5-1950

The Lilly Mine of Powell County, Montana

Wilbur Aikin

THE LILLY MINE

OF

POWELL COUNTY, MONTANA

By

Wilbur Aikin

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science
in
Geological Engineering

MONTANA SCHOOL OF MINES

Butte, Montana

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THE LILLY MINE

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INTRODUCTION

For many years the Elliston District of Powell County has been a minor producer of gold, lead, zinc, and silver. Although never among the largest producing districts of the state, it has with the exception of the war years supplied a notable tonnage of ore to the neighboring mills ever since the first placer and lode claims were located there during the late eighteen hundreds.

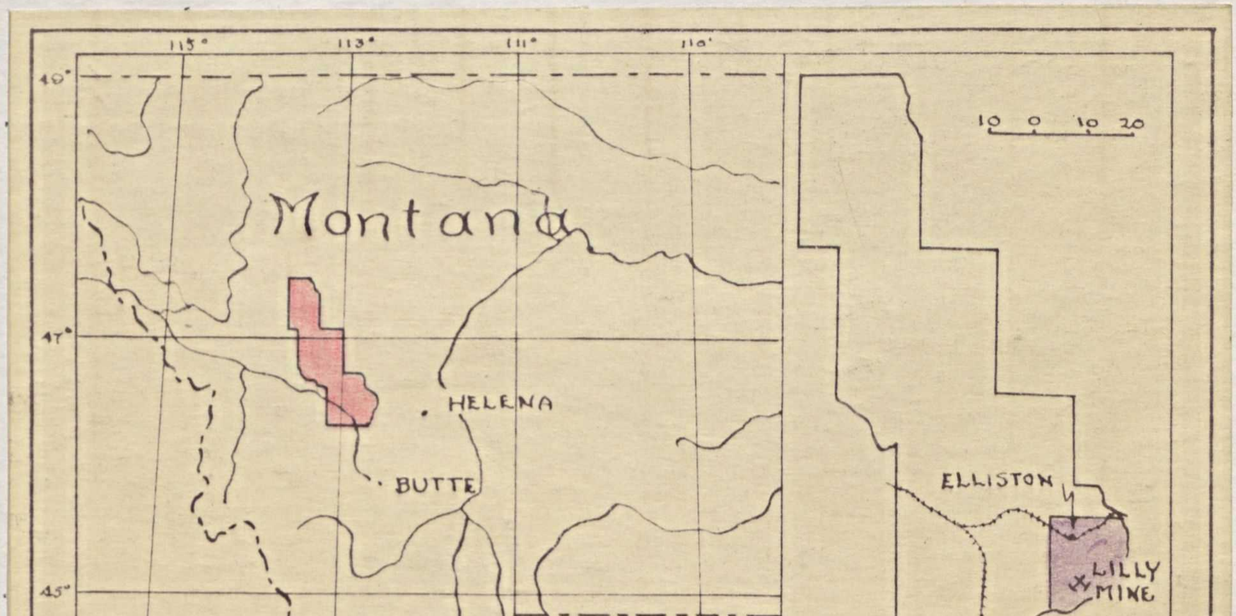


FIGURE 1

Since these early days the productivity of the district has waxed and waned considerably; however, late activity such as that shown at the Lilly Mine, gives promise that with new information the area may continue its yield of metals.

In view of this, the Montana State Bureau of Mines has taken an active interest in the area, and it was during the summer of 1949 that Professor Forbes Robertson of Montana School of Mines conducted a field study of the many mines which lie within the district. When the question of under-graduate thesis arose at the "Mines," Professor Robertson recommended one of the better looking prospects to the author in the hope that he might be able to use this problem to partially fulfill the requirements for graduation. Hope was also expressed that the resulting report might prove of interest to leasees Dave and Lee Newman of Elliston, Montana, without whose whole-hearted support and cooperation this paper would not have been possible.

