SLOCAN PROPERTIES

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A Report
on the
Geology of the Idaho Mine Area

This report is submitted with the hope that it will be of some value as an interpretation of the geological structure in the Idaho mine area, and particularly of those structures bounding the southwesterly continuation of the Queen Bess lode. It is hereby tendered to Mr. Paul Billingsley for his approval and distribution.

Respectfully submitted by:

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April 15, 1950.

TABLE OF CONTENTS.

ACKNOWLEDGEMENTS

Survey control established by S.M. Gulley and B.T. Stephens was of prime importance in the preparation of the accompanying maps; the accuracy of their work is acknowledged and highly appreciated by the writer. The fine surface mapping accomplished by E.H. Nickel and assistant D. Yonge is gratefully acknowledged, as is the excellent field assistance supplied by M.D. Kierans. Survey-geological ties by J. Lamb facilitated office plotting of surface geology and are much appreciated.

Thanks are due to Mr. R. Avison for the loan of old maps showing the pattern of workings within inaccessible sections of the mine. Details contained in geological maps by C.E. Cleveland and the B.C. Department of Mines proved useful.

The writer is obligated to Mr. Paul Billingsley for the use of informative plans and sections prepared by him a long time previous to this report, and which guided the preparation of maps accompanying this report.

Finally, the writer is grateful to Dr. E.B. Mayo for his examination of, and comments with reference to maps accompanying this report.

ACCOMPANYING MAPS

1. Forty-scale plan; "Surface and Underground Geology of the Idaho mine area."
2. Forty-scale; Composite Longitudinal Vertical Projection of "Idaho mine area Footwall Geology".
3. Forty-scale; Composite Longitudinal Vertical Projection of "Idaho mine area Hanging Wall Geology."
4. Forty-scale; Cross-Sections No's. 3, -5, -9½, and -14¾.
5. Two hundred-scale; "Idaho - Queen Bess"; Composite Longitudinal Section of Footwall Geology.
6. Two hundred-scale; "Idaho - Queen Bess," Composite Longitudinal Section of Hanging Wall Geology.

~~However, as they are now inaccessible to detailed mapping, it is not possible to prove or disprove their apparent influence of restricting mineralization to a relatively short section of the lode.~~

Summary and Conclusions

The Queen Bess and Idaho lodes apparently represent local sections of one continuous lode structure. The actual trace of that part of the lode which traverses Hawson Creek Basin has not yet been determined. The lode structures have developed primarily through a strong easterly-and-downward relative displacement of the hanging wall ground. Late stresses were apparently relaxed through small normal displacements along the lode. There is some evidence that this late increment of displacement was effective in maintaining "open" sections along the lode during the period of mineralization.

Westward, from the northeasterly part of the mine area, a wide section of steep northeasterly-dipping footwall beds flattens upward, southwest of the Idaho stock. This flattening is accompanied by a warp to northerly dips in the footwall of the Cumberland lode. By this warp a pronounced bedding nose, which plunges northerly into the west part of the Idaho stock, has been developed. Soft argillites were apparently most intensely altered close to this nose.

In cross-section, the hanging wall bedding structure is marked by the complete over-folding of steep northeasterly-dipping beds to flat-lying up-side-down attitudes. At the bend, strong buckling has developed a broad arch of highly-folded soft argillites. Below, and to the southwest of the arch, bedding forms a thick, flat, up-side-down section of variably-siliceous argillites. All of the Cumberland and Idaho orebodies lay, to some extent in this section of the bedding structure.

No major bodies of ore were discovered in the mine area; however, those bodies that were of economic importance were deposited at certain favourable sections of the lodes. The Cumberland stopes lie within a steeply-dipping section of the lode, close to the footwall "nose" of brittle quartzitic argillites, and below rather flat-lying siliceous argillites forming the hanging wall. Downward and eastward lode displacements apparently were primarily responsible for the development of the lode. Possibly, later normal displacements, involving the brecciation of brittle flat-lying wall rocks, and the creation and maintainance of "open" spaces on the steeply-dipping, locally irregular lode, provided important structural control of mineralization. Generally, ore minerals have not been sheared by late displacements.

The mineralized section of the Idaho lode occurs at a local, or temporary swing to the north. Displacements here, within a section of brittle beds have produced permeable, fragmental lode fillings. At this section, the lode is relatively steep, or contains steeply-dipping strands through all accessible levels, and evidence of a late normal displacement is plentiful. Evidently, structural control of mineralization was produced, to some extent, by a combination of a downward movement of the hanging wall over irregularities of dip, and across the ends of flat-lying, brittle wall rocks. Local steep, mineralized strands probably have a "gash" relationship to the main lode structure, and ~~a such~~ provide additional evidence of the effectiveness of a late normal displacement.

Mineralization within the old westerly section of the lode is also associated with steeply-dipping structures at a temporary bend of the lode to the north. The latter feature suggests that mineralization favoured open spaces created by an easterly component of hanging wall motion. However, evidence of normal displacement on steeply dipping fractures that intersect flat-lying beds, suggests that ore deposition might have been closely timed with this downward movement of the hanging wall.

