposits, limestone has, of itself, a great variety of industrial uses.[1]

Clay

Cairnes, C.E.: Mineral Resources of Northern Okanagan Valley, B.C.; Geol. Surv., Canada, Sum. Rept. 1931, pt. A, pp. 99-100.

Richmond, A.M.: Dept. of Mines, British Columbia, Non-metallic Mineral Investigations, Rept. No. 4, Some Undeveloped Clay Deposits of British Columbia, p. 14 and elsewhere.

The area contains a great variety of clay deposits, some definitely glacial in origin, as the many boulder clay deposits; some deposited from glacial lakes, as the white silts bordering Okanagan lake; some deposited from streams laden with rock flour ground by contemporary glaciers; and some formed in recent times along streams or underlying dried up, or partly dried up, lake bottoms. Depending on their physical and chemical properties various uses may be made of these clays, as outlined in the report by Richmond, cited above. Within the area the only

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[1] Gouge, M.F.: Mines Branch, Dept. of Mines, Canada, "Limestone in Industry", Pub. 719, pp. 43-53.

considerable use being made of clay is at Kelowna where a bank of thinly stratified, clayey, glacial-stream deposits is being utilized for the manufacture of common, red brick. The plant, operated by Wm. Haug and Son, has a daily capacity of 10,000 to 12,000 brick. J.G. Phillips, of the Department of Mines and Resources, Ottawa, has supplied the writer with the following memorandum with respect to this operation:

> "The plant is located about one-half mile easterly from the centre of Kelowna. The clay is taken by gravity from the side of a hill between 200 and 300 feet high. The bank is highly stratified and consists of thin beds of silt, sand, and clay. The run of bank material is taken for production of common brick by the soft-mud process. In gathering the clay, efforts are made to avoid the very sandy layers......This clay works well in the soft-mud process of manufacture, but is considered too silty to be worked satisfactorily by the stiff-mud process."

Diatomite

A deposit of nearly pure diatomite has been discovered by Mr. L.D. Hitchener on his ranch at Glenrosa on the west side of Okanagan lake. It consists of microscopic, siliceous skeletons of freshwater organisms known as diatoms. Where dug into, the deposit is about 3 feet thick, underlying several inches of humus. No attempt has been made to outline its size, but it may cover upwards of 5 acres. It occurs in a swampy area that is being gradually drained.

The uses of diatomite and other features related to its origin and occurrence are covered by V.L. Eardley-Wilmot in Rept. No. 691, Mines Branch, Dept. of Mines, Ottawa, on "Diatomite, Its Occurrence, Preparation, and Uses", published 1928. According to this report the two principal uses of diatomite are as a filtering medium and as an insulator against heat, cold, and sound.

Garnet

Limestone deposits at or near the contacts of granitic intrusives have, in many places in the area, been altered to masses of chiefly lime-silicate minerals among which a brownish red garnet (andradite) is commonly most conspicuous and, in places, may form as much as 90 per cent or more of the altered rock. Such occurrences are common not only in this area but in many localities throughout the province. With the idea that perhaps some of the larger, conveniently situated deposits of this garnet rock might be of use in industry as an abrasive, the writer collected samples from a large body outcropping alongside the motor road up Greata creek, a tributary of Peachland creek, at locality 4 on the accompanying map. These samples were forwarded to the Division of Industrial Minerals, Bureau of Mines, Department of Mines and Resources, Ottawa, for tests. The results are reported on by R.K. Carnochan as follows:

"Four bags of garnet, gross weight 266 pounds, were received on September 8, 1936. The garnet came from the valley of Peachland creek, a western tributary of Okanagan lake, near Peachland, B.C., and was sent in by Dr. Cairnes of the Bureau of Geology and Topography.

"Two of the bags were marked Lot No. 1, and two Lot No. 2, and both lots consisted of brown garnet with very little impurities.

"Tests were required to determine the value of the garnet as an abrasive material.

"Abrasive Paper Tests

"Part of both lots were concentrated by tabling and magnetic separation and garnet paper was made from the cleaned garnet size to -28-35 mesh. The garnet paper was tested by putting it on a drum sander and letting it cut a hardwood block for 10 minutes.