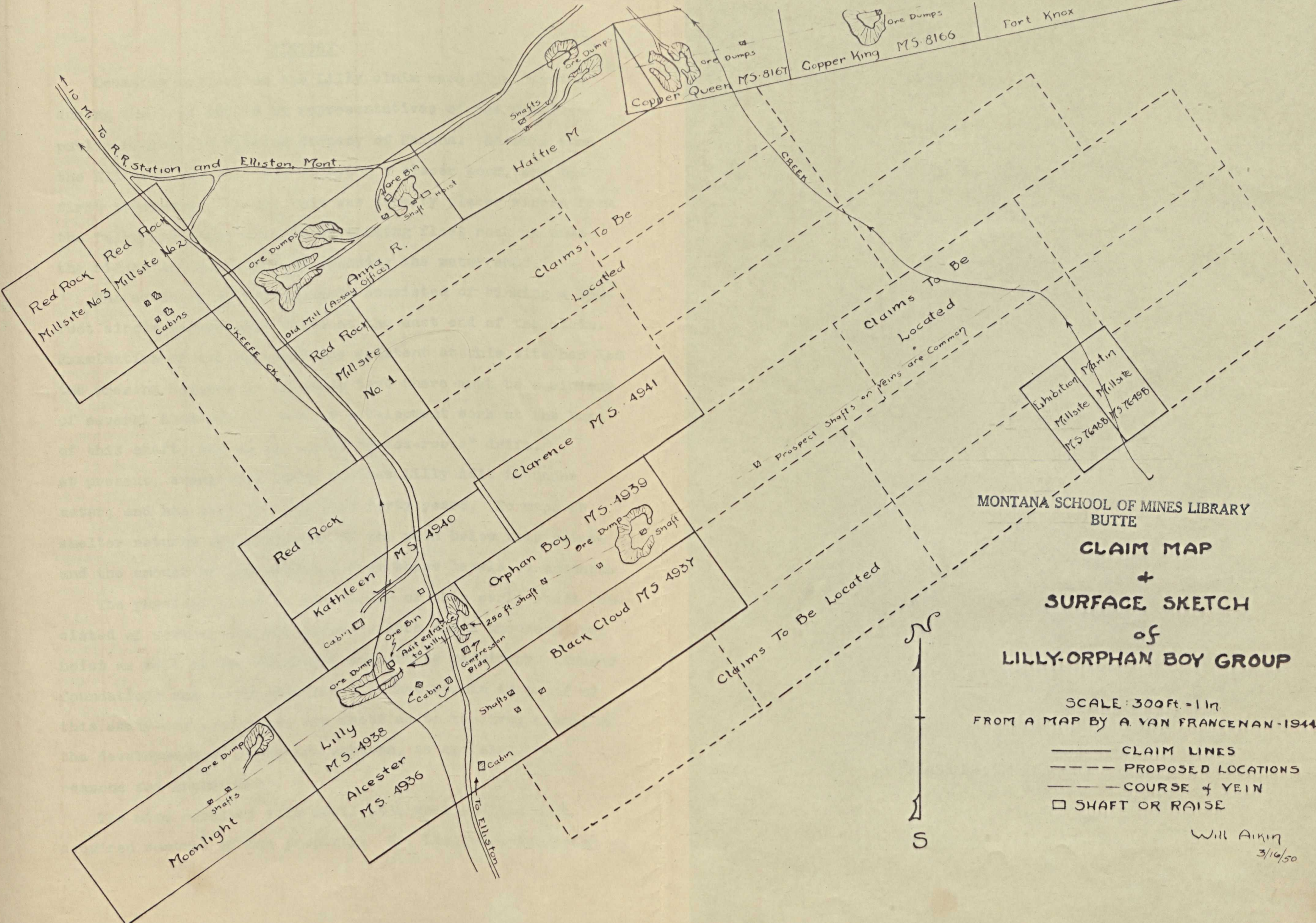
Preliminary Brunton Compass surveying and sampling began in September, and several supplimentary trips were taken to the underground workings during the following spring months. Adverse weather conditions prevented a detailed inspection of the surface geology and the author has, therefore, made free use of all maps and previous work on the area in drafting conditions and facts by which he could adjudge the geology and ore deposition of the Lilly Mine.

GEOGRAPHY

The Lilly Mine lies in the center of Section 15; T. 8. N., R. 6 W., ten miles south of Elliston, Montana. From this point the mine can be reached easily by a dirt road which first follows the water course of Telegraph Creek, and then of O'Keefe Creek. Other cities within reasonable distance are Butte, 65 miles to the south, and Helena and East Helena, 35 miles to the east. Smelters are located at Anaconda and East Helena. Both U. S. Highway 10 and the main line of the Northern Pacific are routed through Elliston, hence the proximity of the mine to available transportation has proven a valuable asset both in shipping ores and in maintaining mining operations.

