GEOLOGY AND STRUCTURAL ORE CONTROLS OF THE EAST VICTOR ORE BODY, VICTOR MINE (VIOLA MAC MINES LTD.), NEW DENVER, B. C.

W. M. SHARP,
Mine Manager.

S.J. PEDLEY,
Mine Geologist.

ABSTRACT:

The Victor mine produces a relatively high grade silver-lead -zinc ore. The main ore zone, the East Victor, lies in a heavily fold -ed and faulted section of the Slocan sediments. The cross cutting lode-and to a greater degree, the veins which are formed within it-are strongly influenced by the structural environment.

Ore bodies are developed where the Victor lode intersects a highly-folded section of thin bedded argillites and quartzites. In detail the ore body consists of a number of high-grade vein swells within what is generally a narrow vein structure. These swells are localized by minor fold structures and by formational faults.

Normal post-ore movement along many formational faults and later flat thrusting along certain of these faults offset the vein.

INTRODUCTION:

Viola Mac Mines' Victor property lies four miles east of New Denver, B.C. Access is along a 2½ mile road which leaves the New Denver - Kaslo highway at Three Forks.

The mine is situated on the north-east slope of the Queen Bess Ridge and it is developed by eight adits and several sub levels which range from the 3650 foot elevation up to the 4600 foot elevation.

A high grade silver-lead-zinc ore is mined with production coming from the West Victor zone, the East Victor zone and the Cinderella zone. The East Victor, which has supplied by far the largest proportion of the production to date, is the subject of this paper.

1900
72
3800
13300
136800

The Victor Mine was discovered in 1921 by G. A. Petty, when, by ground sluicing, he opened up a narrow high grade vein fifty feet above what is now Number 1 portal. This ore constituted the extreme upper portion of the East Victor Ore body.

Development by Petty and later by leasers opened up Number 1, 2 and 3 levels and by 1947, 1400 tons of ore had been shipped which had an average grade of about 180 ounces of silver, 45 per cent lead and 10 per cent zinc.

In 1948 the property was acquired by the present owners. Successful development on Number 4 and Number 5 levels followed with high grade silver-lead ore being shipped directly to the smelter. In 1950 a small mill was built on the property to treat low grade material. The mill was abandoned in 1952 when arrangements were made to mill an increased tonnage at the Western Exploration mill at Silverton. By 1955 the monthly mine production was about 1900 tons with an average grade of 20 ounces of silver, 14 per cent lead and 9 per cent zinc. In addition some sorted lead ore was shipped directly to the smelter. By the end of 1955 the mine had (in recovered metal) produced 1060 ounces of gold; 2,531,700 ounces of silver; 30,318,700 pounds of lead; 17,160,600 pounds of zinc, and 93,430 pounds of cadmium from about 95,000 tons of ore.

1948-55 - 95,000 tons ore.
1956 - Feb/62) 138,000 tons "
232,000 tons + pre-op + post-op. leasing tonnage
not Gross 240,000 tons ore

HISTORY OF GEOLOGICAL INVESTIGATIONS:

W. A. Carlyle published the first technical account of the camp in 1896. McConnell in 1894 and 1895 did first systematic mapping which included in the Geological Survey of Canada's "West Kootenay Sheet". In 1906 the report of the Zinc Commission described several properties.

For the Geological Survey, C. E. Cairnes made extensive field studies from 1925 to 1928 which provided the material for his comprehensive memoirs describing the geology and mining properties of the camp. These are still the basic reference works.

Kelowna Exploration Co., started the first detailed mapping in the camp in 1940 - 41, in the Payne - Washington area. This company did further detailed mapping in 1946 - 51 covering most of the area between Carpenter and Silverton Creeks.

At this time the B. C. Dept. of Mines carried out a similar program which was summarized by M. S. Hedley in Bulletin No. 29 -- "Geology and Ore Deposits of the Sandon Area". This publication is the present reference for details of the structural geology of the camp.

ROCK TYPES:

Sediments of the Slocan Series are host to the East Victor ore body. In the mine area these consist of mixed assemblages of argillites, quartzites, and miner amounts of limestone. They are thin to moderately thick bedded (1/8" to 1') and strike north-westerly. Dips vary greatly as several recumbent folds are developed in the sediments.

The sediments, where they can be seen unaltered, are similar in appearance across the entire mine section. However, they change physically where folding is intense. Close spaced bedding slips and cross fractures are strongly developed and these are filled with a graphitic gouge. The degree of this softening is, in part, directly proportional to the intensity of the buckling. As folding is extensive the original character of the host rock is largely masked and for this reason a detailed lithological subdivision is impossible. However, variations in competency, within local sedimentary sections, is indicated by the marked change of fold form from one section of the mine to another. (See Fig. #1) This [inconsistent] (separate) development of structure [within the whole bedding section] almost certainly reflects variations in [lithologic character and later competence under folding] ~~original competence~~ although unequal stressing of the sections must also be a contributing factor.

