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INVESTIGATIONS BY KELOWNA MINES HEDLEY LIMITED in the SLOCAN DISTRICT, BRITISH COLUMBIA

August 31, 1951

Provided by Bill Hogg during 1972.

Evans B. Mayo

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SUMMARY AND CONCLUSIONS

In the Slocan District, British Columbia, the formations, beginning with Paleozoic ones to the east, and ending with Triassic, and possibly Cretaceous ones to the west, lie in an arc, concave westward. The southerly extension of the Triassic Slocan Series has been replaced by granite, and the supposedly youngest rocks to the west have also been granitized. Most of the ore deposits lie in the Slocan series, north of the Nelson granite.

Kelowna Mines Hedley geologists have determined that the Slocan Series was deformed into a system of recumbent folds, one on another; these, beginning at the bottom, are Payne recumbent anticline, Queen Bess recumbent syncline, Silver Ridge recumbent anticline.

The axial planes of these recumbent folds are themselves folded into (1) a fan of broad anticlines and synclines that diverges eastward, and, (2) a system of broad anticlines and synclines normal to (1).

The lodes have moved as strike-slip faults with southern walls carried eastward, and as normal faults. They are offset on eastward and westward dipping normal faults related to interbedding movements on the recumbent folds. Downwarpings of the axial planes of the recumbent folds on the flanks of a broad, axial plane fold of class (1) causes transverse panels that may approximately parallel a lode.

Ore is localized on lodes near the axial planes of the recumbent folds if there is the appropriate association of relatively weak and relatively strong rocks. Some specific controls in such situations have been: (A) Plunging noses in especially steep portions of the lodes on strong-weak rock boundaries, (B) places in the upright W. limb of a recumbent fold where a lode, angling acutely across a transverse panel, crosscuts part of the "normal" panel.

SUMMARY AND CONCLUSIONS (Cont'd.)

The presence of a few of the favorable factors is no guarantee of ore. The list, at any given place has to be practically complete. Because it is very difficult to find all of these features together, it is recommended that, if further exploration is contemplated in the Slocan, several prospects be investigated as nearly simultaneously as possible.

The chance of finding, in the closely investigated part of the Slocan district, an ore body larger than the largest already found, is considered to be practically nil.

INTRODUCTION

The Slocan silver-lead-zinc district of British Columbia has had several periods of mining activity, beginning in the last decade of the last 19th century. Some of its mines, such as the Lucky Jim, Victor, Standard, and Mammoth are now in production. According to Paul Billingsley (1947, p 11) the total production from the Slocan area had been approximately $68,620,294. This figure has surely increased during the past four years.

The geology of the Slocan district has been studied by various Canadian Government geologists. Previous to 1939, the latest general geological investigation had been by E. E. Cairnes (1935). Plate 1, compiled from old and new sources, is a rough sketch of the district geology. On it are shown some of the mines of the district.

The interest of Kelowna Exploration Company (now Kelowna Mines Hedley Limited) in the Slocan district dates from 1939. In that year Messrs. Paul Billingsley and W. C. Douglass visited the Slocan and in August, September and October, 1939, Mr. L. W. Cramer mapped, with plane table control, the Queen Bess and Carnation areas. In 1940 Cramer established plane table control in the Payne mine area, and E. B. Mayo mapped the surface and underground geology. In 1941, Mayo studied the geology of the L. H. Gold mine, of the Washington mine, near the Payne, and mapped accessible portions of 5 level of the Queen Bess Mine.

In 1945 Kelowna Exploration Company purchased the Carnation group of claims and an option was acquired on the Ruth-Hope group, east of the Carnation ground. In 1946, under the direction of Mr. Paul Billingsley, surface mapping was begun in this area, and underground exploration was started on the west Silversmith lode on Ruth-Hope ground. This work, which included also

INTRODUCTION (Cont'd.)

some underground mapping in the Standard Mine, was supervised in the field by Messrs. A. E. Buller and R. S. Meehlman. W.S. mapped Standard surface in fall of 1946.

In 1947, under the field supervision of Evans B. Mayo, the west Silversmith investigation was concluded. The surface mapping was continued through the field seasons of 1947 and 1948, during which time the Mammoth, Carnation, Wakefield and Hewitt underground workings were mapped.

Underground exploration began on Carnation ground in 1949; the geological work was then under the field direction of W. M. Sharp. In 1950, this direction passed to Mr. John Lamb, who had taken part in the geological work since 1947. In July, 1951 the Carnation underground exploration was stopped.

In 1949 an agreement was entered into between Kelowna Exploration Company and Bralorne Mines Company to investigate and explore the Queen Bess and Idaho mine areas. Surface and underground mapping for this investigation was done by Kelowna geologists in 1949 and 1950. (mainly W.M.S.) Underground exploration began in 1950 and is still in progress. e Carn 5480 site.

In the following report an attempt is made to record the history of investigations by Kelowna geologists, to review critically the theories that have developed as a result of these investigations, and to discuss the remaining prospects for ore on Kelowna Mines Hedley's Slocan ground.

It was originally intended to include with this report two more plates, one a 400 scale reduction of all the 100 scale surface mapping done by Kelowna geologists, the other a 1200 scale district map showing the positions of the principal recumbent folds with relation to the mines. There was not time enough to prepare these but it is hoped that they will be prepared

in the near future, for in no other way can the results of the past four year's field work be summarized and related to the possible future problems of Slocan exploration.

Also planned for this report was a complete list of this Company's Slocan maps. The partial list at the end of the report does include all important maps, and a complete list is not essential to an understanding of what has been done. It is, however, important as a matter of record, and it will be compiled when the problem of filing and storing the Slocan data is solved.

During the preparation of this report, I have had the benefit of several conferences with Mr. John Lamb, who prepared most of the illustrations.

GEOLOGICAL SETTING

Formations - The Slocan district, (Pl.1) lies between Kootenay lake on the east and Slocan lake to the west. The oldest rocks are the Lardeau series, with outcrops along Kootenay lake. This series, which consists of schists, crystalline limestones and quartzites, locally very intensely metamorphosed, was originally referred to the late pre-Cambrian, but more recent studies by government geologists, in the State of Washington and in southern British Columbia, suggest a correlation with certain Paleozoic formations. Dips in the Lardeau series are, in general, westerly, and the Lardeau rocks are disposed in a broad, westward-concave arc. Younger formations lie within the concavity. The upper contact of the Lardeau series is said to be an unconformity, (Cairnes, 1935, p.32).

pre- M.S.H. "KOOTENAY ARC."

Overlying the Lardeau series is the Milford group, which consists of slates, argillites, limestones, quartzites, cherts, cherty greenstone and various volcanic rocks. The evidence of fossils indicates that both Carboniferous and Mesozoic horizons are included. No recognizable contact has been found between these deposits of the Paleozoic and Mesozoic eras. The Milford, like the Lardeau, lies in an arc, concave westerly, or southwesterly, and its dips are generally westward, although, northwest of Kaslo, are a large, northerly-plunging syncline and anticline of Milford rocks, and Cairnes states (1935, p.41) that the strata are locally vertical, and even overturned. The significance of such observations has only recently become appreciated.

The Kaslo series, next in the succession, is partly intrusive, partly extrusive, and partly sedimentary in origin. According to Cairnes (1935, p.44) "The series ... is made up of overlapping lenses of volcanic flows, pyroclastic deposits, and tuffaceous sediments associated with sheets,

GEOLOGICAL SETTING (Cont'd.)

dykes, plugs and laccolithic masses". There are two serpentine members in the Kaslo series and these, so far as seen by Kelowna geologists, appear to be replacements of coarse basic, or ultrabasic, tuffs. There are also some minor chert members. The serpentine, and some of the fragmental rocks are schistose, but much of the Kaslo is said to be massive. This series also displays the arcuation, first noted in the Lardeau series, and indeed in somewhat sharper form. Dips appeared to be mostly westerly, toward and under younger rocks. The same was once thought to be true of the dip of the upper Kaslo contact, but some highly significant exceptions were found in 1949. Some interesting observations on the structural behavior of the eastern Kaslo contact were presented by Bancroft, (1919 B, pp. 44-45). The Milford syncline, northwest of Kaslo, has a core of Kaslo rocks, and these rocks transgress the Milford structure in a manner that suggests that here the Kaslo intruded the Milford along the synclinal axis. Above the upper Kaslo contact the basal portion of the overlying Slocan series contains material derived by erosion from the Kaslo series.

Fossils indicate that the Slocan series is Mesozoic in age, and it is probably Triassic. This series, which is composed mostly of argillites, with subordinate impure limestones and quartzites, lies along its contact with the Kaslo, in a southwestward-concave arc that resembles the quadrant of a circle. Within the concavity, the arcuation is still further sharpened, and it becomes intensely plicated or rippled. Reversals of dip are common, and these were once thought to be expressions of upright folds in the Slocan series. Cairnes showed such upright Slocan folds in cross sections.

What appears to have been the most intensely deformed portion of the Slocan series is now occupied by the vast expanse of the Nelson granite.

GEOLOGICAL SETTING (Cont'd.)

Within this granite, strips of Slocan sediments and swarms of Slocan inclusions suggest how some of the Slocan series has disappeared. Many small bodies of granitic porphyry appear in the main body of Slocan sediments to the north.