PHYSIOGRAPHY

The region considered herein lies on the west side of a north-south trending ridge between O'Keefe Creek and Telegraph Creek gulches. Drainage along these streams drops approximately 1800 feet in the 10 mile stretch prior to entering the Little Blackfoot River about 3 miles west of Elliston. The elevation at Elliston is 5046 feet above sea level, and that of the mine about 6809. The ridge, however, continues upward to join the east-west regional divide at about 7600 feet. The area immediately adjacent the mine is well forested with pine, and the resistant granitic ridge has developed a 400-foot difference in elevation between the creek bottom and the crests on either side. Being high, the climate varies widely within a 140 degree temperature range.



CLAIM MAP
+
SURFACE SKETCH
of
LILLY-ORPHAN BOY GROUP
SCALE: 300 Ft. = 1 In.
FROM A MAP BY A. VAN FRANCENAN - 1944
CLAIM LINES
PROPOSED LOCATIONS
COURSE of VEIN
SHAFT OR RAISE
Will Aikin
3/16/50
N
S
10 Mi. To R.R. Station and Elliston, Mont.
Red Rock Millsite No. 3
Red Rock Millsite No. 2
Cabins
O'KEEFE CK.
Ore Dumps
Old Mill (Assay Office)
Anna R.
Ore Bin
Hoist
Shaft
Hattie M
Shafts
Ore Dumps
Copper Queen M.S. 8167
Copper King M.S. 8166
Fort Knox
CREEK
Claims To Be Located
Red Rock Millsite No. 1
Clarence M.S. 4941
Red Rock
Kathleen M.S. 4940
Orphan Boy M.S. 4939
Ore Dump
Shaft
250 ft. Shaft
Black Cloud M.S. 4937
Cabin
Ore Bin
Adit entrance to Lilly
Compressor Bldg
Shafts
Lilly M.S. 4938
Alcester M.S. 4936
Moonlight
To Elliston
Prospect Shafts or Veins are Common
Exhibition Millsite M.S. 7648B
Martin Millsite M.S. 7649B

HISTORY

Location notices on the Lilly claim were first posted during the late 1890's by representatives of the Grand Republic Mining and Milling Company of Helena. At this time the Elliston district was enjoying a placer boom, and the first prospecting on the vein was done by placer miners from the Telegraph Creek area while tracing float rock up onto the ridges and mountains surrounding the water shed.

The activity of this company consisted of sinking a 250-foot single-compartment shaft at the east end of the claim. Examination of the ore dump now existent at this site has led the present leasees to conclude that there must be a minimum of several hundreds of feet of development work at the base of this shaft, and in the caved "grass-roots" drift.
At present, everything below the new Lilly Adit is under water, and has been for the last forty years. No maps or smelter returns are available of the vein below this point, and the amount of ore produced from these levels is unknown.

The physical plant at the collar of this early shaft consisted of several 40-inch steam boilers and a thousand foot hoist as well as the necessary supporting machinery. Unused foundations and rusty iron are all that remain in proof of this early-day operation, and facts as to the true nature of the development at depth are unknown, as are also the reasons for abandonment.

The mine remained idle until 1934 when E. Lindquist acquired control of the property. Mr. Lindquist proceeded to drive the new Lilly Adit, and two years later his son took over the property, and shipped approximately 300 tons of hand-sorted ore before turning control of the lode claims over to the Newman Brothers of Elliston in 1941. The present leasees have actively worked the mine intermittently ever since this date. During the war it was one of the few mines in the district which remained active, and with government backing a special priority road was built to the mine late in 1945.

Until the spring of 1950, the method of mining consisted of single-jack drilling and hand sorting in the slopes. Today the mine is equipped with rock drills and a small compressor which are used in conjunction with more hand sorting. The ground is well contained, and timbering has been more of a precaution rather than an absolute necessity. Standard drift sets along the haulage way and well placed stulls in the stopes have proven sufficient.

Production from this second period of activity has been approximately 1000 tons of hand sorted ore. Most of this ore has come from the drift extensions, and from Stope B (Plate II) on the east side of the shaft. Some ore was also taken from a winze at the west side of the drift, but this operation was abandoned because of ventilation and gas problems. The average value of the ore has fluctuated widely over the years; however, a ratio of 2 ounces of silver to 1 per cent lead has averaged from 20 to 25 dollars per ton.

At present the owners are trying to incorporate this and other properties in an attempt to raise money for a small mill as well as provide improved mining machinery.