Between the east slope of Idaho Ridge and the Queen Bess Road Tunnel, hanging wall and footwall formations are composed of hard, brittle, steeply-dipping sediments (200-scale composite sections). In the footwall of the lode, the bedding is further stiffened by strong sills and lenses of porphyry extending from the Idaho stock. Probably porphyry sills in the footwall section occur more frequently than is suggested by the sparse outcrops. Within this section of the lode, the principal eastward-and-downward hanging wall movement across steeply-dipping brittle, and occasionally soft, formations may have formed deeply penetrating ore-forming structures. Fortunately, the strong, steep, footwall formations are matched across the lode by rather similar, but more varied assemblages of brittle quartzitic, and soft, thick argillites. The lode should traverse favourable wall rocks for over 3000 feet between the Road Tunnel and the zone of porphyry intrusions on Idaho Ridge.

GEOLOGY OF THE IDAHO MINE AREA.

Introduction

As was suggested in the Queen Bess report, the Idaho lode is very probably the southwesterly extension of the Queen Bess lode. Consequently the Idaho mine area is continuous southwestward with the Queen Bess mine area. For purposes of description, it may be defined as the block of ground which holds the Idaho and Cumberland workings, plus footwall and hanging wall formations lying within a few hundreds of feet to the northwest and southeast of the lodes. The northeast and southwest boundaries of the block may be arbitrarily established at the Queen Bess Road Tunnel and the southwesterly limit of the upper Idaho mine workings, respectively. This block will extend several hundreds of feet to the northeast of the area delimited by the accompanying 40-scale drawings. However, pertinent cross-sectional details of the major bedding structures within the mine area are covered by the 200-scale Idaho-Queen Bess composite longitudinal sections.

Detailed surface mapping of the Idaho mine area was done as part of the 1949 field program, which covered the Queen Bess - Idaho - Alamo area. This program was summarized in the Queen Bess report. Mapping of Idaho underground geology was started by the writer when surface mapping was stopped by falls of snow late in October. The underground mapping was done in some haste, as daily trips through the snow to the portal site were becoming increasingly difficult. However, most of the accessible workings were mapped in fairly close detail.

No details of the property's history will be given in this report. For this information the reader is referred to a description of the Idaho mine, in Mem. 184 of the G.S.C., by C.E. Cairnes.

BROAD STRUCTURE OF MINE AREA:

The Lodes

The southwesterly projection of the Queen Bess lode from the Road Tunnel, using the local strike and a dip of 60 degrees southeast, results in a surface trace which extends across the head of the main Hawson Creek basin to a point on Idaho Ridge at only a short distance below the mine road. At this point, a zone of small fracture-shears and joints has a general ENE TO NE strike and steep-to moderate southerly dips. Individual fractures are generally not more than a few inches wide, and are mineralized only by small quartz veinlets. No single fracture structure was found that compared in strength and character with the lode as seen in the mine workings. It appears that, locally, the surface expression of the lode is a wider zone of weaker fractures, possibly arising from a stranding-out of the lode towards the surface at this point. The strongest individual structure is one which traverses the nose on a north 60 degrees east strike, with a dip of 80 degrees to the south, and which includes up to three feet of crackled and silicified argillite. At this point, it lies close to, and trends parallel to the southerly contact of the Idaho stock. As an indication of how this surface structure may correlate with the northeasterly part of the Idaho lode on No. 6 Level, the upward and northeasterly projection of the footwall strand on No. 6 Level, assuming a consistent 50-degree dip, lines up rather closely with the trace of the above surface structure. The outcrop of the main strand of the Idaho lode, as mapped at the northeasterly end of No. 6 Level, may be represented by the zone of weak surface fractures dipping from 47 to 50 degrees southeasterly, or, by a single strong lode structure which has escaped mapping. The southwesterly course of the Idaho lode may be traced within the mine levels to the west end of No. 5. Closer to the surface, it extends southwestward through No. 3 Level. Above the westerly end of No. 3 level, the outcrop may be traced through the old Silver Bell workings for several hundreds of feet to the southwest. Throughout the workings, the lode maintains a northeasterly strike, and dips between 40 and 70 degrees southeast.

In the portal area of No. 5 level the Idaho lode is joined by the Cumberland lode, which curves gently from an easterly to northeasterly strike towards the junction. The Cumberland lode is decidedly steeper than the Idaho, having a dip of 60 to 80 degrees southerly. On No. 6 level, the two lodes converge about 300 feet southwest of the junction of No. 6 crosscut with the drift.

Throughout No. 6 level, the Idaho lode is seen to be a composite structure, possessing distinct footwall and hanging wall strands. These are separated by generally less than 50 feet of variably-contorted soft argillites and hard quartzitic argillites. Locally, smaller "link fractures" angle acutely on a more northerly strike from the hanging wall to footwall strand. The composite lode structure, with local convergences, appears to extend from below No. 6 to above No. 5 level within the main lower section of workings. Within the northeasterly half of No. 6 level the Cumberland and Footwall Idaho lodes join to form single strong structure. At a short distance west of No. 6 crosscut the lode again splits, but the stronger "split" is apparently joined by the "Hanging Wall" lode within the northeasterly end of No. 6 Level.