"The results of the tests on the paper made from the two lots and a good grade of commercial garnet paper were as follows:

Paper	Grams of hardwood cut
Lot No. 1	464.6
Lot No. 2	531.6
Commercial	733.5

"The above table shows that the garnet is not suitable for making abrasive paper as it does not cut fast enough.

"Blasting Tests

"A large part of both lots of garnet was crushed to 20 mesh and screened on a 60-mesh screen and blasting tests were made on the -20+60-mesh material using the method developed in our laboratory. The results of these tests, and tests on two good commercial blasting sands are given below. The second column gives the grams of steel cut by blasting at 80 pounds air pressure 20 pounds of sand or garnet in $6\frac{1}{2}$ minutes; the third column gives the amount of sand or garnet consumed or broken to minus 60 mesh with the same pressure, charge, and time; the fourth column is the number of grams of steel cut per pound of sand or garnet consumed with the same pressure, charge, and rate; and the fifth and last column gives the sand or garnet consumed per minute when the sand or garnet is blasted so as to cut 2 grams of steel per minute.

ABRASIVE	Grams steel cut	Pounds abrasive consumed	Grams steel cut per pound abrasive consumed	Pounds abrasive consumed per minute
Garnet Lot No. 1 -20+60,	10.6	12.6	0.84	2.61
Garnet Lot No. 2 -20+60,	11.1	11.5	0.97	2.25
Rounded sand, -20+35,	11.0	5.0	2.20	1.07
Angular sand, -14+28,	15.2	8.4	1.81	1.04

"The above table shows that the garnet cuts about 0.9 grams of steel per pound of garnet consumed, whereas the good sands cut about 2.0 or if the steel is cut at the rate of 2 grams per minute the garnet is consumed at over 2 pounds per minute and the good sands at a trifle over 1 pound a minute. All this indicates that the garnet would not make a good blasting material.

"Summary

"Both lots of garnet are unsatisfactory for making garnet paper or use in blasting."

CONCLUSIONS

A review of the mineral deposits of this area, their geological environment, compositions, and modes of formation brings to light several important facts and considerations.

In the first place it will be noted that all the metallic lode deposits occur in either bodies of the Okanagan intrusives or in pre-batholithic formations. None occurs in the Tertiary formations and intrusives and none, of any significance, has been observed anywhere within the broad area of the Shuswap complex. Two conclusions may be drawn from this observation, (1), that the Tertiary and Shuswap areas may, in general, be eliminated by the prospector in his search for mineral deposits, and (2), that the probable source of the mineral deposits was the Okanagan intrusives. Whether the Tertiary intrusives of the area are in any way responsible for mineral deposits in their vicinity is, perhaps, a question that cannot be answered definitely in the negative in spite of the fact that they themselves are not mineralized. Reinecke[1] was of the opinion that the mineralization at Beaverdell camp was related to the Beaverdell batholith which, as remapped for the present report, is partly, at least, of Tertiary age. The facts, however, that similar, Tertiary intrusives occur elsewhere in the area without attendant mineralization of the invaded rocks and, that deposits not unlike those at Beaverdell camp may occur where there are no Tertiary intrusives, are highly suggestive that the mineral deposits at Beaverdell, as well as at the numerous other localities, are probably related to the respective bodies of Okanagan intrusives in which, or nearest to which, they occur. This, in general, was the opinion reached by the writer in studying the mineral deposits of the northern Okanagan valley.[2]

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[1] Reinecke, L.: Ore Deposits of the Beaverdell Map-area; Geol. Surv., Canada, Mem. 79, pp. 111-113.

[2] Cairnes, C.E.: Mineral Resources of Northern Okanagan Valley, B.C.; Geol. Surv., Canada, Sum. Rept. 1931, pt. A, p. 71.