Porphyritic intrusion occur throughout the mine and these are particularly common in the eastern part of the workings. These are almost entirely sill-like, although, to conform with local contortions in the sediments, they may have extremely irregular outlines.

The sills are from an inch up to several tens of feet wide. While, in strike they are persistant structures, in dip they lens out quickly seldom traversing the entire mine section.

In general the number and width of the intrusives increase toward the crest of the major folds with local thickenings forming at the crests of subsidiary drag folds. This crestal filling is more strongly developed in the tight crests than in the open crests.

FOLDING:

The northwest-striking sediments are strongly folded along nearly flat axial planes. The folds in the mine area occur in couples which are drag folds related to a much larger regional structure.

The workings lie within what is generally a large west-dipping panel of sediments, which is an element of a larger structure whose form ~~is not known.~~ may only be inferred. Within this west-dipping panel many drag folds with various sizes and amplitudes are developed. These may involve a single bed or assemblages of beds up to several hundreds of feet thick.

The drag folds result from the normal interbed movement associated with recumbent folding with the upper beds crowding down over the lower ones. The resulting drag folding in effect steepens the bedding so that, on the average, over the mine section, the dip is steep westerly and in places nearly vertical.

Numerous small drag folds together with elements of two major drag folds occur in the mine. Of the major drags, the lower-or the Number 1 - Drag Fold lies along the lower eastern boundary of the ore body while the upper-or the Number 2 - Drag Fold lies along the upper western boundary.

The No. 1 Fold is fully outlined in the mine workings. The sediments dip steeply to the southwest both above and below the complimentary crests. The center panel has been rotated into an easterly dip.

On section (See Fig. #2) the axial planes dip to the southwest crossing the more competent beds at a dip of 3 to 5 degrees. The uniformity of the plunge is interrupted where soft bedding sections are encountered. Here the axial planes are offset with the western segment stepped down. The overall effect is that the average axial dip is steepened to about 12 degrees.

The sediments in the crestal region and especially in the overturned northeast dipping panel are faulted and sheared showing an extreme degree of softening. In comparison the bounding west-dip panels are relatively unaltered.

The East Victor ore body, in relation to the No. 1 Drag Fold, lies in the upper west-dipping limb and overlaps the upper crest of this structure, eventually bottoming in the rotated east-dip panel.

The upper crest of the No. 1 Drag Fold is outlined in the stoped areas of the mine (See Fig. #1). In the eastern limits of the workings the fold shows a large degree of "similar" folding. Crestal thickening is extreme. Close packed, recumbent, isoclinal drag folds pack the crest. This is accompanied by extensive sill intrusions.

Proceeding westward this fold shows less evidence of "similar" folding and more evidence of "parallel" folding. Crestal thickening through drag folding and intrusions becomes a minor feature and consequently the fold becomes progressively more open, until, in the western limits of the ore section, it is represented by an open flexure in a series of steep dipping sediment.

The lower crest of the No. 1 Drag Fold is only sketchily outlined by the workings. It also dies out to the west following a course parallel to the upper crest and about 200 feet below it.

The No. 2 Drag Fold is outlined, in part, by the upper western mine workings. The east-dipping panel of this drag fold forms the upper western limits of the East Victor ore body. The lower crest of this fold is open to the southwest and where it is adequately exposed it shows a moderated amount of crestal thickening. The crest displays a disjointed axial plane similar to that seen in the No. 1 Drag Fold. The average plunge appears to be about 15 degrees. The upper crest of the No. 2 Drag Fold is not exposed in the workings and hence the complete form of this structure is not known.

JOINTING:

A northeast-striking, steep southeast-dipping set of joints are well developed. These appear to favour certain of the bedded argillites and quartzites and they are particularly well developed in the crest region of the more isoclinal folds. In attitude they are nearly perpendicular to the axial planes of the folds and it is thought that their origin is related to the folding with their development concurrent with the later part of that folding.

FAULTING:

The folded sediments are heavily broken by a system of conjugate faults. Two sets of faults are represented and these are the formational faults and the lodes.

The formational faults tend to parallel the local bedding structures in both strike and dip. Exceptions occur when the faults (cross the bedding on dip) at (flat) angles, usually at points where the bedding attitude is abruptly reversed. Displacements are normal and in harmony with the average interbed movement. This fault set obviously originated and developed from interbed adjustment throughout the period of folding with the stronger faults formed along the local argillaceous bands.

traverse bedding dips? low?