GENERAL GEOLOGY

The Elliston district lies centrally in the intensely folded and faulted mountain ranges of western Montana. Strata range in age from pre-Cambrian to late Cretaceous and thousands of feet of late Cretaceous and Tertiary lavas blanket the sedimentary rocks. The Boulder batholith was intruded into the sediments and late Cretaceous lavas during the late stages or shortly after the Laramide orogeny, probably in Paleocene time. This igneous derangement has been more definitely described as a three phase tectonic disturbance which started with an Upper Cretaceous Andesite series followed by an Paleocene granitic intrusion and ended with the extrusion of an Eocene rhyolite series.

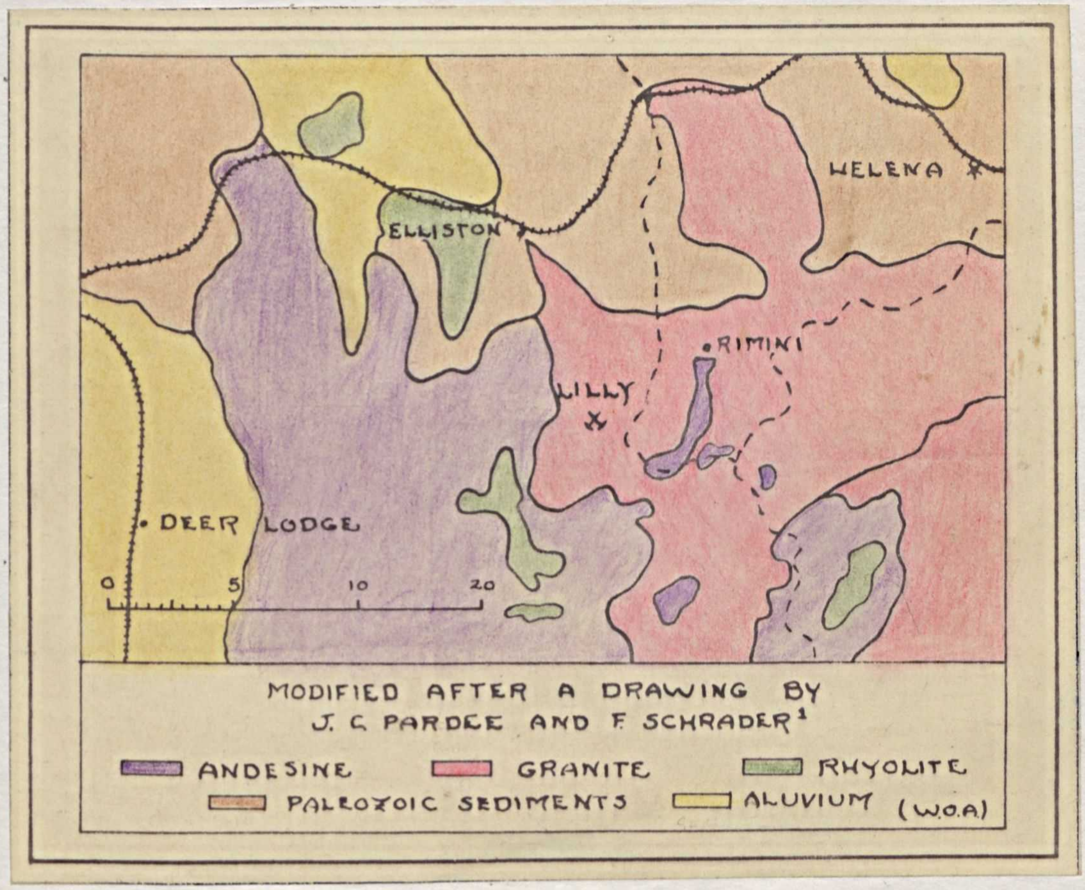


FIGURE 2

From the geological reconnaisance map shown in Figure 2, it is apparent that the Lilly Mine lies on a broadly exposed segment of granitic material and has no local relationship whatever to the Andesite and Rhyolite contacts.

The vein lies entirely within the granite, and while not shown on this small map, the granite phase is also characterized by a diversified group of rocks which have resulted in diorite, quartz monzonite (90%) and aplite, all of which may have been related to the source of many ore deposits in the batholith. A light-colored aplite dike is said to crop out 100 feet to the south in the Alcester claim; however, unless intersections of veins occurs at depth, the Lilly vein will fill the unusual condition of fissure filling and replacement unrelated to any rock other than the quartz monzonite.