To the southwest the Footwall lode proves to be the major through-going structure. This inference is based on the apparently "weaker" behaviour of the Hanging Wall lode. Within the southwesterly ends of No. 6 Level and 5-6 Sub-Level the main parts of the structure curve sharply southward and flatten to become, essentially, rather weak easterly-dipping bedding faults in the hanging wall of the Idaho lode zone. On 5-6 Sub-Level, the Footwall lode may lie within the bedding at only a few feet? beyond the north wall of the drift at its southwesterly end.

In the old upper mine workings close to the head of Idaho Basin, the greater part of the Idaho mine ore came from both the Idaho lode and the St. John lode, the latter outcropping at least 150 feet to the northwest of the former. The relative position of these structures, with subordinate strands, and the probable outline of stoped orebodies is best shown by Cross-Sections 14 and $14\frac{3}{4}$ studied in conjunction with the 40-scale plans and sections. Within this area both lodes dip steeply to the southeast within a flat-lying section of thickly-bedded soft, and hard-altered argillites. The search for the downward extension of the St. John lode, by way of a crosscut driven from the Idaho No. 3 drift and below No. 2 portal, revealed only small weak fractures at the expected zone of intersection.

~~with the lode~~. Possible explanations of its non-appearance at depth are: It formed as a fracture zone that has been cut off to the northeast by cross-faulting; it weakens rapidly at depth; or, it may actually flatten in dip to join the Idaho lode a short distance above No. 3 Level. In view of the fact that the lodes lie within a section of flatly-bedded soft argillites within which the lode may characteristically flatten, the latter explanation seems the most plausible.

The Idaho, Cumberland, and St. John lodes are all strong zones of fracturing and shearing which vary in width from one foot to 40 feet, greater widths occuring where much relatively undeformed wall rock is included within the zone. Fracturing and coarse brecciation usually predominate over shearing and fine crushing where the lodes traverse relatively hard, brittle formations. Within these sections the lodes usually steepen, and the lode fillings are likely to be better mineralized. Where lodes traverse sections of soft, relatively plastic beds, the wall-rock bedding generally shows the effect of folding under strong shearing stresses, or is dragged towards the plane of the lode to form rather regular northeasterly-trending "lode panels" of bedding. Within these sections a strong tendency to branch into the plane of the bedding appears to be largely responsible for the flattening of the lode, and the distribution of shearing movements over wide sections of wall rock.

Major Bedding Structures and Lithology

The description of the above features is based largely on the accompanying 200-scale composite sections, and upon a 200-scale preliminary map of the Idaho - Queen Bess area.

(a) North of Cumberland - Idaho Lodes: Footwall

The major bedding structure, viewed in cross-section, is marked by the abrupt upward flattening of the "east-dip panel" at a horizon well above the Queen Bess axial plane, and within the vertical range of the Cumberland workings. Accompanying this upward flattening is a strong warp to northerly dips, and involving the section of beds which encloses the extension of the Cumberland lode within Silver Bell Ridge. This ridge lies to the northwest of, and trends sub-parallel to the mine workings.

Within more westerly sections of the workings, lower beds of the flat, up-side-down section appear to bend downward to steep easterly dips, such as those which form the gently-arcuate axial zone of the Queen Bess overturn at the Road Tunnel. However, to the east of the lower portals area the bedding section is formed chiefly of thinly-bedded, soft, incompetent argillites with minor thickly-bedded quartzites and firm argillites. Consequently this section of beds, lying within, and several hundreds of feet east of the mine area, is intensely folded and crumpled. Although much of the section is composed of apparently-rigid beds, particularly within the alteration halo of the Idaho stock, the frequent appearance of brittle, but intricately folded beds suggests that the original unaltered rocks behaved in a typically incompetent manner.

In contrast to the section described above, is the regularity of the easterly-dipping section that extends from the Queen Bess lower portals, beyond the Road tunnel and westward almost to the Idaho stock. This section appears as a broad up-ended arch formed by steep northeasterly-dipping beds which bend to vertical and steep southwesterly dips downward along the bedding. The rocks involved are medium- to thickly-bedded firm argillites, quartzites, and sandy limestones. Metamorphism, by heat and differential movements, and perhaps locally by siliceous fluids, has hardened many originally soft argillaceous beds. Although bedding attitudes are steep through a wide vertical range, possibly they may flatten to more decided westerly dips at a horizon lying some 200 to 300 feet below the Road Tunnel.

To the west of the above competent section, the Idaho stock has intruded the originally soft, plastic argillites forming this section of the structure. In plan, this body of dark feldspar porphyry has a crudely-circular shape. Strong porphyry sills and short sill-like prongs extending from its west margin, and southeast corner, suggest ~~that the stock-like shape~~ the form of a marked local expansion of a sill-like intrusion in a particularly plastic section of beds. The few attitudes recorded on flow layers and lines, plus the attitude and folding of marginal beds, suggests that the porphyry melt rose along a generalized axis plunging steeply SSE below the northeasterly end of Idaho No. 6 level.