The lodes are moderate to steep southeast-dipping structures which strike north-easterly, cross cutting the bedding and formational faults. Mapping on a district scale shows "evidence...that the (lodes) were initiated during the closing stages of the period of folding and it is presumed that they served as avenues for the ultimate relief of essentially the same stresses as those that produced the folding". p. 51 M. S. Hedley, Bull. 29; Dept. of Mines. ("Tear" faults caused by some variation of stress along the section?)

The Victor lode has a conjugate relationship with the formational faults. This is shown by the inclusion of primary vein matter within those local sections of formational faults which connect lode segments. In plan the vein follows a normal north-easterly strike, then turning abruptly at right angles it follows a formational fault for a short distance, and then with another abrupt turn it reverts to its normal north-easterly course. These apparent offsets are termed "steps" and they usually follow the right hand rule.

This consistent variation in the veins course appears to be the result of the lode being refracted while in the more competent rocks. In this case the lode takes a course nearly normal to the bedding while in the more competent sediments. On intersecting a formational fault it takes a right hand "step" sufficient to adjust to the average north-easterly strike. In this refracting the pre existing joints were a major contributing factor as they supplied planes of weakness along the ideal refraction course.

Movement along the formational faults is usually normal. However, in the East Victor a late flat thrust movement has been imposed along certain of the formational faults. For this reason a sub division of the formation faults, the flat thrust faults, will be made. (See Fig. #3)

The main locus of flat thrusting in the eastern part of the mine dips flatly to the west following the lower limits of the ore body. On approaching the more open fold structure to the west it splits along two strands, the 41P fault and the 3880 fault. These roll into flat to moderate east-dips cross cutting the structures and the ore zone. It is surmised they will eventually ~~run into~~ *parallel the bedding of* the upper east-dipping ~~bedding~~ panel.

The 41P and the 3880 faults are believed to be cross links between the two east-dip panels and were originally part of the formational fault set.

The last movement along these faults is horizontal with the upper block moving to the northwest. Along these main loci of flat thrusting, components of the movement have been bled off along the numerous intersecting formational faults, applying to them, in varying degree, additional movement.

AGE RELATIONSHIP:

Before further description of the faults and their relationship to the ore body it is essential to outline the age relationship between the structures.

The structural history begins with the folding of the Slocan sediments in response to regional stresses. Normal interbed slippage initiated the formational faults. As folding approached its climax, *"apical-plane" slicing* extended development of the formational faults produced the cross links which in the Victor later became the flat thrust faults. Also the late folding developed the joint systems which lie normal to the bedding.

The culmination of the folding was marked by lode formation which, in the Victor, represented the extension of the joint system. This accompanied with extended action along the formational faults represented the ultimate release of the fold-forming stresses.

Sill and dyke intrusions occurred about this time. These formed largely in the bedding faults, particularly near the fold crests, showing that these areas had low confining pressures. The sills did not form in the lodes but rather formed against them. This is seen in the footwall and hanging wall traces of the intrusions which are similar but not identical (See Fig. #4). The *early development of ?* lode obviously was pre intrusion and as porphyry seldom lies in the plane of the lode this fault must have been in compression at the time. *later lode movement caused some actual dislocation of intrusions?*

There now followed a period of relaxation of stresses with first an extension of activity along the lodes. This final movement was nearly normal with the hanging wall moving down with, as slickensides suggest, a slight eastward shift. This was accompanied by vein formation in the northeast striking, steep dipping lode segments.

After the vein formation, relaxation continued with emphasis next along the formational faults. Normal displacement occurred along all major elements of this set, with the west-dipping strands offsetting the vein to the right and east-dipping strands offsetting the vein to the left. Where these coincide with existing steps the west-dip faults augment the apparent offset while the east-dip tend to cancel it.

The final stage of faulting now occurred with the upper block being thrust to the northwest along the complex system of flat thrust faults. Along the flat strands the vein is moved to the northwest or to the mine foot wall. Where these faults dip to the west they show a right hand offset and where they dip to the east they offset the vein to the left. Again where the flat thrust faults coincide with earlier vein offsets they tend to either augment or cancel the ~~total~~ existing offset.

In the mine the amount of movement along any fault plane is difficult to estimate. The lode is perhaps the best understood. Here the total movement varies from a fraction of an inch to, at the most, ten feet. The ratio of the horizontal throw to the vertical throw is roughly 1:5. The movement changes abruptly in both magnitude and direction from one section of the mine to another.

The length of the original lode steps or apparent right hand offsets is shown, by included vein matter, to vary from a fraction of an inch up to at least 40 feet. In the eastern part of the mine much larger steps are suspected.