After the intense folding of the Rocky Mountain orogeny, each succeeding phase was marked by a series of faults, folds and/or varying degrees of peneplanation before and after each of the succeeding phases. The final rhyolite phase was followed by a long interval of stability and erosion during which the old Eocene peneplanation surface was formed. Thrust faulting and erosion then combined to give t he Elliston district its present topographic form. The development of this erosion surface has been the responsible factor in removing the overburden of Paleozoic sediments and thereby exposing the near-contact vein now being mined at the Lilly group of claims.

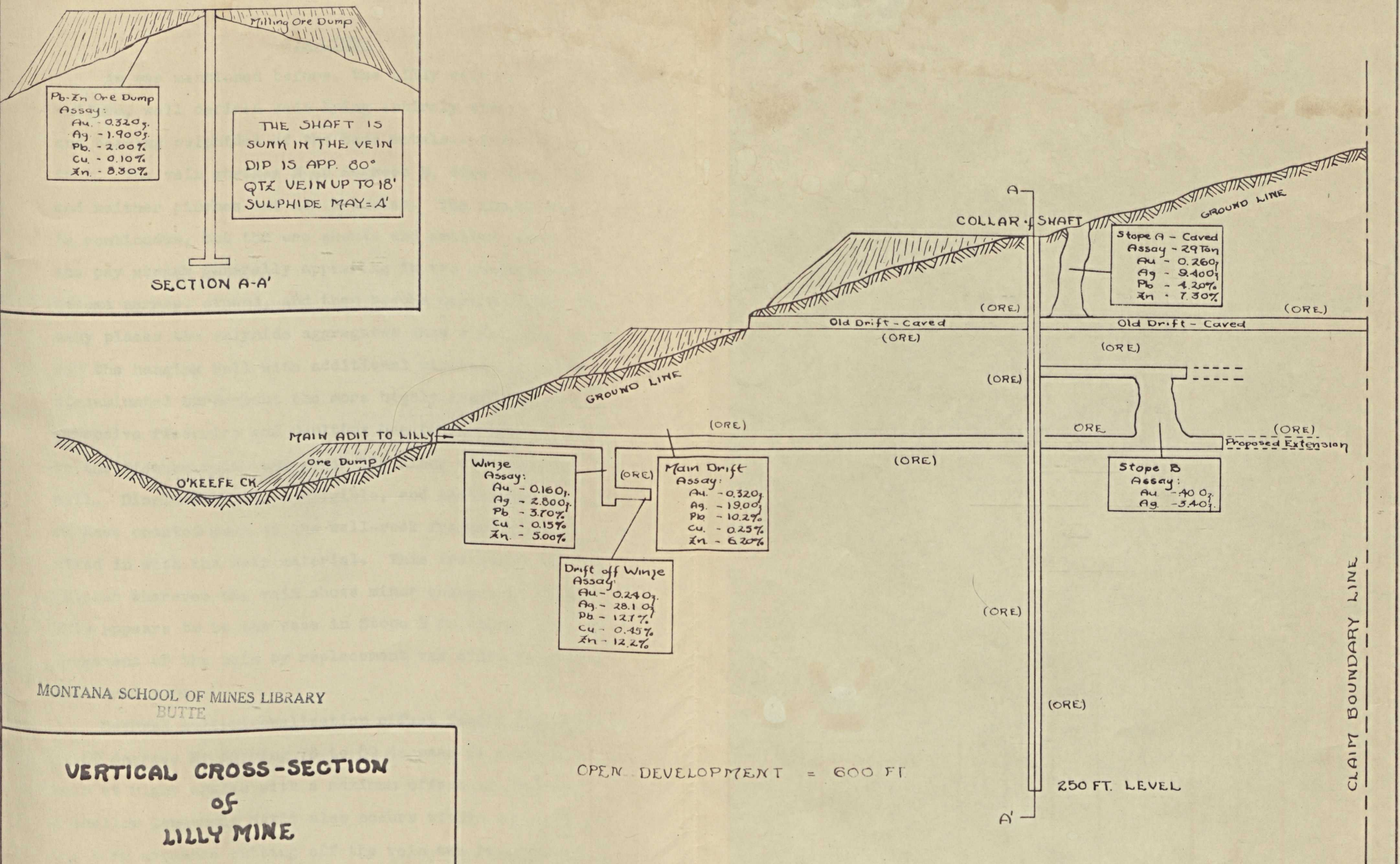
THE LILLY MINE

After the granite of the Boulder batholith had consolidated at depth, it was fractured along the outer periphery. These fissures then served as conduits for the deep seated ascending earlier silicic, and later mineral bearing solutions. Evidences of this early filling are apparent throughout the mine in the form of thick tourmalinic-quartz bodies which occur either in the foot or hanging wall and often appear as "horses" within the mineralized portions of the vein. In the grass roots drift above, ledges in excess of six feet were reported, and in the richer mines throughout the region, the better ore shoots have commonly been found in association with the thicker ledges. At the Lilly this fact cannot be applied accurately because there are many toumaline blocks which appear to have little significance other than for a host to the disseminated pyrite and gold-bearing arsenopyrite found therein. Amathystene quartz was also found near the shaft, but for the most part quartz is all of the smoky variety.