On both sides of Slocan lake, south of Silverton, is a gently eastward-dipping layer, several hundred feet thick, of strongly crushed, mostly porphyritic Nelson granite. Below this layer, and exposed along both shores toward the southern end of the lake, are banded gneisses, apparently part of a granitized terrane. Above the crushed layer, in the high mountains west of Slocan lake are various granites with included slabs of highly metamorphosed schists, gneisses, marbles, etc. It was once thought that these crystalline rocks correlated with the Windermere series, (of which the Lardeau series is the upper part) but the results of recent work by Canadian government geologists strongly suggest that these are no older than the Slocan series and they may even be Cretaceous in age. If this is the case, then, travelling from east to west across the district, one goes, in spite of appearances, from older to younger rocks.

Structure Pattern - The crystalline rocks west of Slocan lake are warped into a broad, anticlinal arch that, west of Silverton, trends northeastward, then eastward, to plunge under Slocan lake and the Slocan sediments. This eastward-plunging crystalline anticline seems to give rise to a fan of eastwardly-diverging ripples in the Slocan rocks and in the Nelson granite. One of the most pronounced of these ripples can be traced from the vicinity of Silverton eastward through the mines Standard-Mammoth-Silversmith-Utica toward the upper Kaslo contact. This fold is followed for part of its length by the Standard-Carnation-Silversmith lode, to date the most productive structure in the district.

The complicated structural pattern, (Pl. 1) is obviously a very

GEOLOGICAL SETTING (Cont'd.)

striking anomaly in the general northwesterly trend of the cordillera. Regional studies have shown that such structural anomalies are likely to occur on the intersections of major structures that follow several different directions, and it has been suggested that ore districts favor such intersections.

Lodes - The so-called lodes of the district are faults, fissures or shear zones that vary in width from a few inches to more than 100 feet. Within the lodes may be veins, lenses, sheets, pipes or irregular bodies of quartz, carbonate, gouge, breccia or sulphides, mostly pyrite, galena and(or) sphalerite. The ore is in part fissure filling, in part replacements of gouge or breccia. In the Lucky Jim and Whitewater mines, the ore replaces limestone.

The lodes are very widely distributed. They occur in the Slocan sediments, the Nelson granite, the Kaslo series, and in Milford and Lardeau rocks along Kootenay lake. Only a few of the many lodes are shown on Plate 1. From the standpoints of trend and relation to district structure, the lodes appear to fall into 4 classes:

A. - Lodes that follow (transverse bedding warps generally ripple axes) and parallel the trend of the northern contact of the Nelson granite. Examples, - the Standard-Carnation-Silversmith lode, and the Galena Farm-Hewitt-van Roi lode. These appear to be the strongest lodes, and (one of them has been the biggest producer) in the district. (and respectively comprise the most + next most productive structures)

wide! my transverse tear faults!

B. - Lodes with northeasterly trend that disregard local structures or are complementary to them. Examples, Payne, Washington, Surprise, Noble Five, Scranton, MacAllister. The richest Slocan ore bodies occurred on these lodes. It is thought that northeasterly fissures, intersecting the Lucky Jim and Whitewater limestones, may have provided inlets for replacing ore solutions even though the resulting ore bodies are controlled by various northwest-trending structures.

C. - Lodes that follow, or approximately follow, older planar structures, particularly in granite. Examples, Ottawa, Enterprise.

GEOLOGICAL SETTING (Cont'd.)

D. - Northwest-trending shears in limestone in Lucky Jim-Whitewater area. These are structurally analogous to the lodes of class C, and the ore associated with them may have been supplied through fissures of Class B.

Mineralization - The mineralization is as widespread as the lodes. In the Kaslo series a greater variety of potentially valuable minerals occurs than elsewhere, but apparently none of this mineralization can be extracted at a profit. Many small, high-grade bodies occur in the Nelson granite, and at least two of these, the Ottawa and the Enterprise are reported in production. At the present high metal prices more of these may be workable, but in 1941 Mr. Arthur Lakes announced that in his opinion no money had been made up to that time from lodes in the granite.

Some producing properties are in Lardeau, and perhaps in Milford and Slocan rocks near Ainsworth, but the preponderance of the commercial deposits has been and perhaps still is in the Slocan series in the New Denver-Silverton-Sandon-Whitewater area, in the northern, sedimentary portion of the previously-mentioned fan of ripples, along lodes of classes A, B and D. In this part of the district, therefore, Kelowna Exploration Company began its investigations in 1939.

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY

One of the most striking features of the Slocan district is the great Standard-Carnation-Silversmith lode, or main lode. As already stated, this lode has been the most productive structure in the district. Its production has come mostly from two mines, the Standard and the Silversmith, with a broad interval of little explored lode between them. In the 1920's a portion of this lode, at a high elevation, had been explored by Victoria Syndicate, without success, but in 1933 the Mammoth mine was discovered, thus helping somewhat to close the gap between the two big producers. It seemed logical to suppose that, in spite of Victoria Syndicate's experience, important ore bodies remained to be discovered on the big lode between the Mammoth and the Silversmith mines.

Another important fact had been the occurrence of relatively small, but very high grade, ore bodies on the lodes of class B. In the vicinity of the Carnation gap, one of the most important of these high-grade mines had been the Queen Bess.

Before the beginning of 1939 field work, Paul Billingsley summarized the Slocan outlook in a report entitled "Silverton-Sandon Area, Slocan District, B. C., Appraisal of Exploration Possibilities". Therein the principal lodes were treated as thrusts. An analysis of tonnages and grades of ore from various lodes was given, which showed the contrast between the relatively large and low grade ore bodies of the Standard-Carnation-Silversmith lode, and the smaller, high-grade bonanzas such as the Queen Bess and the Payne. The lack of previous detailed geological studies, and the fact that thousands of feet of lode remained untested, were stressed. A program of geological study was recommended, and it was emphasized that crucial ground

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

must be secured by options before the geological study began. Such options were secured with the help of Arthur Lakes.

1939 - During late Summer and Fall of 1939, L. W. Cramer, assisted by Richard Foreman, mapped with plane table control on 200 scale, an area extending southward from the Monitor and including the Queen Bess and parts of the Corinth, Wonderful, Black Colt, and Carnation properties. At that time the Kelowna geologists were strongly influenced by the results of earlier studies by Canadian government geologists.

Cramer's work had two very important results. First, a supposed syncline, called the Queen Bess syncline, was found on Queen Bess ground and was followed south-southeastward into the Carnation gap. Secondly, a band of hard, strong quartzite was also found on Queen Bess ground and traced southerly into the Carnation gap. Further, the possibility arose that this quartzite had localized the bonanza stopes of the Queen Bess mine. It seemed, therefore that hard, resistant formations, folded into synclines and crossed by lodes, were the secret of the localization of the rich ore bodies. Of course this knowledge made the Carnation gap appear more attractive than ever, although it seemed from Mr. Billingsley's analysis that the big Standard-Carnation lode might contain a relatively large, low grade ore body, rather than a smaller one of bonanza type.

At the end of the 1939 field season, apparently, efforts to acquire an option on the Queen Bess property had failed. In a letter "Slocan District Geological Study" to Mr. O. P. Ebeling, Mr. J. W. Mercer wrote "It would be most desirable to secure a continuation of one of those high grade mines but that seems to be out of the question at present." However, by the time the

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1940 field work began, an option had been secured on the Payne group.

1940 - In August, 1940 plane table control was established on Payne Mountain by Cramer and Mayo, and Mayo mapped the surface geology on the scale of 200 feet to the inch, and the accessible underground geology on the scale of 40 feet to the inch. Arthur Lakes, assisted by ~~Jean~~ Gene Peterson, did the underground surveying.

During establishment of the plane table control, it was noted that the sedimentary rocks in the vicinity of the Payne mine dipped toward the center of an elongated, trough-like structure, thus suggesting a syncline, like the Queen Bess syncline. The rock type in which the Payne ore body was formed appeared to be limestone which, as later seen underground, was locally silicified, forming a hard, strong rock somewhat like the Queen Bess quartzite.

The underground mapping failed to reveal the supposed syncline, and re-consideration of the surface mapping brought out the confusing fact that the limestone, which occupied one flank of the supposed syncline, was not repeated on the other flank. At one place on the cliffy northern slope of Payne mountain southwesterly dips were almost directly over northeasterly dips. This observation should have furnished the key to the structure of Payne mountain, but at the time its significance was not realized.

Underground, it was noted that the Payne lode, followed northeastward, steepened and turned northward where it entered the stronger rocks (silicified limestone, hard slabby argillite) thus causing a local, steep nose in the southeastward-dipping lode. The ore had deposited mainly on this nose (Pl. 2). The ore was mostly in the stronger rocks, but on or near the boundary between strong and weak rocks.

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

1941 - Beginning in August, 1941, Mayo mapped first the underground and surface geology of the L. H. Gold Mine, south of Silverton, then the surface and underground geology of the Washington mine, east of the Payne. Because of the unsatisfactory result of structural investigations on the Payne the year before, it was decided to make one more section across the supposed Payne syncline. It so happened that a small cliff was situated where the reversal of dips occurred. At the top of the cliff, dips were southwestward; at the bottom northeastward. From a trail at the foot of the cliff it was possible actually to see the southwesterly dips steepen and turn over to become northeasterly. The structure was obviously a recumbent fold, but there appeared to be no way of deciding whether it was a recumbent anticline or syncline, hence it was called the Payne overturn. With this discovery, the underground structure of the Payne mine (Pl. 2) made sense. The Payne ore trap (localizer) then, included three elements:- a) the boundary between strong and weak rocks, b) the steep nose in the lode, c) the Payne overturn.