In addition to the radial and upward rise within a generally circular boundary, the melts have pushed apart, and forced their way westward and northwestward into the bedding which trends northwesterly from the west margin of the stock. From the southeast corner, sill-like prongs have again forced their way into southeasterly-striking beds. In addition, a prominent lens of porphyry extends eastward along the footwall of the Idaho lode zone, being connected with the main body only by a narrow sill-like neck. Bedding enclosed by the porphyry prongs and lens has been highly buckled into east-west strikes, particularly along the north margin of the lens. It is very likely that the lens occupied a pre-existent buckle developed by the earliest "lode movements." The general northerly and steeply-upward direction of

intrusion is proved within the panel of bedding immediately north of the stock. Here, E. H. Nickel has mapped a section of altered, folded argillites, within which individual folds are overturned upward to the north about east-west axes, – reflecting marginal drag by the rising intrusion. Along the northeasterly and southwesterly marginal areas, where the stock approximately parallels bedding trends, the bedding is only broadly arched, and shows no evidence of extreme buckling.

The relationship of that section of bedding that is warped down to the north on Silver Bell Ridge, with respect to the major bedding structure, is shown by the progressive change of attitudes to the northeast along the ridge. Above the 6500-foot elevation, soft sandy limestones and thinly-bedded hard and soft argillites dip to the southwest, within a right-side-up panel of bedding. This panel is complicated by frequent local reversals of dip. At the 6500-elevation, beds fold under sharply to up-side-down attitudes. To the northwest down the ridge, and following a very restricted section with northeasterly dips, the inverted section is abruptly warped down to the northwest, to form a northeasterly-trending panel of highly-contorted, variably-altered beds. Pale siliceous argillites, gray quartzitic- and soft limey argillites are involved in this latter section of bedding that contains the westerly extension of the Cumberland lode. Again, the brittle nature of beds that are involved in extremely tight folds, suggests that soft beds were ~~highly~~ folded, and later, altered to form the present rock types. The pale cherty appearance of some beds also suggests that alteration involved the recrystallization or silicification of original argillites or siltstones. Recent petrographic studies, by Dr. E. B. Mayo, may provide ways of recognizing the various types of alteration met in the field.

Within this warped panel, numerous drag folds are overturned to the northeast about axes plunging slightly or steeply to the northwest. Evidently structurally higher beds have moved to the northeast with respect to lower beds. This is the characteristic inter-bed motion of the "east-dipping panel". Consequently, and in spite of northerly down-warp of the enclosing beds, folds axes trend northwesterly in b_1, about which rotation is clockwise. In spite of the presence of the Cumberland lode within this section of drag-folded beds, no drag folds which would suggest the steeply-plunging b_2-lineations were found, although the area was closely mapped. However, if footwall beds were very locally warped downward at the lode, and hanging-wall beds bent upward, with a consequent reversal of the plunge of b_1 lineations to the b_2 direction, inter-bed, and lode motion would be harmonious. Possibly this may account for the lack of "interference" by conflicting drag folds.

When the warp is closely studied, the northwesterly and northeasterly sections of bedding apparently form a NNE-trending nose, which plunges below the surface in this direction, and into the Idaho Stock. Near the contact of the stock, relatively-unaltered beds have the usual northeasterly dip. It seems probable that volatiles or solutions, which caused either thermal or metasomatic alteration of wall rocks, and related to the stock in origin, or through its ability to provide deep fractures as channels for the escape of volatiles, rose to the surface by way of the nose structure. The presence of the nose may explain the greater alteration of beds more distant from the stock than of some less-deformed marginal beds.

As the east flank of the nose is formed by the downwarp of the flat up-side-down section to steep northeasterly dips, and the west flank by the less steeply-dipping northwesterly down-warp, the axial plane of the fold should dip to the west. This may account for the general non-appearance of the structure in footwall beds of Cumberland No. 3 Level. However, a section of more northerly-dipping footwall beds at the west end of this level suggests that the nose may be present at this, and greater depths in the lode footwall. The presence of a deep section of brittle footwall beds, somewhat restricted to this nose, may have had some effect in providing strong ore inlets to the Cumberland lode.

That originally soft, relatively plastic sections of bedding, including mudstones, siltstones, and tuffs, may be altered to hard brittle rock types, where they have been intruded by large bodies of porphyry, is shown by recent petrographic determinations by Dr. E. B. Mayo. Of particular interest are his findings with respect to the alteration of beds on the northeasterly margin of the Idaho Stock. Specimens ~~A15~~, A16, and A17, represent a belt of altered sediments extending 300 feet from the stock where exposed in Idaho Creek.

A-16

(a) Hand specimen: Brownish-gray, finegrained "quartzitic argillite"; finely-banded with hazy lighter layers.
(b) Microscope: "Many small primary quartz grains with good dimensional orientation across the bedding. There are a few very tiny detrital zircons and apatites; much secondary, pale brown mica and some cryptocrystalline silica. Small opaque grains may be magnetite.

Original siltstone, or mudstone, with recrystallized matrix, and possibly some introduced silica. Not definitely a replacement quartzite."