Knopf (6) speculates that this tourmalization proceeded form fissures and joint planes where these openings occurred closely spaced, or where the tourmalization was so intense that the granite was completely and solidly altered to a quartz-tourmaline rock. In the Lilly vein proof of this can be seen in the way the ledges appear to merge in the altered granite; however, the placement of these quartz-tourmaline intergrowths was certainly premineralization, and does little other than identify the earlier stages of this magmatic reaction as a relatively high mesothermal type deposit. Locally (Stope B) the black quartz is often brecciated and numerous fragments of tourmaline stand out in dark relief against the vein as the ore material grades abruptly in the tourmaline rock.

After studying the ore deposits of the Boulder batholith, Billingsly and Grimes (3) cataloged many of the mines in the granite according to their major characteristics, ores, and types. In applying these considerations, the Lilly mine can most easily be classified as a tourmalitic, lead-silver, fissure vein of the granitic phase. They also studied the depths to which veins of this type remain mineralized and found strong evidence that many veins grade downward to quartz stringers within a maximum one thousand feet of the granite contact. Examination of the thin sections taken from the fresh country rock enclosing the vein has shown a fine-grained granular texture which indicates that the present operations are taking place relatively near the contact between the granite and eroded overlying sediments. These facts imply that the greater portion of the vein still lies below the level of the new Lilly adit; however, mineralization in these lower regions can only be proven by further development work.

Although common, hoizontal zoning cannot be determined owing to the absence of data along the vertical plane. Undoubtedly the vein is still in the upper lead-zinc zone, as copper assays from all points are extremely low. This absence is attributed to segregation within the original magme.



VERTICAL CROSS-SECTION OF LILLY MINE

SCALE 1" = 50'