By reconnaissance, the overturn was traced for a surface distance of 10,000 feet in a southwestwardly-concave arc. It was seen that this structure lay west of the Washington workings, in ground where the Washington and other lodes were not known. In an effort to find out whether the Washington vein would extend to intersect this structure, a bulldozer cut was later made on the southwestern slope of Payne mountain where the continuation of the vein should have appeared, but nothing recognizable as Washington vein was found. The results of the structural study were presented in a letter to Mr. W. C. Douglass, entitled "Investigation of the Washington Property, Slocan District, British Columbia".

During the same field season, one day was spent on Queen Bess surface,

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

and two days on Queen Bess 5-level. It was seen that the underground structure did not fit the concept of a Queen Bess syncline, but not enough information could be gained to reveal the true structural condition. It was seen, however, that the bonanza stope was in quartzite, and that the Queen Bess lode, as the Payne had done, steepened as it entered the hard rock. These findings were reported to Mr. Douglass in a letter entitled "Report on Visit to Queen Bess Property, Slocan District, B. C."

There was no further work by Kelowna Exploration Company in the Slocan District until 1946.

1946 - By 1946, the economics of mining in the Slocan district had changed considerably from the status of 1941. In 1941 the prices of lead, zinc and silver were respectively 3.36¢/lb., 3.41¢/lb. and 38¢/oz. This had changed by 1946 to 6.75¢/lb., 7.81¢/lb. and 89.4¢/oz. The new prices, which were to go still higher, favored the large, relatively low-grade ore body, and at the same time made the small bonanza even more attractive.

Kelowna Exploration Company had, meanwhile, purchased the Carnation group of claims, and was negotiating for ownership of the Wakefield group. To provide a starting point for this exploration, and to provide a more immediately accessible target, an option was secured on the Ruth-Hope property. Sandon, then (Pl. 1) became the base of operations.

On January 16, 1946, Robert S. Moehlman submitted a report entitled "Silverton-Sandon Area, Slocan District, British Columbia". In this report, Moehlman noted under ore controls the intersections of folds with veins, and vein and fault intersections. Two possible ore targets, the intersection of Queen Bess syncline with the Carnation lode, and the intersection of Washington

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vein with Payne overturn were listed.

The 1946 field and underground work was under the direction of Mr. Paul Billingsley, consulting geologist, and was supervised in the field by A. E. Buller and R. S. Moehlman. Ruth 5 level was rehabilitated, and a new lateral, the 501, was started to explore the westward continuation of the Silversmith lode. The "mill" level and the 5, 4, 3 and 2 levels plus sub levels and raises of the Ruth mine were mapped as were the Silversmith 10 level and parts of the Slocan Star and Slocan King mines, the main adit of the Wonderful mine, the Mascot workings, the adit level of the Slocan Boy and parts of the 5 and 6 levels of the Standard mine. The Mammoth mine, and accessible parts of the Carnation workings were briefly visited. Surface mapping was done in the Payne-Washington-Slocan Boy areas, the Slocan King-Slocan Star area, and along roads and trails (which had to be "swamped") in the Ruth-Ivanhoe area, the Minniehaha-Carnation area, Evening basin, Wild Goose basin, Yakima-Sunshine area and on Idaho Peak. Late in the season, W. M. Sharp mapped part of the Standard surface.

Sharp's mapping first brought out plainly a feature later observed at many places along the Standard-Carnation-Silversmith lode and on some other lodes. The lodes are locally bordered by broad zones in which the dips and strikes of the sediments are approximately parallel to the attitudes of the lodes. These bands have been called "transverse panels" because their structure is transverse to the 'normal' northerly or northwesterly strike of the Slocan sediments. In the Standard area the transverse panel appears to be folded, as suggested on Plate 1.

During the summer an option had been obtained on Payne-Washington ground, and in the fall, a crew opened, re-conditioned and retimbered the

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

Washington 4 level portal. It was planned to do surface mapping on the Washington the following year, and to start exploring for a westward continuation of the Washington vein across the Payne overturn.

On one of his visits to Sandon, Mr. Billingsley, with A. E. Buller, in studying Cramer's 1939 maps, noticed that at one locality the northeastward-dipping limb of the Queen Bess syncline was almost vertically above the southwest-dipping limb. With the example of the Payne overturn in mind, they realized that the Queen Bess syncline was itself an overturn, which they named the Queen Bess overturn. This explained why the structure on the Queen Bess 8-level failed to fit the concept of a syncline. Kelowna geologists were now freed once and for all from the earlier idea of upright folds in the Slocan series.

A field party from the B. C. Department of Mines, directed by Dr. M. S. Hedley, spent the summers of 1946, 1947 and 1948 in the Sandon area. Information was exchanged between this party and the Kelowna geologists. One member of the Government party, a Dr. Black, postulated that the Queen Bess overturn, concave southwestward, was a recumbent anticline. This made the underlying Payne overturn, concave northeastward, a recumbent syncline, and the Silver Ridge overturn, a northeastwardly-concave structure above the Queen Bess, and exposed near the highest summits on Silver Ridge, a second overturned syncline. Unfortunately, the nature of Dr. Black's evidence is not known. Kelowna geologists were of the opinion that the Queen Bess was a recumbent syncline, and that the Payne and Silver Ridge were anticlines, although proof was lacking.

Mr. Billingsley, using Mayo's 1940-41 mapping, drew a number of cross sections through Payne mountain and showed that the axial plane of the Payne overturn, which dipped northeasterly in the vicinity of the Payne and

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Washington mines (Pl. 2) reversed its dip on the southwestern slope of Payne mountain so that, on the southwest side of Carpenter creek this overturn should appear in the upper workings of the Ruth mine. Early in 1947, Buller was able to confirm this by observations on the Ruth upper levels (Pl. 3). The concept of district structure and ore, then, was about as indicated below:

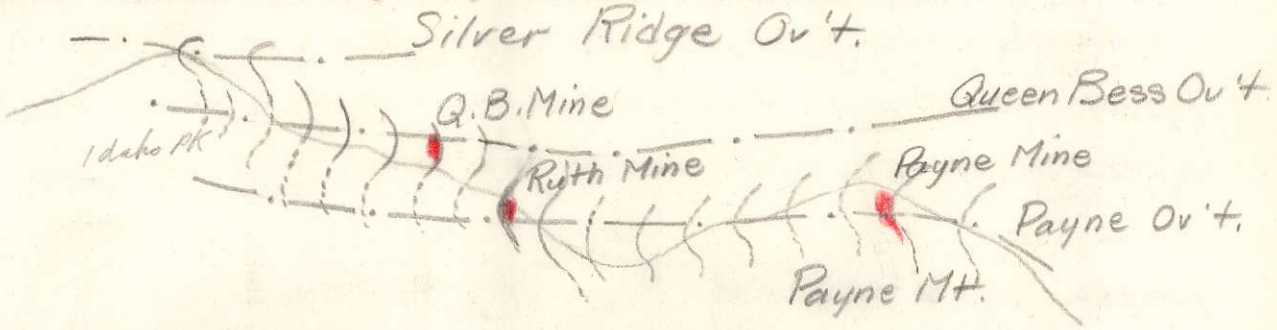

Fig. 1 - Section through Sandon area, Slocan District.

Not to scale.

Diamond drilling from the new Ruth 501 lateral failed to reveal ore, except that one hole, R-6 had a 9½' intersection of mineralized lode that assayed Ag 0.71 oz./ton, Pb 0.70%, Zn 9.36%. Perhaps this intersection was the factor that led to the decision to continue the Ruth underground exploration in 1947.

Under date of November 6, 1946, H. S. Moehlman submitted a "Preliminary Report on the Slocan District, British Columbia, Canada". The report was divided into three sections, I) The Slocan District, II) (a) Ruth-Hope Area, (b) Carnation Area, III) Western Exploration Company - Standard, Mammoth and Enterprise Mines. An option, or a merger with Western Exploration Company, then under consideration, was not thought by Moehlman to be very attractive. Further geological studies on the Company's purchased and optioned grounds were recommended, and it was further recommended that additional development work

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not be planned before the geologic studies were completed.

In summarizing what was then known about the ore controls, Moehlman listed: 1) Northeasterly and easterly trending thrust zones (lodes), 2) Porphyry intrusions (which, he suggested, formed strong buttresses) 3) Minor folds with axes parallel and sub parallel to the thrust zones, 4) Payne overturn, 5) steep dips along major thrust zones. For the first time, the zone of northeasterly strikes southwest of the Sandon area, and the "hinge line" so-named by Mr. Billingsley, between sediments of northeast strike and of northwest strike, were mentioned.

Mr. Billingsley's report, "Geological Investigation of Slocan District, B. C., Status as of January 15, 1947" summarized the geological position reached at that time, and pointed out the favorable targets. Mr. Billingsley recognized that to acquire and explore all of these would have been a task beyond the resources of Kelowna Exploration Company, and he proposed a minimum program to be carried out by Kelowna geologists. It so happened that even this minimum, which included more work on Standard and Washington ground, proved beyond the capacity of the geological staff.

1947 - The geological and engineering staff that had been at Sandon in 1946 was almost completely reorganized by 1947. Mayo was in charge in place of A. E. Buller, and one more geologist, Mr. John Lamb, was added to the staff. Mr. Lawrence Gulley was surveyor. Only Mr. W. M. Sharp, geologist and Mr. William Orr, topographer, had been at Sandon before.

During the field season of 1947, the Ruth-Hope and Carnation areas were covered, but not in final form, and work planned for Standard and Washington ground was never done. Later, the option on Washington ground was dropped.