The specimen ~~is~~ probably represents low-grade thermal, and perhaps metasomatic, alteration of an argillaceous sediment. As dimensional orientation of quartz grains is across the bedding (and normal to the porphy contact) they probably developed in the line of least resistance, or in the tension-direction, while the stock was cooling and shrinking.

A-17

(a) Hand specimen: Brownish color; relatively coarse granular texture; containing quartz, mica, and feldspar. Characteristic of highly-altered beds within the sediments; interbedded with A-16.
(b) Microscope: "The centers of some of the plagioclases are altered to felted masses (paragonite?). The biotite is abundant and unaltered. There is a little epidote with barely-perceptible pleochroism, and some apatite and sphene. The matrix is a cryptocrystalline aggregate and is sparse.

The rather good dimensional orientation of most minerals is swirly, and wraps about the plagioclase.

No primary quartz was identified; there are some pyrite grains.

The rock seems to be related to the lamprophyres. It could, however, be interpreted as a further stage of A-14."

It is probable that the specimen represents the thermal, and perhaps metasomatic, product of alteration of an inter-bedded tuff or graywacke. The apparently-higher grade of metamorphism, compared to that of A-16, may be due to compositional differences; or to its more permeable texture which would allow easier alteration by volatiles from the stock.

Alteration of this thick assemblage of argillites and tuffs or graywackes has produced harder, more brittle rock types. A rather similar section of altered beds was seen at 800 feet northeast of the contact of the stock. At 1200 feet +-- "Probably original siltstone or mudstone recrystallized under shear, with some metasomatism by emanations from the stock" (E. B. Mayo).

(b) South of Idaho Lode: Hanging Wall

The cross-section of major bedding structure is marked by an arch of intensely-contorted up-side-bedding within Idaho Ridge, the fold centering close to the portal of No. 5 level. To the southwest, on the surface and through the mine workings, the arch is followed by a thick section of flat-lying inverted beds, within which the lodes contained the orebodies of the Idaho mine. To the northeast, bedding in the east limb of the arch is involved in at least three major easterly over-folds, before steepening to join the relatively-competent, easterly-dipping section of beds above the Queen Bess apical plane. In the remaining 1500 feet between the most easterly major drag fold, from the west slope of Howson Creek Basin to the Queen Bess Road Tunnel, the competent beds dip moderately to steeply east. This latter section of beds, which shows only very local contortions, is composed of thick, hard quartzites, quartzitic argillites, sandy limestones and minor sections of soft, thinly-bedded to massive argillites.

Beds forming the complex arch in Idaho Ridge are generally soft thick-and thin-bedded argillites with minor quartzitic material. Frequent truncated cross-beds prove the general up-side-down position of the section. In accordance with their situation in the east-dip panel above the Queen Bess apical plane, minor drag folds are overturned northeastward; that is apex are in b, and rotation is clockwise. However, a few drag-folds found within the upper part of the arch showed anomalous overturns to the southwest, but were not associated with upright sections of bedding. This fold pattern suggests a partial collapse of the arch, creating a relatively downward movement of structurally higher-over-lower beds. Another possible explanation is that these locally-incompetent beds reflect the general differential movement related to the major Slocan underthrust, rather than the normal inter-bed adjustments related to the development of the containing recumbent folds. The presence of large, intricately- and tightly-creased sections of beds, with highly compressed drag folds flattened eastward, points to strong differential movements within higher parts of the Slocan section, such as the Idaho Peak area. These intense movement structures may have originated from stresses opposing the downward & eastward major underthrust.

OMIT

Throughout the mine workings, bedding of the thick, flat, up-side-down panel is harder, and apparently more siliceous than that forming near-surface sections of the arch. This difference may be due to either deep silicification of wall rocks adjacent to the lode or, more likely, to the appearance of a more quartzitic section of beds at this part of the structure. Bedding, in any event, was firm enough for the formation of distinct zones of fracturing, bounded by strong continuous walls.

(c) Between the Idaho and Cumberland Lodes.

Exposures on No's 5 and 6 Levels indicate a similarity of the rock types and general bedding attitudes within the major sections lying across the Cumberland lode. Although strong displacements must have occurred on both the Idaho and Cumberland lodes, compressive and differential stresses have produced only local contortions within the intervening wedge of bedded rocks.

(d) Mineralization with respect to Major Bedding Structure.

The Cumberland stopes probably lie across the east flank of the northerly-plunging nose formed within footwall bedding. These altered wall rocks are of a hard, brittle, quartzitic character. Possibly, elements of the "nose" are present in hanging wall beds across the lode.

By reason of an easterly movement of hanging wall ground along the lode, more westerly, and less steeply-dipping beds of the northerly down-warped section may be represented by such bedding attitudes in the footwall of the Idaho lode. Bedding in the north wall of the westerly part of No. 5 Level is probably most representative of the true footwall structure. The 40-scale 'Footwall Projection' shows the main Idaho stope on No. 5 Level to lie against the footwall warp, about which bedding dips northeasterly and northwesterly. Thick quartzitic beds form the footwall of this mineralized section of the lode.