On the other faults pre-vein movement is impossible to estimate. Some indication of the post-vein movement is obtained by measuring, on the vein, the horizontal offsets.. Total dislocation across the formational faults measure from a fraction of an inch up to 20 feet. Offsets across the flat thrust faults along a single strand are up to 40 feet. ~~with total throw in the order of 60 feet.~~

The strongest single left hand offset is in the western part of 5 level where a combination of flat thrust faulting and formational faulting throw the vein 65 feet.

The strongest right hand throw is in the eastern part of the mine where the total flat thrust movement, plus west dip formational faults, plus ~~bending~~ stepping give a vein offset of about 300 feet.

ORE CONTROLS:

The East Victor ore body was formed and influenced by several interdependant structures. The lode is the essential element. Along it the ore forming solutions found access, and in it veins formed in certain favoured areas. In detail the ore body comprises of several shoots which lie along a flat west-plunging panel (flatty west raking or pitching?) of steep dipping sediments. The individual shoots lie in the competent thin-bedded mixed quartzites and argillites and are framed on top and bottom by faulted - usually east-dipping-sediments and on either side by near vertical faulted sections of argillites. This soft frame is an ~~irregular~~ essential structure, ~~in~~ for it gave the lode freedom to develop forming an irregular structure, in which the steep dipping sections became host to the ore.

The steep lode sections occur where the lode is refracted when crossing thin bedded argillites and quartzites. For optimum refraction well developed bedding is important. In the more massive sediments the lode crosses the bedding obliquely without any major variation in altitude. For optimum refraction the mixture of argillites and quartzites is also important. The lode in quartzites alone or in argillites alone again assumes an unfavourable regular strike and dip.

In summary the main ore controls in the East Victor section are:

1) The lode along which mineral bearing solutions had access.

2) The fold structure.

3) The thin bedded argillites and quartzites.

Within the generally favourable ore structure there are a number of secondary ore controls other than those supplied by the unpredictable changes in strike and dip, associated with weak lode structures.

1) Stranding - Splitting of the lode is the most important of these secondary controls. The lode on 3 level at the top of the main shoot forms a series of mineralized joints over a width of 100 feet (See Fig. #5). These joints are too narrow to mine separately and too widely spaced to mine a s a group. Below the No. 2 Drag Fold structure these joints converge with the widest and most productive vein lying in the hanging wall. At about one-third of the way vertically down the ore zone, the joints collect into a single vein.

2) Rotation Panels - These are small west-dipping elements of drag folds which occur in otherwise unfavourable east-dipping sediments. (See Fig. #6). The ore forms just where the lode crosses these west dipping beds.

3) Drag Folds - Where the lode crosses small drag fold structures in the main panel of west-dipping sediments good ore forms just at crest of these structures. (See Fig. #7).

4) Formational Faults - Vein swells lie under or over formational faults. Probably these occur as a result of increased lode tension on one side of the crossing faults. Fault damming may be an associated control. (See Fig. #8).

METAL DISTRIBUTION:

The lode in the East Victor is almost entirely vein-filled. Gouge along the lode is rare and brecciation of the wall rock occurs only in the lower limits of the ore section. The average width of the vein in the stoped areas is less than 16 inches, however, the width varies from a fraction of an inch up to over 8 feet.

Within the vein the metal content varies. In general galena is the predominant filling in the wider sections and sphalerite is the predominant filling in the narrower sections. The gangue minerals siderite, quartz, calcite and pyrite are present in all portions of the vein and they may fill it entirely in the narrowest sections. There is one exception to the general pattern in the lower eastern part of the ore body, siderite fillings envelope the ore lenses with the vein eventually becoming entirely filled with siderite in widths of up to 7 feet.

The silver occurs with the galena. The unit value of the ore, then, increases as the width of the vein increases.

The East Victor ore shoot can be described as a series of high grade swells within a narrower relatively low grade vein.

The variation of the metal content is probably controlled by the vein's structure, (Hedley, (Bull. 23, Dept. of Mines) suggests that the lead deposition favoured the more open structures while the tighter parts of the lodes do not. These instead were filled with the more mobile, less selective zinc and gangue minerals. There is a suggestion in the Victor Mine that this pattern of mineral distribution was supplemented, by a period of lead mineralization which came shortly after an earlier zinc, lead and gangue deposition. This lead found access only in the most open parts of the structure and here it was deposited replacing much of the earlier vein.

ACKNOWLEDGEMENTS:

For earlier maps, reports, and other details pertaining to the Victor property, the authors express their appreciations to Messrs: J.C. Black, J.W. Ambrose, N. Babey, H.R. Tibbett and D. Jeffs. Particular thanks are due to Mr. Black for much valuable information and assistance, and for permission to present this paper.