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

The new geological concepts had been developed so rapidly as to leave a feeling of unreality. The existence of the overturns could hardly be questioned, but their extent, their natures (anticlinal or synclinal) and the positions of their axial planes were open to argument. The lodes had been said to be thrust faults by some geologists, normal faults by others. As a matter of fact, we knew almost nothing about them, nor did we know the nature and significance of the cross faults, which offset the lodes. To try to overcome this lack of certainty, the surface was mapped on the scale of 100 feet to the inch, and an effort was made to find and map every existing outcrop. No doubt this ideal was not attained, but a real effort was made to attain it. In order to determine the nature of the overturns, a record was kept of primary depositional features, such as cross-bedding, ripple mark, graded bedding, etc., in the rocks. Cross-bedding was found to be by far the most useful criterion. Its use proved that the southwest-dipping beds were usually right-side up, whereas the northeast-dipping beds were usually up-side-down; therefore the Payne overturn is a recumbent anticline, as is the Silver Ridge overturn, and Queen Bess overturn is a recumbent syncline. Further, all these recumbent folds must "root" or go to depth somewhere to the northeast. This was in agreement with the regional geology and the fact that one goes from older to younger rocks from east to west. Sketches made of the surrounding mountains from the summit of Idaho Peak suggested that overturns dominated the structure for many miles to the northeast, north, and northwest. Previously to making these sketches, Mayo and E. H. Nickel had visited the Millie Mack property, on the summit of Grouse Mountain, east of Burton, B. C. This area lies beyond the northwestern edge of Plate 1. At the Millie Mack a flat gouge layer some 30 or 40 feet thick caps

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the Slocan series, and above the gouge is a plate of volcanic rocks apparently belonging to the Kaslo series. It may be, then, that the sequence as seen at the Millie Mack is inverted; that is, here the older Kaslo series may lie on the younger Slocan series, suggesting that overturning is indeed a widespread phenomenon in the Slocan region. So the ideas developed the previous year were broadened and strengthened. more probably due to décollement, overthrusting.

In spite of this progress, however, the underground locations of the axial planes of the overturns, and the application of newly acquired knowledge to exploration remained highly uncertain matters. Cross-bedding was usually lacking underground, as well as in some critical areas on the surface. By November, 1947, it was felt that for the effort expended, progress in understanding Slocan structure had not been good enough.

Meanwhile the 501 lateral had been extended farther westward, into porphyry, and diamond drilling, from new stations, had been finished. No ore was found, and the new information showed rather conclusively that the intersection in hole R-6 had been caused by grazing along a narrow seam (Pl. 4). At the end of this work, W. M. Sharp called attention to interesting structures in some old workings on West Silversmith lode, into which a stub off the 501 lateral had broken. A preliminary examination showed the possibility of obtaining vital information on the nature of lodes, cross faults, porphyry, and occurrence of ore. Accordingly, the 501 lateral was washed down, as was the safer portion of the old workings. All were mapped on 40 feet to the inch, and because this scale was too small to show all necessary detail, many large scale sketches and sections were made. In order to record systematically the many structural features, the system of coordinates used by students of petrofabrics was employed. As a

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

result of the study, it was found that: (Pl. 4)

1.) West Silversmith lode was a strike-slip fault; the hangingwall had moved relatively eastward, and gently downward.

2.) Lone Star fault, in 501 lateral was a normal fault, but, followed southward, it became a strike-slip fault, with hangingwall moving relatively southeastward; that is, near the West Silversmith lode, Lone Star fault began to partake of the lode movement. In the interval where West Silversmith lode was offset, Lone Star fault showed evidence of very strong strike-slip movement.

3.) Lone Star fault apparently did not extend beyond the southern segment of West Silversmith lode. Instead, the fault, and all evidence of movement, turned the corner and followed the lode.

4.) There was no evidence at all of forceful emplacement of the porphyry. All small, steep faults in the porphyry, regardless of dip, were normal faults. Many small remnants of Slocan sediments appeared in the porphyry.

5.) The porphyry appeared to have come in on trough-like warps in the ~~and~~ lode.

6.) The ore appeared to have come in on noses in the lode; the stopes occupied the steeper portions of the lode in the "lee" (i.e. eastern) sides of the noses, as had been the case at the Payne Mine.

These conclusions were presented under date of January 7, 1948 in a report entitled "Structural Study on Ruth 501 Lateral and West Silversmith Lode".

Although it was felt that some real progress had been made, it was realized that this was a very small study, and that its results still had to be integrated with the overall picture.

In the Fall of 1947, Kelowna geologists mapped part of the surface at

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

the Hewitt mine, and they also mapped the accessible parts of the underground workings. The Hewitt lode, unlike the lodes farther north, dips northward. The hanging wall has moved relatively ~~downward~~ westward, and the footwall has moved relatively eastward. There are two stoped areas, a western one, in which the lode, in hard quartzite, splits into several branches connected by gashes related to the eastward travel of the footwall, and an eastern one, the Cunningham ore shoot, in which the ore appears to be controlled by crumples related to the eastward travel of the footwall. note N. dips of Hewitt-Vanderbilt lodes.

1948 - After the investigation on Ruth 501 lateral and West Silversmith Lode had been completed, the Kelowna geologists visited the Silversmith 10 Level, where Moehlman and Buller had mapped, east of the Silversmith fault, a pile of northeastwardly overturned isoclinal folds, thought by Moehlman to be evidence of thrusting from the southwest. With the evidence of normal and strike-slip faulting of the Ruth 501 area in mind, it was thought that such evidence of compression and thrusting could not exist, but the piled-up isoclinal folds were found, just as Moehlman and Buller had mapped them. An explanation was soon forthcoming.

In order to relate the conclusions of the Ruth 501 study to the district structure, Mr. Billingsley suggested that the cross faults were formed along the boundaries between strong and weak rocks by interbedding movements consequent upon folding. Therefore, in a west-dipping, right-side-up panel, the cross faults would be west-dipping normal faults, and where these crossed the southerly-dipping lodes the left hand lode segment would always appear to have been carried forward. Where the strike slip movement on the lode was strong, the southerly continuation of the cross fault would be carried past the end of the right hand lode segment:

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

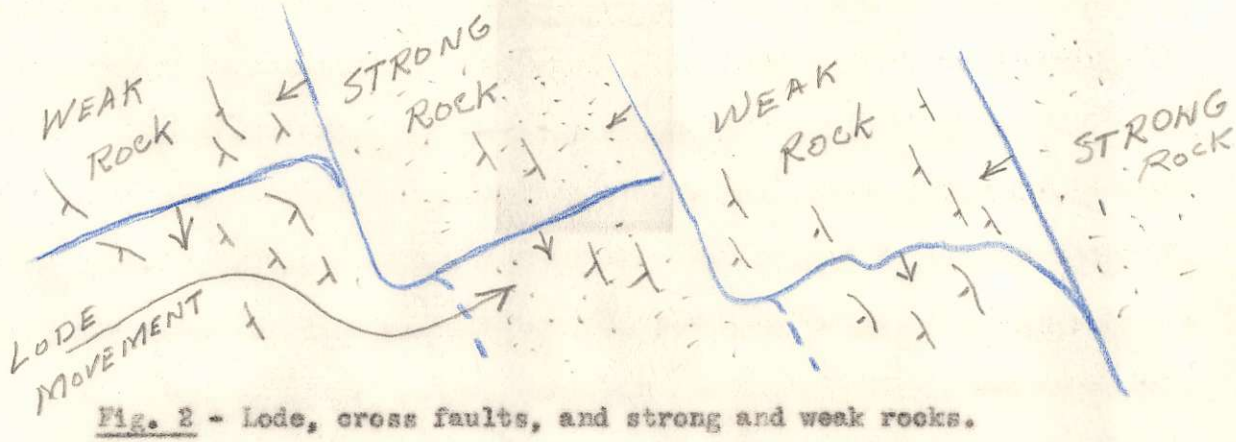

Fig. 2 - Lode, cross faults, and strong and weak rocks.

In an east-dipping, up-side-down panel, however, the cross faults would be east-dipping normal faults, and where they crossed a lode, the right hand lode segment would always be set forward:

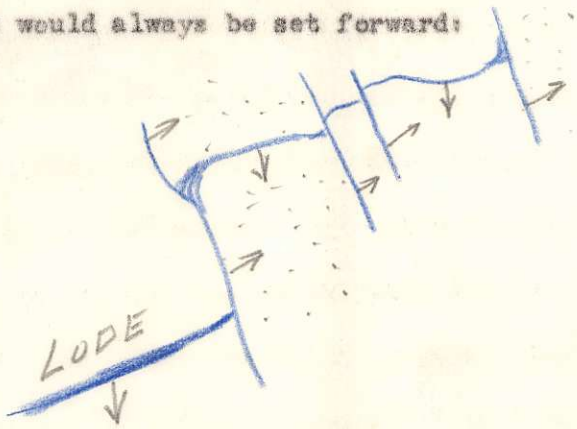

Fig. 3 - Lode and Cross Faults in an east-dipping panel.

These ideas and conclusions were presented in a report by Billingsley and Mayo entitled "Geological Investigation of the Slocan District, B. C. Status as of February 18, 1948". In this report, the 1948 geological program was outlined to include mapping the Mammoth underground and surface geology, the Carnation underground and surface geology, and an extension of the mapping down the southern slope of Silver Ridge far enough to establish the position and trend of

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

the Queen Bess axial plane. Before this work was completed, the Wakefield group had become Kelowna property.