Hanging wall bedding, adjacent to the main stope on No. 5 Level, is part of the flat up-side-down section which extends at least 300 feet below, before bending into a northeasterly dip. Beds involved are soft, thin argillites and brittle, quartzitic argillites.

Stopes of the upper, old section of the mine lie within the lode where both footwall and hanging-wall beds belong to higher parts of the flat up-side-down panel ~~of bedding~~. Bedding of the footwall section is hard and siliceous, but probably less altered than beds ~~involved~~ closer to axial region of the nose. Locally, the hanging-wall section is composed of thick, to massive soft argillites, with minor quartzitic interbeds.

Introduction

The method of mapping geological details, particularly minor structures, was described in the report on the "Geology of the Queen Bess Mine". The following level-by-level descriptions of the underground geology, plus interpretations and correlations, are based on the accompanying 40-scale drawings.

No. 5 Level

(a) Cumberland lode:

The attitudes of the Cumberland lode and wall-rock bedding are fully shown on the 40-scale composite plan. In additional to the large angular convergence of the Cumberland and Idaho lodes, which also shows on No. 6 Level, there is a pronounced flattening of Cumberland lode, close to their junction, to a dip which coincides with that of the Idaho lode towards the portal area.

Rock types on both sides of the lode compare closely throughout the greater part of the level. These are generally well-bedded, brittle, siliceous argillites and quartzites, with soft thin-bedded argillites towards the west end of the level. Close to the west end, footwall beds warp from progressively flatter northeasterly dips to gentle northerly-dipping attitudes - closely reflecting the ~~observed~~ warp of the surface bedding above. Bedding in the hanging wall of the lode, and which dips less steeply than that of the footwall section, flattens more quickly to the west, to form an extensive panel of gently-rolling beds. Small bedding faults showing normal displacements (minor drag-fold axes in b_1, with clockwise rotation); together with the larger drag-fold pattern suggested by the local steepening within beds dipping gently northeastward; indicates a relatively downward-and-northeastward movement of structurally higher beds. In addition, the truncated cross beds mapped on the surface show that this bedding section belongs to the east-dipping panel of overturned beds above the Queen Bess axial plane.

The Cumberland lode, on this level, is a wide zone of graphitic, crushed and sheared material lying between smooth, regular walls. The lode varies in width from one- to four feet. A gangue of quartz and calcite, lacing the filling of the more coarsely-broken sections, is mineralized with sphalerite and galena. Sections of ore-grade material are rather completely mined out.

The smooth walls and dense lode-filling provide few indications of the displacement. However, 60 feet west of the portal crosscut, drag-folds within the sheared lode filling plunge down-dip and are overturned eastward; these are shown as b_2-lineations with clockwise rotation. Relative hanging wall movement should be at 90 degrees to b_2 in the plane of the lode, that is, eastward and almost parallel to the strike. At the west end of the level, grooves on the footwall plunge at 20-25 degrees southeast. These evidently lie in a_2 for a slightly downward and southeastward movement of the hanging wall.

The Cumberland stopes, in addition to lying against the footwall "warp" of brittle beds, are also situated in a locally steeper section of the generally steep lode (Cross-Sect. 9½). This steepening occurs, to the northwest, where the lode lies within flatly-rolling and northerly-dipping sections of beds, respectively, in the hangingwall and footwall. In addition to the local steepening, small irregularities of dip are present within the vertical range of the stopes. Possibly, it was a combination of a steep, slightly irregular dip, normal displacement, a warped footwall bedding structure, and the presence of hard, brittle, rather flat-lying beds on both walls, that influenced the formation of a more permeable filling at this section of the lode.

(b) Idaho lode:

The lode, on No. 5 level, has a general northeasterly strike, but is complicated mid-way by a local, abrupt bend to the south. At this section, where the main lower Idaho stope lies in a steeply-dipping fissure ~~of the lode~~ that trends acutely to the average strike, the westward continuity of lode fracturing is maintained by footwall strands. As far as it could be followed southwestward on No. 5 level, the lode maintains a steep dip of a little less than 60 degrees southeast (Cross-Sec. 11½). Throughout No. 5 level the Idaho lode is a comparatively stronger structure than the Cumberland lode. It averages from 3 to 5 feet wide, with a filling of sheeted, sheared graphitic rock, gouge, and breccia where it cuts brittle wall rocks. ¶ The lode is generally veined by slight amounts of calcite and quartz. Strong lenses of coarse calcite with sparse sphalerite have formed close to its intersection with the Cumberland lode. From 140 feet east of the main stope, a fracture angling westerly into the footwall, holds a few inches of calcite with a little sphalerite. The stoped section of the vein, which is oriented as a "gash" fracture developed by a strong downward movement of the hanging wall of the lode zone, contains up to 6 feet of breccia cemented by quartz and less calcite. Sphalerite and minor galena form a spotty breccia ore within which a more strongly mineralized "rib" lies towards the hanging wall of the vein. Mid-way of the westerly part of the drift is a thick lens of almost pure white barren calcite. Locally, the only sign of mineralization is a narrow seam of sphalerite within the hanging wall bedding. At the west end of the level, steep sets of fractures appear within the lode. The lode filling consists of crushed-to coarsely-broken and sheeted wall rocks, with narrow bands of sheared sphalerite and galena. On the surface ~~directly~~ over the most westerly stoped section, a steep hanging wall branch dips into the lode. Both this branch and the lode on No. 5 Level are filled with a siliceous breccia cemented by calcite, thinly veined by galena and sphalerite.