DRAWING BY A.V. VAN FRANCENEN

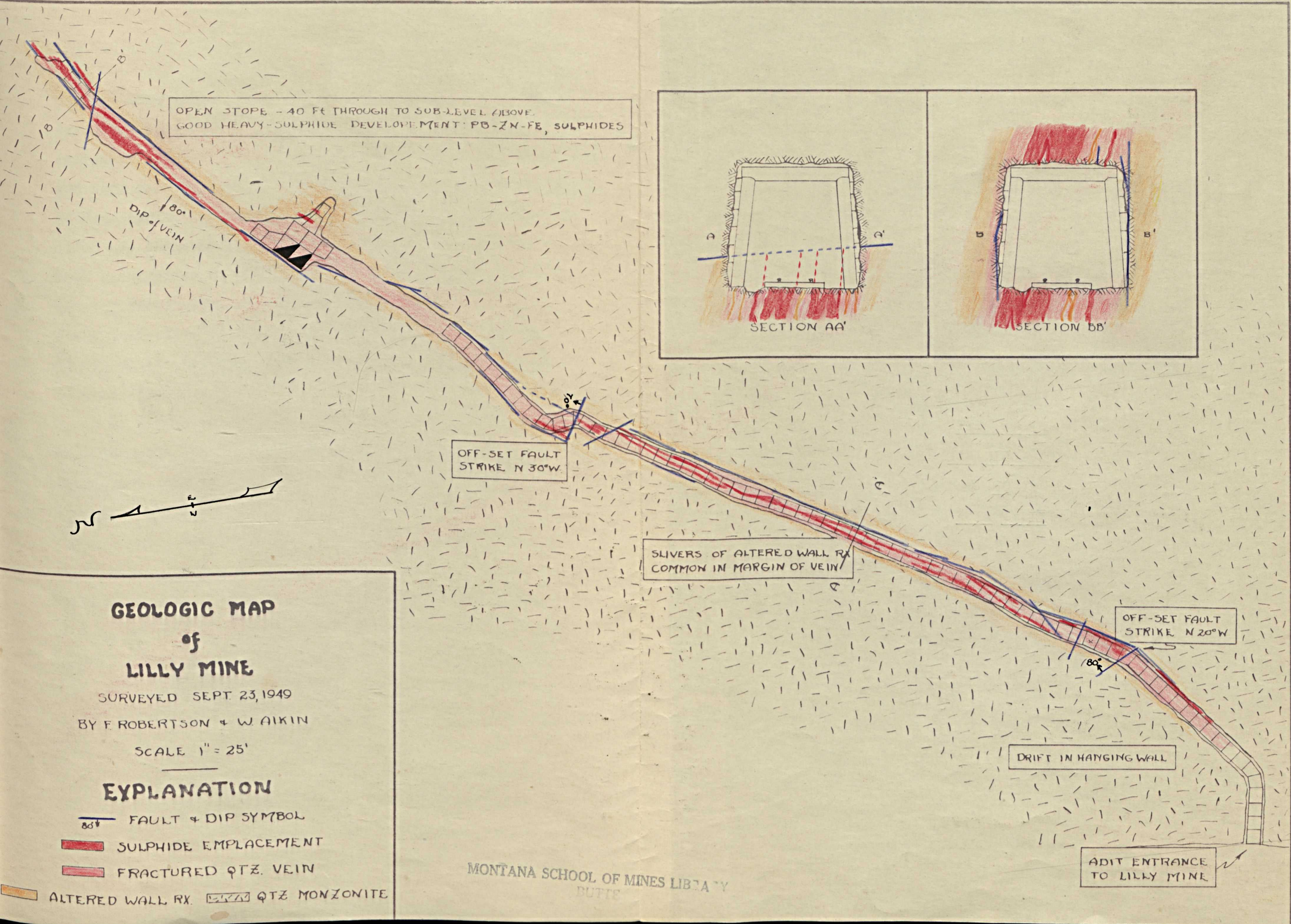
REVISED: 1944 & 1950

Will Aikin
4/5/50

STRUCTURE

As was mentioned before, the Lilly vein is a persistent, uniform, well defined vein lying entirely within the granite and bearing sulphides of the base metals---lead, zinc, and iron. The vein strikes N 40 degrees E, dips 80 degrees N, and neither pinches out nor branches. The mineralized zone is continuous, but the ore shoots and smaller veins are not, the pay streak generally appearing in two stringers which become narrow, expand, and then become narrow again. In many places the sulphide aggregates show a definite affinity for the hanging wall with additional mineralization highly disseminated throughout the more highly fractured footwall. Extensive fissuring and faulting has taken place parallel to the fissure vein, and generally along the southern footwall. Displacement is negligible, and shattering appears to have created much of the wall-rock fragments which occur mixed in with the vein material. This fractured zone is thicker wherever the vein shows minor changes in trend. This appears to be the case in Stope B in which later enlargement of the vein by replacement was aided by a wider fractured zone.

Several post-mineralization offset faults (Strike N 10 to 20 degrees E; dipping 70 to 80 degrees E) cut across the vein at right angles with a maximum offset of five feet. A shallow low-angle fault also occurs within 100 feet of the adit entrance cutting off the vein two feet above the haulage track. Displacement along this fault was considerable before merging into the ore zone again.


OPEN STOPE - 40 Ft THROUGH TO SUB-LEVEL ABOVE
GOOD HEAVY-SULPHIDE DEVELOPEMENT: PB-ZN-FE, SULPHIDES
80°
DIP of VEIN
B
B'
A
A'
SECTION AA'
SECTION BB'
OFF-SET FAULT
STRIKE N 30°W.
SLIVERS OF ALTERED WALL RX
COMMON IN MARGIN OF VEIN
OFF-SET FAULT
STRIKE N 20°W
80°
DRIFT IN HANGING WALL
ADIT ENTRANCE
TO LILLY MINE
N
GEOLOGIC MAP
of
LILLY MINE
SURVEYED SEPT. 23, 1949
BY F. ROBERTSON & W. AIKIN
SCALE 1" = 25'
EXPLANATION
80° FAULT & DIP SYMBOL
SULPHIDE EMPLACEMENT
FRACTURED QTZ. VEIN
ALTERED WALL RX.
QTZ MONZONITE

MINERALOGY

The mineralogy of the Lilly ores is one of the most interesting features of the entire problem. The major metals contained include gold, silver, copper, zinc, antimony, iron, and very rarely nickle. The minerals containing these metals include pyrite, arsenopyrite, galena, sphalerite, tetrahedrite, and chalcopyrite, which comprise 98% of the mineralogical occurrences of all metals. Several other minerals including jamesonite, tennantite, and millerite have given every indication of being present, but with the exception of millerite, definite identification is beyond the scope of this paper.