Meanwhile, Mayo and Lamb had re-studied the old Ruth 5-level, re-mapping, in an effort to apply the results of the Ruth 501 experience, the workings previously mapped by Moehlman and Buller. The 4 level portal had caved, so we had to be content with an analysis of data gathered by others on these levels. A year or so later, Black and Higgins reopened the 4-level portal and W. M. Sharp re-mapped the upper levels in great detail. The structure (Pl. 3) is essentially as found by Buller. Sharp's later detail furnished conclusive proof of the presence of the Payne overturn, at the axial plane of which the overlying ore body abruptly cut off. and of the occurrence of normal a subsidence faulting later than the principal lode displacement.

The study on the 5 level showed much new evidence of the strike slip movement on Ruth lode, and it brought out the fact that if an overturned panel of sediments happened to dip westward, the west dipping bedding faults within it would be thrust faults, and any minor folds formed would seem to indicate thrusting from the southwest. This explained Moehlman and Buller's observations on Silversmith 10 level. The pile of northeastward-overturned folds was, in fact, up-side-down west-dipping beds beneath the axial plane of the Payne overturn:

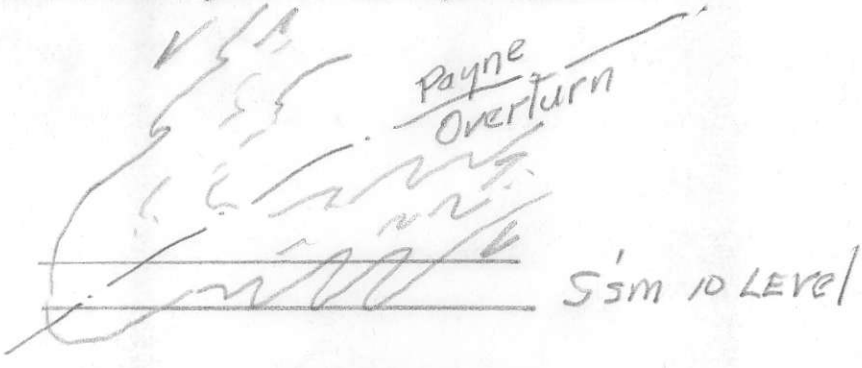

Fig. 4 - Apparent thrusting from the southwest in relation to Payne overturn.

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The results of Mayo and Lamb's study were presented, May 14, 1948 in a report entitled "Structural Study of the old Ruth Mine". As a result of this study, we gained two more criteria for recognizing the upright and overturned limbs of recumbent folds, and for locating the axial planes of these overturns, namely, the natures of cross faults, and the direction of overturning or rotation of drag folds. As the 1948 field season began it was felt that the Mammoth mine study could be started with sharper tools than we had ever had before.

Shortly after the structural study of the Old Ruth mine was completed, the option on the Ruth-Hope property was dropped.

On the 1948 field crew, Mr. M. D. Kierans replaced William Orr as topographer.

The Mammoth mine workings were mapped on 40-scale, as was the surface above the workings. Carnation west portal tunnels were also mapped on 40-scale, Wakefield workings on 100-scale, and Mascot workings were re-mapped for evidence of lode motion and ore control. Survey control was extended down the southern slope of Silver Ridge to cover Wakefield ground. The 100-scale mapping of Kelowna holdings was practically completed, and reconnaissance traverses were extended as far as Silverton Creek. The Mills group of claims, beyond the Wakefield Group, had been brought to the Company's attention, and surface and underground mapping was started on these claims.

That Fall, a road was constructed to a new portal site at elevation 5480 in Carnation Basin, from which it was planned to drive a tunnel to reach the Carnation lode just under the axial plane of the Queen Bess overturn. A program of surface diamond drilling planned to gain information on lode, wallrocks,

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

structure and mineralization on the overturn was started, but it failed because of broken, siliceous ground in which bits were destroyed and caves were frequent. In the late Fall the east portal of the Carnation 6500 level was opened; the workings were surveyed, and the geology was mapped on 40-scale. This work was finished in December, just as deep snow made this area inaccessible.

During the Mammoth investigation, particular attention was given to evidence of the movements on the lode. Details indicating nearly horizontal movement, hanging wall relatively eastward and slightly downward, were found, and, in addition, there was much evidence of normal faulting on the lode. Strangely enough, evidence of the normal faulting was found at one place within 20 feet of evidence of strike-slip movement. It appeared that normal faulting had followed alternated with the strike-slip movement. - comprising a late or final stage of lode displacements

When the Mammoth investigation started, it was thought that the so-called transverse panels, that is, those zones in which the strikes of the sediments were approximately parallel to the strikes of the lodes, were a result of drag, caused by strike-slip movements on the lodes. The relations on 7-level of the Mammoth mine (Pl. 6) seemed to confirm this, but on the 4-level, the bending of the northwesterly strike to conform to the transverse panel would appear to have resulted from a westward travel of the hanging wall. Since it was improbable that the hanging wall had travelled in opposite directions, it seemed that the transverse panels were not caused by movements on the lodes.

It appeared, then, that a sharp southward-downwarping of the axial planes of the overturns would result in a local change from normal to transverse strikes, and further, west dipping limbs, followed northward, would turn to the left (west) into the transverse panel, whereas east dipping limbs would turn to

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

the right (east), thus explaining the relations seen on 7 and 4 levels.

An attempt was made to explain the normal faulting on the lode as a result of concentrated interbedding adjustments in the transverse panel. Although it still seems likely that such adjustment was a factor, subsequent studies by W. M. Sharp in the Ruth mine have shown that the normal faulting can take place where no transverse panel exists.

Applying the results obtained from studies in the Ruth and Silversmith mines, it was decided that the Mammoth ore body was localized where a change from relatively weak to relatively strong rocks had caused a counterclockwise buckle in the course of the lode. Again it is thought that this was indeed a factor, but another element, the transverse panel, also appears to have played a role, realized only by Mr. Billingsley in 1948.

On 7 level (Pl. 4) the lode appears to angle acutely from foot wall to hanging wall side of the transverse panel, dividing where it encounters changes of strike within the panel, and forming a broad, rhomb-shaped area of sheared, crushed rock where it encounters the normal, northerly trends on the hanging wall side of the transverse panel. The ore entered on the eastern, or lee side of this rhomb.

From 7 level to 5 level, the shapes of the stopes appear to have been controlled by: (1) northeasterly fractures, breaking across between en echelon segments of the lode, and (2) north-northwesterly bedding, connecting normal panel to transverse panel. On 6 level, the rhomb has begun to flatten and disappear, therefore it is thought that the axial plane of the Queen Bess overturn must lie near 5 level. The results of the Mammoth investigation were submitted December 21, 1948, in a report entitled "Mammoth Mine".

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The surface mapping on the southern slope of Silver Ridge disclosed that the axial plane of the Queen Bess overturn dropped rapidly southward toward Silverton creek. Apparently, the Standard-Mammoth lode "hinge line" marked the beginning of this rapid southward fall of the axial plane. This fall, plus a supposed rapid rise of the plane beyond Silverton Creek, is probably responsible for the panel of northeasterly trending sediments previously mentioned south of the hinge line. Apparently, the structure of the valley of Silverton creek is synclinal, and this syncline represents a sharp downwarp in the axial plane of Queen Bess, and other, overturns.

In 1948 Dr. M. S. Hedley gave Kelowna Exploration Company a copy of his map of the Ivanhoe basin. The information on this map suggested that the Ivanhoe ore body had made in a down faulted segment of the Silver Ridge overturn. Thus was added one more to the list of mines probably associated with the axial plane of an overturn.

The results of the 1948 work, and of work that had gone before, were presented by Billingsley and Mayo in a report entitled, "Geological Recommendations for Carnation Basin Project, March 8, 1949". In that report, the structural and lithological features that localize ore were listed, and specific examples were figured. It was pointed out that the relatively unexplored gap on the Standard-Mammoth-Carnation lode, on Carnation ground was covered by a high, thick "blanket panel" of unfavorable easterly-dipping rock, representing the upper limb of the Queen Bess overturn. The rather strong mineralization in the areas of the east and west portals (Pl. 6) were regarded as upward leaks from more favorable structures on and below the axial plane of the Queen Bess overturn. These leaks were supposed to be analogous to the fingertips of ore

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

found in the upper levels of the Mammoth mine, (Pl. 5). The presence of the unfavorable blanket panel seemed to explain the failure of Victoria Syndicate to find ore on Carnation ground in the 1920's. In this and other reports it was stated that the west-dipping, upright panels in the vicinities of the axial planes of the overturns were the favorable panels. On certain sections accompanying reports, these were labelled 'optimum panels'.

1949 - It was originally planned to report in some detail on the geology of each of the 4 100-scale Slocan map sheets, prepared by the Kelowna geologists. However, unexpected events made this impossible, and only two of the projected reports ever appeared. These were "Geology of the Ruth-Hope-Silversmith-Slocan Star-Mascot Area" (Map Sheet No. 1), submitted June 6, 1949, and "Structural Principles and the Carnation Underground and Surface Mapping" (Map Sheet No. 4), dated June, 1949. In the first-mentioned report, the inferred traces of the axial planes of the Payne and Queen Bess overturns were shown underground and on surface, and supporting evidence was discussed. The results gained in the study of Ruth 501 lateral and West Silversmith lode were applied to what was known of the Ruth, Silversmith and Hope mines, and tables were presented to show the coincidence of ore and other mineralization with counter-clockwise buckles in steep lode segments near the axial plane of an overturn. Information was incomplete, but it appeared that the theories developed thus far showed a good "batting average" in the area of Sheet 1. The results suggested interesting possibilities on the Mascot and Mimiehaha prospects.