Within the section of the principal stope on No. 5 Level, northeasterly-dipping beds of the footwall section flatten to the west, where they form a gently-wavy, slightly northerly-dipping section of bedding. With the exception of a belt of soft argillites northeast of the main stope, footwall rocks are medium- to thinly-bedded siliceous, or quartzitic argillites.

Near the portal crosscut, the up-side-down hanging wall bedding arches from northeasterly to flat, wavy dips westward through the section. Reference to the 40-scale footwall section shows this arch to pass upward into the major crumple in soft argillites. Downward it decreases to little more than a bend from flat, to northeasterly dips.

at the main No. 5 level stope, thick hanging-wall quartzites locally steepen, possibly being involved in a local "east-panel" drag fold.

The frequent ~~occurrence of~~ steeply-eastward plunging grooves and striae on the hanging wall of the lode provide the most clearly-defined minor structures that may be related to the relative displacement of the lode walls. These grooves are best developed in the section of the lode from the portal crosscut to the main stope. These grooves, plunging at only a few degrees less than the dip of the lode, most apparently lie in the a_3 direction, for a large downward and lesser eastward displacement of the hanging wall. However, within the lode at 120 feet east of the stope, shear cleavage dips southerly. The intersection of cleavage planes with the hanging wall of the lode constitutes a b_2-lineation, about which differential movement, or rotation, is counter-clockwise for a primarily eastward movement of the lode hanging wall. Within this section the easterly bend of hanging wall beds upon nearing the lode, supplies further evidence of the early eastward movement of the hanging wall.

In the westerly section of the level, minor structures in the lode supply further evidence of both strike-slip and dip-slip displacements. A few feet east of sec. 11, drag folds within a flat hanging-wall strand plunge down-dip at 33 degrees, and are overturned to the northeast. At 60 feet to the west, weak striae on the footwall plunge easterly at 40 degrees. Although these a_2- and b_2-lineations do not lie exactly at right angles to each other in the plane of movement, they at least supply mutual evidence of a strike-slip component of ~~the~~ displacement. The b_3-lineation mapped at the west end of the level, is related to steeply dipping "gash" fractures within the lode and to the axis of an upward bend of the bedding on the hanging wall ~~of the lode~~, thus indicating the existence of a late normal component of lode displacement.

~~The pattern of lode displacements deduced from~~ The orientation and symmetry of the minor structures described above, are apparently related to a composite displacement which involves an early eastward and slightly downward movement, followed by a steeply downward and slightly eastward movement of the hanging wall of the lode. The development of the mineralized fissure containing the main stope seems more closely related, in character and attitude, to the later downward movement. The presence of sheared galena and sphalerite within the most westerly mineralized section of the lode, shows that lode displacements occurred after, and probably accompanied mineralization

No. 5-6 Sub Level

Within this level the lode bends to a more northerly strike within the best mineralized section. This bend is apparently made on footwall strands of the lode on No. 5 Level. In addition, the dip increases within this mineralized area in contrast to flatter dips at adjacent sections of the lode (Cross-Secs 8, $9\frac{1}{2}$, and $11\frac{1}{2}$). Locally, the lode filling also has a more fragmental, and less-sheared and-gougy character than that of adjacent sections. To the east of sec. $11\frac{1}{2}$ and below the easterly end of No. 5 Level, the lode splits to form Footwall and Hanging Wall strands, which continue beyond the east limit of mine workings. On 5-6 Sub-level these strands are well separated at the mineralized, buckled section of the lode. Towards the west end of the level, sparse mineralization occurs in a short section of siliceous breccia developed in the lode at a point of near-convergence of the parallel structures, and below stronger mineralization on No. 5 level.

On this level, there is also evidence of two separate displacements on the lode. On the Footwall strand, flatly northeast-plunging grooves, and southerly-dipping shear cleavage provide related a_2 and b_2 lineations ~~, the latter account~~ for an easterly movement of hanging wall ground. Throughout the sub-level many hanging wall striae plunge easterly at the same, or a slightly smaller angle than the dip of the lode. These are particularly evident within the steep, mineralized section of the lode in the northeasterly part of the sub-level. However, there are a sufficient number of b_2 lineations present within the lode, to establish the existence of an earlier a strong easterly and downward movement of the hanging wall. Like the No 5-Level movement pattern, a smaller normal ~~lode~~ displacement probably followed an earlier major strike-slip displacement of the lode walls. See other side for 'insert' here.

Bedding in the footwall of the lode dips gently, and rather uniformly eastward, locally swinging into parallelism with, and bending down at the footwall of the lode. Hanging-wall beds form a uniformly flat, wavy ~~section of~~ up-side-down structure, locally interrupted by steeper northeasterly dips. Wall rocks in both walls of the lode are slabby, thin- to medium-bedded, brittle siliceous argillites.