A second consideration, bearing also on the genetic relationships of the mineral deposits to the Okanagan intrusives, is the fact that in spite of the great variety of types of lode deposits nearly all contain much the same suite of ore minerals though the proportions may be quite different. Pyrite is a common and generally the most abundant, or one of the most abundant, minerals, but depending on the type of deposit, it may constitute from less than 1 per cent to over 50 per cent of an ore-body. Galena, sphalerite, and chalcopyrite are generally present in each ore-body, but may be rare in some deposits or the most abundant minerals in others. Molybdenite, again, a relatively uncommon ore mineral, is widespread in this area, but in most of the deposits occurs in only very limited amounts. Certain ore minerals, such as pyrrhotite and arsenopyrite, are abundant and particularly characteristic minerals of the replacement deposits in pre-batholithic formations near granitic contacts, but are not confined to such deposits. The replacement deposits, too, are widespread and may occur in association with batholithic intrusives of quite different compositions. Another feature of interest relates to the occurrence of gold in nearly all types of deposits in this area. In many of these deposits gold is the metal of chief importance; in others it is a minor or even negligible constituent of the ores. Gold-bearing deposits, too, such as the auriferous quartz veins of Camp McKinney and at Fairview appear to be almost exactly similar in all their structural and compositional characteristics and yet are associated, in place, with quite separate intrusive bodies that are, also, quite distinct in appearance and composition. All these features seem to indicate a general relationship of the various types of deposits to each other and to the Okanagan intrusives.

In matters relating to the associations of particular types of mineral deposits with particular kinds of rocks, certain facts may be assembled. Considering first the pre-batholithic formations it seems obvious that replacement deposits, such as those described earlier in this report, are best developed in bodies of limestone and, to a lesser degree, greenstone. Areas, therefore, where bodies of limestone occur, especially near or at the contacts of Okanagan intrusives, may be prospected for this type of deposit. Auriferous quartz veins in this area, on the other hand, appear to find their best development in the more schistose, pre-batholithic formations. The veins tend to conform with the schistosity and are, in general, more persistent in sediments than in greenstones probably because the structures in the former are more regular. Large quartz veins do occur in more massive sediments and greenstones, but in general are poorly mineralized and of little economic interest. The quartz veins in the schistose rocks are generally sheared and fractured and it is not improbable that some, perhaps most, of the gold was introduced into the fractured quartz, thereby enriching these veins in a manner that was not possible in the cases of those quartz veins occurring in more massive formations where the quartz is less shattered. Mineralized shear zones, again, seem to be of most importance in the greenstone members of the pre-batholithic formations. This seems due partly to the relatively structureless character and incompetency of the greenstone masses which, under stress, tend to yield irregularly by shearing rather than by more sharply defined faulting; partly also it is due to the sheared greenstones being capable of ready replacement by mineralizing solutions. Vein deposits are apt to be small and irregular in such shear zones, but sulphide impregnations and more solid replacements may extend far out into the wall-rocks of the veins. Pyrite and chalcopyrite are the most common sulphides and values are principally in gold and copper. The great abundance of greenstone, particularly in southern parts of the area, renders this type of deposit particularly worthy of investigation in spite of the fact that it has yielded comparatively little production.

Mineral deposits have been found in all the various rock types included with the Okanagan intrusives. Undoubtedly the majority of the deposits, including many of the more important ones, occur in rocks having about the composition of quartz diorite or diorite. In addition a rather striking number of mineral deposits have been found in bodies of alkaline intrusives, as compared with those of more siliceous types. Large areas of the latter, including mainly granodiorite and granite, are practically unmineralized, but some bodies of rocks may contain a number of deposits. In general, however, it has appeared that the distribution of mineral deposits in these batholithic rocks is more directly related to the relative ages of the intrusives and to the depth of mineralization than to the composition of the intrusive masses. Mineralizing solutions, gases, etc., no doubt accompanied each separate intrusion as it rose towards the surface, and contact zones with the overlying, pre-batholithic formations are invariably mineralized to some extent regardless of the composition of the invading rock. Thus at Osoyoos camp and in the valley of Peachland creek, where the intrusives are of about quartz diorite (though quite different in appearance, high-temperature, replacement deposits have formed in the same manner as at the Golden Zone where the invading rock is granite. In most places, however, the invading bodies in contact with pre-batholithic formations have about the composition of diorite and quartz diorite and hence are the ones most commonly associated with mineral deposits at or near intrusive contacts. Especially is this true of the smaller intrusive masses of Okanagan rocks scattered through the area as stock-like or relatively long and narrow bodies. Almost invariably there is conspicuous evidence of mineralization both in and along, or around, the borders of such bodies. Conversely the large areas of intrusives, especially at a distance from their contacts with older formations, are sparsely mineralized not, in the writer's opinion, because their intrusion was unaccompanied by mineralizing solutions, etc., but because, in the main, they have been eroded to below the zone of mineral deposition. These larger intrusive masses are mainly about granodiorite in composition and are relatively younger than the dioritic intrusions. Where they occur in smaller bodies they may, as in Fairview mining camp, not only contain mineral deposits, but otherwise be regarded as the source of important deposits in the formations they intrude.