In the second report the structural principles underlying the theories derived from the Slocan work were reviewed, then the location of the

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

Queen Bess overturn, as shown on Map Sheet No. 4 was discussed, and finally, the Carnation underground geology, as then known, was described. Perhaps the most interesting feature of Carnation geology was an intensely altered area, containing scattered veinlets and disseminations of galena on the surface in Read basin, and appearing with more ore type minerals near the eastern end of the Carnation 6500 level, (Pl. 6) all in the upper limb of the Queen Bess overturn. It was thought that this mineralization would carry down to the axial plane of the Queen Bess overturn, where commercial values would be found. This target was made the major, or primary, objective of the Carnation exploration.

Early in 1949, interest was renewed in the Hewitt property, and as soon as snow permitted the 9 level portal was opened, and the workings at the lower end of the Cunningham ore body were re-mapped on 20-scale. A report on the Hewitt Mine from the geological viewpoint was submitted by Billingsley and Mayo in March, 1949. Once again, it was decided not to try to develop ore in the Hewitt Mine. At about the same time, it was decided to enter into a partnership with Bralorne Mines Company to explore the possibilities for ore on the Queen Bess - Idaho property.

At a conference held in Hedley in March 1949, the possibility of attempting further diamond drilling in the Carnation east portals area was reviewed, and it was decided that, in view of the disappointing experience of the previous fall, it was better not to attempt further drilling. Accordingly, plans were made to start underground exploration from the new portal site at elevation 5480. At the time of starting this new work, the axial plane of the Queen Bess overturn was thought to lie some 200 or 300 feet above the 5480 level; the overturn was thought to be a single, large, simple structure, and

INVESTIGATIONS BY KASLOWNA EXPLORATION COMPANY (Cont'd.)

the axial plane was thought to dip gently westward. The new portal site was chosen with these opinions in mind. The mechanical work, underground and on surface, was placed in charge of Mr. J. C. Black; Mr. W. M. Sharp was in charge of underground and surface geology.

At the beginning of the field season, the Palmetto claim, east of the Queen Bess group, was brought to the Company's attention, so that some surface mapping was done in this area, and part of the Black Colt mine was mapped. Acting on advice from Mr. Robert Grimes, a vein, carrying scattered lenses of galena, was exposed by bulldozing along the Forest Service road on the Palmetto, but no encouragement was found for believing that a commercial ore body might exist in the vicinity; therefore interest in the Palmetto claim was dropped.

In June, 1949, reconnaissance trips were taken by Mayo, Sharp and Kierans on Reco Mountain, and into Jackson and Dardanelles basins, and by Mayo, Lamb and Riddell into the mountains north of Kaslo river. On the latter trip, the Slocan-Kaslo contact was crossed. Dr. M. S. Hedley, following a creek bottom, had determined that the Kaslo contact dipped southwesterly, as described by Cairnes. Mayo, Lamb and Riddell, following the crest of a ridge, did not actually see the contact, although its location was fairly certain within a probable error of 50 feet. Bedding and schistosity in the Slocan sediments at first dipped southwesterly, but when followed up the ridge steepened to vertical and, in the vicinity of the Kaslo contact, overturned to northeasterly. Beyond the Kaslo contact, schistosity in Kaslo rocks dipped northeasterly, and the same appeared to be true in the Milford series above. It appears, then that at the lower elevations the upper contact of the Kaslo series dips southwesterly, and that at higher elevations it steepens to vertical, then overturns

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

to allow the Kaslo to overlie the Slocan series. This agrees with previous Kelowna observations and appears to confirm earlier impressions of overturning on a regional scale.

Most of the Queen Bess - Idaho surface was mapped on 100-scale by field parties under W. M. Sharp and ~~E. H. Nickel,~~ ? and accessible underground workings were mapped on 40-scale by Sharp and Lamb. Toward the latter part of the season, Nickel started surface mapping on the Mills Group. Lamb mapped further surface details in the Carnation area, and kept up the underground mapping in the new (5480) level. The old Carnation 6300 level was opened, and it proved to be much more extensive than shown on old maps. The geology was mapped by ~~John~~ Lamb, Sharp, & Mayo.

A surprising fact revealed on the 6300 level was that almost no ore type mineralization was found there. It was obvious that only part of the full lode ~~part of the lode~~ had ~~not~~ been explored, and it seemed probable that on the unexplored hanging wall strand of it ~~the unexplored segment~~ contained the mineralization. Because of the importance that information on this mineralization would have for the new exploration on 5480 level, it was proposed to search for it by extending one of the 6300 level crosscuts (Paul Billingsley, "Carnation Tunnel Program, Status as of September 28, 1949). This crosscut was extended as planned. The lode was cut, but no ore-type mineralization was found on it.

Meanwhile, the 5480 adit, supposed to advance in west-dipping rocks beneath the Queen Bess overturn, proved to be in east-dipping rocks. Something was obviously wrong with the structural picture as interpreted from the field mapping. In November this adit crossed a lode that carried lenses of high grade galena-sphalerite mineralization. The existence of such a lode,

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

north of the supposed location of the Carnation lode, had not previously been suspected. It was referred to in subsequent reports as the north lode (Pl. 6). South of the north lode west-dipping rocks were finally found, and a second lode (the South lode) carrying a vein of sphalerite, was crossed (Pl. 6).

In the fall of 1949 Mr. Gulley, surveyor, left to continue his studies at University. His place was taken, and filled to the end of the exploration program, by Mr. Bryan Stephens.

Two detailed reports on field work in the Queen Bess - Idaho area were submitted by W. M. Sharp in 1950. The first, dated March 20, was "Geology of the Queen Bess Mine, Slocan District, British Columbia"; the second, "A Report on the Geology of the Idaho Mine Area", bore the date April 15, 1950.

The Queen Bess report included some of the results of the diamond drilling program, started in 1949. A perusal of the report and the accompanying maps and sections reveals clearly the following points:

(1) The Queen Bess ore bodies occurred on a terrace-like steepening of the lode. This terrace coincides approximately with the axial plane of the Queen Bess overturn. Gaps in the stope pattern are occupied by relatively incompetent members of the sedimentary sequence (Pl. 7).

(2) The terrace and the alignment of stopes, and therefore the axial plane of the Queen Bess overturn decline eastward, not westward as previously supposed.

(3) Close under the Queen Bess overturn, too close for the Payne overturn itself, is a Payne-type overturn, below which must be another Queen Bess type overturn. Therefore, the Queen Bess overturn must be a double fold, consisting of upper and lower recumbent synclines, divided by a median anticline. All ore made in the upper syncline, which appeared to be a sharp flexure.

(4) The so-called "B" vein, partially explored at 5170 elevation, appeared to be a segment of the Queen Bess lode, offset to

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

the northwest on No. 7 cross fault.

These findings, obviously, were of much significance for the Carnation exploration. There, in aiming to enter below the "Queen Bess overturn", we had actually entered the upper limb of the lower syncline.

Maps and sections accompanying the Idaho mine report showed that, above the Queen Bess overturn, there was an abrupt change from steep overturned beds to flat overturned beds. Mr. Billingsley named this change the Queen Bess hinge, and the overlying flat panel the Idaho lid. The lower part of the flat sequence was, as stated before, up-side-down, but still higher flat beds were right-side-up, thus indicating the presence of the Silver Ridge overturn, here recumbent and isoclinal. The Idaho ore body appeared to lie in the lid, above the Queen Bess hinge.

1950 - In late January, 1950, the 5450 Adit encountered a large, flat, rolling gouge zone, thought to be the main Carnation lode (Pl. 6). It was decided to drive through this zone, into the Queen Bess quartzites on the hanging wall, but an advance of 125 feet failed to reveal the hanging wall, although some quartzite was seen in the face. Orders came to stop the heading, and to drift westward along the South lode. This drifting, and crosscutting, continued into 1951. Nowhere was the Queen Bess quartzite found. The so-called south lode lateral, and cross cuts from it, stayed in east-dipping rocks, and there were only a few feeble showings of ore type mineralisation.

On July 10, 1950, Billingsley and Mayo stated the then-condition of the Carnation exploration in a report, "Carnation-Sandon Exploration Program, Status as of July 1, 1950". In that report the results of Sharp's findings in the Queen Bess mine were taken into consideration. The advance of No. 2

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crosscut, 6300 level, in another attempt to locate the downward extension of surface and 6500 level mineralization was recommended, as was the reopening and mapping of the old 6600 level, with portal in Read basin. These recommendations were carried out. Further advance of 6480 level, and starting of a southward crosscut were recommended and subsequently carried out. Two secondary objectives, exploration of the north lode and eastward drifting on the South lode were recommended.

On July 5, 1950 appeared a report by Billingsley and Mayo, "Bess Mines Program, Status as of July 5, 1950". Exploration below the western, or portal, ore body Queen Bess Mine (Pl. 7), was recommended. Suggested means were (1) utilize lower B tunnel (5170) or (2) drill fan of down holes from station south of No. 5 Portal, or (3) re-open No. 7 portal. Subsequently, (1) and (2) were carried out, and a bulldozer cut was extended to cross the surface outcrop of "C" vein.

The recommended diamond drilling was done first, and throughout the fall and winter months, B level was advanced in search for a downward extension of the portal ore body. Some zinery mineralization of possible milling grade was found, but the amount of this was much too small, and no high grade was found.