No. 6 Level.

Within this level, both strands have a slightly-sinuous northeasterly strike through the southwesterly part of the workings. Where the Footwall lode is joined by the Cumberland lode, west of sec. 7, both strands curve to a more easterly strike. Throughout the level, the Footwall lode is stronger than either the Hanging Wall or Cumberland structures, particularly to the northeast of its junction with the Cumberland lode. In it, frequent widely-broken sections contrast with the graphitic-sheeted to gougy fillings within the narrower Hanging Wall and Cumberland lodes.

Beds forming the footwall section dip rather steeply northeastward within the east half of the level, but flatten appreciably to the west. Within the northeasterly parts of the level, footwall rock types are medium- to thickly-bedded, brittle, quartzitic argillites. Close to the Idaho stock, intense alteration has produced green, brown, and pale cherty banding within the beds, and which closely resembles the alteration of argillites in the Carnation 5480 crosscut. Within the portal crosscut are frequent joints which parallel the lode direction, and a few bedding faults showing the typical east-dip panel displacement. At the foot of the main raise, thickly-bedded quartzites correlate with similar beds on the sub-level above. Elsewhere, the footwall section is apparently composed of variably-siliceous, hard and soft argillites.

Within the hanging-wall section wavy, flatly-bedded mildly±siliceous argillites steepen in dip towards the northeast end of the level, probably to normal east-dip panel attitudes. Lying adjacent to the Hanging Wall lode, this softer section of beds probably had much to do with the sheared and gaugy character of the lode filling.

The majority of minor lode structures mapped throughout the level point to a strong easterly and downward relative displacement of hanging wall ground. Occasional grooves plunging almost down-dip and, locally, minor drag folds which are overturned down-dip, provide evidence of at least a small, late normal displacement. At the southwest end of the level the pattern of ground movements, at the intersection of a bedding fault with the Hanging Wall strand, is similar to that at the southwest end of the sub-level.

At the intersection of the Hanging Wall lode on No. 6 level with Sec. 8, a strong drag fold in the hanging wall is overturned directly down dip. The fold has been filled with coarse white calcite, carrying appreaable amounts of sphalerite. The mineralization of this structure provides the most conclusive evidence of the concurrence of mineralization and late normal displacements on the lode.

Old Westerly Section of Mine

Reference to the 200-scale composite sections shows that, locally, the lode traverses the upper part of the thick, flat, up-side-down section of beds extending westward and upward of the lower mine area. Cross-Sections $11\frac{1}{2}$, 14, and $14\frac{3}{4}$ show the Idaho lode to continue southwestward with steep dips. The sections also show the relative position and attitude of the St. John lode and intervening lode strands. The 40-scale longitudinal projections indicate the probable attitudes of beds within the footwall and hanging-wall of the lode, and show the approximate extent of former orebodies. Within the footwall of the lode zone, near-surface beds are quartzitic; at depth the section is probably composed of mildly-siliceous to quartzic argillites, if the upward and westward continuation of footwall beds in the lower mine area involves no severe changes of rock types. A sufficient number of surface exposures were mapped to provide an indication of the thickly-bedded, soft argillaceous nature of the section forming the hanging wall of the upper Idaho stopes.

Southwest of, and above No. 2 Level, the Idaho lode splits and converges again to enclose a lenticular segment of rather sheared and deformed argillites. Evidently, this splitting has locally made the structure more permeable to rising ore solutions. The major part of the development of the local pattern of the Idaho and St. John lode structures probably occurred under the influence of an early eastward, and downward relative displacement of hanging-wall ground. However fair evidence of a later normal displacement on the lodes was had by minor structures. On approaching the Idaho lode, footwall and hanging wall beds are bent upward and downward respectively; the apex of the bends could be interpreted as linear elements in b_3, about which rotation was ~~counter~~ clockwise. Similarly, bedding adjacent to the St. John lode is turned up at the hanging wall. Small northeasterly-trending fractures, dipping northwesterly towards the hanging wall of the Idaho lode are apparently "gashes" developed in response to a downward displacement of the hanging wall. Very small horizontal grooves, or perhaps "wrinkles," on the hanging wall of the St. John lode, cannot be definitely assigned to the a_2- or b_3- direction, but are most probably in the latter, reflecting a small, late normal displacement on the lode. Sections 14 and 14$\frac{3}{4}$ show that mineralization has been most intense close to ~~slightly~~ steeper sections of the lode, and in steeply-dipping fractures which intersect less steeply-dipping parts of the main lode. These occurrences suggest that mineralization of the lode was assisted by concurrent, small normal displacements, which would assist in the maintainance of open channels, and the formation of large "open" spaces as ore traps. Normal lode displacements within the section of flat-lying, soft, to brittle wall rocks would appear to be most favourable for the development of a permeable fragmental filling. Within the Idaho lode, northeasterly-dipping cross-faults appear to have had some effect on the localization of the orebody.

OVER.

However, as the underground extensions of the cross faults are inaccessible, their apparent influence in restricting the lateral extent of mineralization cannot be proved.