Another consideration, bearing on the apparent concentration of mineral deposits in the dioritic, and to some extent, too, the alkaline, intrusive bodies, as compared with more siliceous types, has to do with the fact that the former are relatively older rocks and may have had time to consolidate and to fracture prior to the invasion of the younger batholithic members. Under such conditions they would be susceptible to mineralization by solutions accompanying the invasion of the younger intrusives. It is a common observation that small bodies of the older, intrusive types caught up in large masses of younger intrusives are conspicuously mineralized and in some cases, as those of the King Edward and Silver Star properties, significant mineral deposits have been found in them.

Summarizing the features connected with mineralization in and by the Okanagan intrusives, it will be apparent that, in prospecting, attention should be paid especially to: (1) the smaller intrusive masses where found invading older formations; (2) larger areas of intrusives where roof pendants are common and, mainly, in the vicinity of these pendants; and (3) bodies of diorite, quartz diorite, and alkaline rocks in preference to bodies of granite and granodiorite.

There is little definite information available as to the time or times of formation of the various types and separate occurrences of mineral deposits. No significant instances were noted of a deposit of one type being veined or replaced by a deposit of another type. Presumably, however, the period of mineral deposition for this area was a long one. High-temperature, replacement deposits in the older formations at or near the contacts of batholithic intrusives seem definitely related to the adjacent intrusives and in different cases these intrusives are among the older types. On the other hand, mineral deposits may occur along fractures in all members of the Okanagan Intrusive complex, from oldest to youngest, and, in consequence, it is evident that mineralization was still an active process until after the upper parts, at least, of the youngest intrusives had had time to consolidate and, later, to fracture. Deeper seated parts of these intrusive masses may, however, have remained molten for a long time and any, associated, mineralizing solutions and gases would not have had access to the upper, consolidated parts until fracturing had occurred.

Except, perhaps, at the Beaverdell camp, there is little evidence in the distribution of the various types of mineral deposits in this area to indicate zoning. Partly this is due to the difficulty in distinguishing deposits that formed at different times from those that formed at the same time but at different temperatures, and partly it is due to the fact that most of the deposits seem to have formed at about the same temperature. Exclusive of the chromite deposits, which form a distinctive class mineralogically as well as in their mode of formation, the mineral deposits of the area vary from high-temperature, contact, replacement deposits containing magnetite, pyrrhotite, pyrite, arsenopyrite, sphalerite, and chalcopyrite as characteristic ore minerals and secondary, lime-silicate minerals as the common, associated gangue, to relatively low-temperature deposits in which sphalerite, galena, grey copper, and ruby silver are abundant and vein quartz the principal gangue. Between these extreme types of deposits, which probably formed at different times, the great bulk of deposits in the area are quartz veins and siliceous replacements containing pyrite as the chief ore mineral and, in most cases, some chalcopyrite, sphalerite, galena, and molybdenite. The quartz gangue is commonly vitreous, crystalline, and drusy. In a few places it carries a little tourmaline and, rarely, some feldspar. In general, however, there is little about either the quartz or the ore minerals to suggest that the temperatures at which they formed were other than moderate to fairly high. At Beaverdell camp, however, there is some reason to believe that the rich, silver-lead-zinc ores formed at the same time but under lower temperature conditions than those of the immediately surrounding area in which deposits are valued chiefly for gold and copper. Nowhere else in the area has a like indication of zoning been demonstrated, though work done south of Beaverdell in the vicinity of Westbridge has suggested this part of the area as the one most likely to reveal similar conditions of ore deposition. On the other hand, silver-lead-zinc deposits in other parts of the area, as in the valley of Trout creek, seem quite isolated from other types of deposits and occurring, as they do, deep within a large body of granodioritic intrusives, are perhaps among the youngest of the mineral deposits in the area.