On August 5, 1950, Billingsley and Mayo reviewed the then state of the Carnation program in a report entitled "Carnation-Bandon Program - Final Stages in Exploration of Primary Target". By that time, the 6600 level (X-C) had been reopened and mapped, so that the connection of the surface mineralization with 6500 level was satisfactorily established, but no ore mineralization had yet been found on the 6300 level. For this reason, extension of No. 2

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crosscut, 6300 level was again mentioned, and it was recommended that the lode when found, be drifted on for some 100 - 300 feet (Pl. 6) To enter a west-dipping panel as soon as possible, it was recommended that lode be searched for at 6100 feet elevation and, if found, drifted on some 500 - 600 feet. In order that the entire width of the Carnation lode be exposed, the southward crosscut, then in progress was to advance an additional 200 - 300 feet, after which drifting was to re-commence on the best lode strand revealed. Provision was made for upward diamond drilling if this should seem advisable. The secondary targets, north lode and eastward extension of south lode, were mentioned again and surface stripping was at once started to expose the lode at 5480 level. The stripping, plus surface drilling, revealed the north lode. A drift northeastward on the lode revealed the continuation of lenses of high-grade mineralization along it, and toward the end of the year driving commenced from a new portal site on the north lode.

The long southward cross cut from the south lode lateral (5480) failed to reveal additional lode strands, so westward drifting continued along the south lode, which made a turn and was temporarily lost. At this stage (November 1951) a northward crosscut was recommended. This crosscut found evidence suggestive of a convergence of north and south lodes, so two more northward crosscuts were driven for confirmation.

The No. 2 crosscut on 6300 level was driven beyond the place where it was thought the lode should be crossed, but apparently no lode was found. Study of the map of the workings, however, suggested that a large calcite vein, crossed early in the advance, was in fact the lode. Subsequently, this vein was drifted on both eastward and westward, until no doubt remained of the

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

correlation. Only the tiniest specks of ore mineralization were found. An unexplored gap was left in the lode, but the drift had penetrated into the downward projection of the mineralized area found on surface, in 6600 level, and 6500 level. It appeared that this mineralization did not reach 6300 level, and as stated below it was decided to abandon work in this level.

1951 - On January 11, 1951, Messrs. Billingsley and Douglass (Carnation-Sandon Exploration Program, Review as of January 11, 1951) recommended if, after advancing the westward drift on 6300 level an additional 30 feet and crosscutting to expose full length of the lode, no favorable ore indications were found, work on that level be stopped. Work in the south lode lateral, 5480 level, was also to be discontinued. The 6100 level was to be advanced in the hope of testing the lode in a west-dipping panel, and the exploration of the north lode was given a high priority.

By March, the 6100 level had advanced some 600 feet and a crosscut north had discovered what appeared to be the north lode, but there was no ore type mineralization. North lode on 5480 level had been drifted on both northeasterly and southwesterly from the main adit, and a new drift and crosscut some 450 feet long had entered from the new 5480 portal site and had followed the north lode around a bend within which a large diorite intrusion nestled. Because this was a counter-clockwise bend similar to the ones on which Silversmith and Payne ore had been found, there was much hope of finding ore on it, but only one small lens was found. Some additional galena and sphalerite lenses were found by the drifting from the main adit.

With appropriations running low, the problem arose of finding ore

INVESTIGATIONS BY KELOWNA EXPLORATION COMPANY (Cont'd.)

in the quickest and most economical manner possible. Recommendation was made by Mayo that all but north lode exploration be dropped, and the best looking galena-sphalerite mineralization be developed by a raise and, if necessary, a sub-level. While this work was in progress Mr. Billingsley presented reasons for believing that the ore existed below 5480 level on a Queen Bess type overturn, thought to be the lower syncline. Suggestions of such a structure had been revealed in the north lode drift southwesterly from the main adit (Pl. 8).

The recommended raise, and a second one farther eastward, showed rather conclusively that the lenses of ore mineralization narrowed above the level, so the raises were discontinued. A hanging wall crosscut was driven for diamond drill stations, from which fans of downward holes were drilled to test the lode on the supposed overturn. Results were almost negative; one hole only found a small ore intersection. There was no certainty that the axial plane of an overturn had been penetrated. There appeared to be no further chance of finding ore close at hand, and with appropriations exhausted, the Carnation Exploration was stopped.

Meanwhile, the exploration on the Queen Bess B vein had likewise been stopped, and an old tunnel on the road just east of Howson Creek had been opened. An old report had mentioned a good width of zinc ore in the tunnel. This place was mapped and sampled. The material did not reach ore grade but it was decided by Kelowna Mines Hedley and Bralorne Mines Co. to drive ahead on the lode in the hope that the values would improve. This work is still in progress.

CRITICAL REVIEW OF FACTORS CONTROLLING ORE DEPOSITION IN THE SLOCAN DISTRICT

(1) The association of Slocan ore with lodes is too obvious to require mention. In this analysis we are mainly concerned with a lode of Class A.

(2) In most of those mines that have been investigated by geologists of Kelowna Mines Hedley Limited, the association of ore with the axial plane of an overturn seems obvious. It has repeatedly been stated that the ore always occurs in the west-dipping limb of an overturned or recumbent fold; this limb has been called the optimum panel, and the aim has been to bring exploration into such a panel. It is thought well, therefore, to review those mines that have been studied in some detail in order to see how the ore occurred:

Mine	Overturn	Occurrence of Ore
Payne	Payne	On axial plane and below in east dipping beds.
Washington	Payne	Above axial plane, in west-dipping beds.
Ruth	Payne	Above axial plane in nearly flat west-dipping beds.
Stewart	Minor Overturn above Payne	Above axial plane, in west-dipping beds.
Slocan Star	Payne	Above axial plane in west-dipping beds, and below axial plane in east-dipping beds.
Silversmith	Payne	Above axial plane in west-dipping beds.
Queen Bess	Queen Bess	On, above, and below axial plane in east and west-dipping beds.
Idaho	Silver Ridge (?)	Above and below A. P. in flat beds.
Mammoth	Queen Bess	On, above and below axial plane, best ore in west-dipping beds.
Standard	Payne ?	Relations not clear.
Hewitt	Queen Bess ?	Possibly the east-dipping, overturned limb (?)

CRITICAL REVIEW OF FACTORS CONTROLLING
ORE DEPOSITION IN THE SLOCAN DISTRICT (Cont'd.)

Of the listed 11 mines, 2 give questionable information. In the remaining 9, ore occurs in west-dipping beds only in 4 cases, in east-dipping beds only in 1 case, in both east-dipping and west-dipping beds in 3 cases and in flat beds in one case. All 9, with the possible exception of the Washington, are closely associated with the axial plane of an overturn. It appears that the west-dipping beds have the advantage, but ore can occur in east dippers. The presence or absence of the axial plane of an overturn may be a vital factor. In all known occurrences of ore the overturn is tight.

(3) The association of relatively hard, competent rocks with relatively weak, incompetent rocks seems to be an important factor. This does not mean that a broad belt of quartzite will localize a big ore body. Ore seems to make in the transition between weak and strong rocks. Unfortunately, there are many degrees of hardness or softness, competence or incompetence, and during an exploration attention becomes focussed on very small differences, with the result that a slight change of formation may be taken as a favorable indication, and the plan of exploration altered accordingly.

(4) Where a lode is accompanied by a strong transverse panel, apparently the chances for ore improve where the lode, angling acutely through the transverse panel, begins to crosscut the beds of the normal panel, as on 7 level, Mammoth mine. This conclusion assumes westerly dips in the normal panel. In all other situations, a transverse panel appears to be unfavorable.

(5) Unfortunately, the studies by Kelowna geologists in the Standard area did not go far enough to lead to definite conclusions, but in the Silversmith area, the great Standard-Silversmith lode is associated with a belt of strong cross faults and porphyry intrusions. This belt includes the Richmond Eureka,

CRITICAL REVIEW OF FACTORS CONTROLLING
ORE DEPOSITION IN THE SLOCAN DISTRICT (Cont'd.)

Silversmith, Slocan Star, Ruth and Hope mines and extends as far west as the Mascot and Minnie-haha prospects. Although such a belt of cross structures may not be a vital feature, as seems to be exemplified at the Mammoth mine, it is felt that location in such a belt inereases the chance of finding ore. This amounts to saying that a belt in which strong and weak rocks alternate should be especially favorable.

(6) Association of ore with noses in the steeper parts of lodes has been noted. This relation was clear in the Payne mine, and it was emphasized by the study of Ruth 501 lateral and West Silversmith lode.

(7) There may be other factors that make certain segments of a lode more favorable than others. For example, it is known that the axial planes of the overturns are themselves folded on two sets of axes. One set, as mentioned before, trends slightly north of east, and the Standard-Silversmith lode lies just south of the crest of the principal fold that follows this direction. This fact may account for the exceptional productivity of the Standard-Silversmith lode. The second set of axes trends directly across the first set. These folds are expressed in the southwesterly and northeasterly dips of the axial planes of the overturns. Our information on these, the most fundamental folds in the district, is very fragmentary, so that it is difficult to evaluate the possible role of such structures in localizing ore. Most of the mines in the heart of the Slocan district are on a broad E-NE trending nose, and the troughs to north and south appear to be less favored. As for the cross folds, a belt of mines that includes the Payne, Washington, Noble 5, American Boy, Surprise, Last Chance, and Reco lies just east of the crest of an anticline. (The axial plane of the Payne overturn rises westerly, but is soon to decline westerly). The Richmond Eureka,

CRITICAL REVIEW OF FACTORS CONTROLLING
ORE DEPOSITION IN THE SLOCAN DISTRICT (Cont'd.)

Slocan Star, Silversmith, Ruth and Hope appear to be just east of the bottom of a trough, and the Queen Bess and Carnation appear to be just east of the crest of the next anticline. It is felt however that these relations are not well enough defined to be of much value.

The combination of favorable factors needed to localize ore would seem to result in fairly small ore bodies. For example, fairly tight overturns with ore seldom or never far from the axial plane, localization on noses in the steepest part of a lode, localization on the transitional border between strong and weak rocks, etc. would seem to preclude the existence of very large ore bodies. This fits the mining history, and the chances of finding an ore body bigger than the largest already found seem very remote.

Further, the ore is localized by a combination of the favorable factors. It is believed that the crossing of an overturn by a lode is of no significance unless there also occurs at that place rocks that differ significantly in competence, such as quartzite and slaty argillite. In this respect, the Carnation exploration has been surprisingly negative. Except possibly at the face of 5480 Adit, the Queen Bess quartzite was nowhere identified; therefore an important favorable factor has been missing. In view of the sameness of the rocks traversed across the strike, it might well be futile to explore the lode, either upward or downward to the axial plane of an overturn. Surface mapping, however, indicates that the Queen Bess quartzite is distributed widely over the surface above the Carnation workings. At depth it may possibly have been carried eastward, out of range, by the gentle eastward decline of the axial planes of the multiple Queen Bess overturn.

PROSPECTS REMAINING

At present there appear to be six prospects remaining on Kelowna Mines Hedley's Slocan property. These are:

(1) West portals area, in which a small amount of ore has been stoped. Exploration target below existing workings.

(2) Original major objective, below the mineralization in the east portals area. Possibilities for ore on and near the axial planes of upper and lower Queen Bess synclines and median anticline.

(3) South lode east of the main 5480 adit. Possibility for ore in west-dipping rocks above the axial plane of median anticline.

(4) North lode, possibility of ore on and below the axial plane of lower Queen Bess syncline.

(5) Minnehaha. Ore possibility below existing workings on intersection of lode and northwest fault zone on Payne overturn.

(6) Mascot. Ore possibility on intersection of lode and northwest fault zone on and below axial plane of Queen Bess overturn.

(1) The exploration target in the west portals area is so far from any new workings that its present prospective value is very low.

(2) Failure to trace east portals area mineralization below 6500 level, and failure to find any definite quartzite horizons on 5480, 6100 and 6300 levels reduce considerably the attractiveness of the original primary objective, so that at present it cannot be considered a first class exploration target.

(3) The zinc vein found where the main 5480 adit crossed the South lode is the best showing of mineralization found on the South lode. Further, this mineralization occurs in west-dipping rocks, whereas almost the entire

PROSPECTS REMAINING (Cont'd.)

South lode lateral was in east-dipping rocks. The zinc vein was followed for a few feet east of the adit, where it pinched down.

In the hope that the mineralization may resume in greater strength farther within the west-dipping panel, it may be well to extend the South lode lateral an additional 100 - 200 feet eastward. The apparent lack of quartzite near here is unfavorable, but an eastward drift might expose quartzite and indicate a target for diamond drilling on the axial plane of the median anticline, below the level. This prospect cannot be given the highest rating, but it does offer the possibility of finding and extracting ore while the other prospects are being investigated.

(4) North lode carried the best mineralization found by Kelowna Mines Hedley Limited on Carnation ground. The nature of the lode is still incompletely revealed in existing workings, and it is not certain that the underground diamond drilling tested the top of the big west-dipping panel below the east-dipping rocks. Also, it could be that the northerly-trending part of the lode, just east of the newer 5480 portal, represents only a split, or spur, of the North lode. The foot wall rocks of the lode are hard, striped, and siliceous; hanging wall rocks are softer. There seems to be no great difference in rock competence, across the strike a fact which lowers the prospective value, unless the lode can somehow be followed into the Queen Bess quartzite. Because of attractive mineralization already found, and because of the more complete information here, the prospect is rated high in spite of some unfavorable factors.

A lower level, with portal site somewhere on the West fork of Tributary creek at an elevation of about 5200 feet may eventually be required, but such an expensive project should not be planned until more is learned about the behavior of the lode.

PROSPECTS REMAINING (Cont'd.)

Exploration of the lode should be completed on 5480 level. This will require about 300 feet of drift and perhaps 160 feet of crosscuts, including an additional 100 foot extension of the existing hanging wall crosscut to provide a station for diamond drilling to test the lode at greater depth. this done w very results

Depending on results, it may be advisable also to plan and drill some deep surface holes from the southeastern end of the bulldozer cut.

Only if the results of the above work are definitely encouraging should the opening of a lower level be undertaken.

(5) Old geological maps of the Minnehaha workings which are now caved suggest that points of intersection of Minnehaha lode and a zone of northwest faults were loci of small masses of high grade ore. The wall rocks are soft, weak argillites with minor quartzite and limestone ribs. South of these workings, and above them, is a large outcrop of siliceous limestone. The silica is thought to be secondary, and to have risen from lode-northwest fault intersections on the axial plane of the Payne overturn, which is assumed to lie somewhere below.

The play at this place would seem to be to locate the lode-northwest fault intersection just above the axial plane of the Payne overturn. The nature of this intersection is imperfectly known, and its location can only be guessed at.

The first step would appear to be to re-open the old workings, map their geology on a large scale, and if it seemed necessary, to extend the workings by hand enough to gain a clear picture of the lode, the mineralization and the intersection.

With this completed, and supposing the results to be satisfactory, it

PROSPECTS REMAINING (Cont'd.)

should be possible to plan an approach to the target. This approach would include a road to a site on the West fork of Tributary creek, which present information suggests should be at an elevation of about 4750 feet, and an adit some 900 - 1200 feet long and perhaps 600 feet of drifting and raising.

(6) The Mascot prospect is located on the East fork of Tributary creek, just above the axial plane of the Queen Bess overturn (probably the lower syncline) in intensely silicified rocks. It is thought that the silicification is related to an intersection of lode and northwest faults near the axial plane, but existing information does not disclose the northwest faults. The intersection may possibly exist near the creek bed, where outcrops are poor, but until this is determined it will not be possible to plan an exploration level. N/A

The lode is thought to be part of the Carnation lode system, perhaps the South lode. There may be other undiscovered lode strands in the hanging wall. Some small fingertips (?) of high grade ore were found and stoped out years ago.

It would be a fairly long drive, some 500 - 700 feet, with limited backs, to reach the supposed site of the intersection from existing workings. It appears best, therefore, to re-examine the surface along the creek and select diamond drill sites from which to probe for the intersection. The trail to the property would have to be repaired so that drilling machinery could be brought in on horses. Probably about 1200 - 2000 feet of diamond drilling would be required. The advisability, or the nature, of further action would depend upon the results of the drilling. N/A

PROSPECTS REMAINING (Cont'd.)

Based on the above discussion, the six remaining Kelowna prospects seem to be fairly classified as follows:

(A) North Lode

(B) (Minnehaha
(Mascot

(C) South lode, east of the main adit.

(D) (Major Carnation objective
(West portals area

RECOMMENDATIONS

It still remains to reduce the 100-scale surface mapping to a single 400-scale sheet, and this is to be recommended first of all because of the improved overall picture it should reveal. The necessary review of the 100-scale mapping might show that local bulldozer cuts should be made near some of the prospects for closer structural control.

At the time the Ruth-Hope-Silversmith-Slocan Star-Mascot report was finished, with its tables showing relation of ore occurrence to structure, it appeared that the exploration of any given prospect would have somewhat better than an even chance to fail. On the other hand it appeared that if several prospects were explored, the chances of failure would be considerably reduced. Applying this reasoning to possible future exploration on Kelowna Mines Hedley ground, it would appear best to explore North lode, Minnehaha, Mascot, and South lode east of the main adit as nearly simultaneously as possible. The first stage of such an exploration program might be represented as follows.

> Rehabilitate the 5480 level as far as South lode; drift and crosscut on North lode and advance South lode lateral eastward, as discussed above.
>
> Open Minnehaha workings, map their geology and, if necessary, plan extensions to further define the structure.
>
> Repair trail to Mascot, select diamond drill sites and start drilling.

Some of the above four prospects might not survive the first phase of the exploration program, and it is also possible that new information would add to the list of prospects. The second stage, depending on the results of the first one, might be as follows:

> Plan and carry out underground and surface diamond drilling on north lode.

RECOMMENDATIONS (Cont'd.)

Build road to selected portal site on the Minniehaha and start new exploration level there.

Extend Minniehaha road to a selected new portal site on Mascot ground.

At the end of each phase, each prospect would need to be reviewed to determine whether it appeared worth while to continue to carry that prospect on the program, and if so, to plan the next phase of the exploration.

Further work on the former major Carnation objective does not appear desirable at present. However, if ore is found on one or more of the other prospects, this objective would have to be carefully reviewed and more work on the 6100 level might then be desirable. A success on this former major objective would almost surely call for an exploration of the west portal area.

Nickel Plate, B.C.
September 1, 1951

Respectfully submitted
Ezra B. Mayo

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MAPS - The following list does not include folded maps, accompanying reports, and it includes only the more important of the rolled maps. These are at present in the vault at the Nickel Plate Mine.

Hard Copy Surface Maps - Engineering control:

Sheet No. 1	1 inch	=	100 feet
Sheet No. 2	1 inch	=	100 feet (2 copies
Sheet No. 3	1 inch	=	100 feet (2 copies
Sheet No. 4	1 inch	=	100 feet
Sheet No. 1	1 inch	=	200 feet
Sheet No. 2	1 inch	=	200 feet
Sheet No. 3	1 inch	=	200 feet
Sheet No. 4	1 inch	=	200 feet
Sheet No. 5	1 inch	=	200 feet
Sheet No. 6	1 inch	=	200 feet
Claim Net	1 inch	=	200 feet

Triangulation Net (Queen Bess 200 scale