T he determinative tests and descriptive characteristics made possible the identification of the following minerals:

Tourmaline, Quartz According to Knopf (6) the tourmaline and quartz of the Boulder batholith occurs as an intimate intergrowth. Specimens were extremely hard and difficult to examine, and the writer was unable to determine this characteristic. The rock, however, may be easily recognized by its dark luster and black brilliance on fresh fracture.

Quartz (SiO_2) Of the gangue minerals intimately associated with the ore minerals, white quartz is the most extensive. Under the microscope the same quartz veinlet relationship exists on a microscopic scale, and both crystal and massive quartz occur in all polished sections. Although not included in the classification of opaque minerals, it can be easily recognized under the reflecting microscope by its extreme hardness, transparency, greyness, and negative reactiveness to all chemical etch tesys.

Pyrite (FeS_2) Pyrite is easily distinguished both in hand specimen and under the microscope. Its dull-yellow color and extreme hardness easily distinguishes it from arsenopyrite. Nitric acid tarnishes the larger well developed crystals, but all other etch tests prove negative.

Sphalerite (ZnS) Light grey and slightly softer than the needle, the sphalerite found in this specimen reacts to both nitric and hydrochloric acid with a slow tarnish. Aqua regia intensifies these reactions but other chemical tests are negative. In this particular set of samples tiny triangular blebs of exsolution chalcopyrite occur within the boundaries of the sphalerite alone and thus aid in identification.

Several samples of this ore were sent by the present leasees to the University of Montana, and in reply the specimen was identified as Jamesonite. In view of the noticeable content of antimony, this correlation seems quite possible; however, all specimens examined by the author were apparently sphalerite, and none showed the crystal form diagnostic of this rather rare mineral.

Arsenopyrite ($FeAsS$) White and very hard, arsenopyrite reacts only with nitric acid in giving an iridescent stain on polished crystal section. On all other tests the results were negative. Arsenopyrite is easily identified in hand specimens by its silvery luster, and well developed crystal form. It is usually associated with pyrite, and many interlocking arsenopyrite-pyrite grains may be observed.

Galena (PbS) Prevalent mainly in the foot wall, the soft yet heavy cubic galena crystals are easily identified in the hand specimen. Under the microscope the white color and triangular pitting make it easily identifiable. Nitric acid, hydrochloric acid, and ferric chloride all tarnish and stain the crystals in differing degrees to verify the initial identification.

Chalcopyrite ($CuFeS_2$) A soft distinctly bras-yellow color, the minute grains of chalcopyrite are easily stained by nitric acid. As was mentioned in conjunction with the sphalerite, the mineral is an exsolution product associated only with the zinc sulphide. Despite its small grain size, it can be easily differentiated from pyrite by its extreme softness.

Tetrahedrite $(Cu,Fe,Zn,Ag,)_{12}Sb_4S_{13}$ Scarce under the microscope and not identified in hand specimen, a form of tetrahedrite can be found in several of the polished sections. Grey, hard, and tarnishing only with nitric acid, the mineral is difficult to find and difficult to test. Whether it actually is tetrahedrite or not is questionable. The ore contains much arsenic, largely due to the abundance of such minerals as arsenopyrite. On this basis it is reasonable to assume that the tetrahedrite contains varying amount of arsenic rather than antimony alone, thereby causing it to approach tennantite. In all probability both varieties occur in varying amounts, but since optic tests cannot distinguish between the two, chemical analysis would be needed to make certain of the correct form.

Millerite (NiS) Although rare throughout the vein, vugs containing millerite and filled with late quartz are found in isolated instances. In several of these cavities hair-like groups of slender capillary crystals were found. Owing to the frail nature of the crystals no microscopic tests could be made; however, a microchemical test for nickle was strongly positive, and the nickle sulphide "capillary pyrite" species was identified among the non-ore late minerals present in the Lilly vein.

ORE MINERALS

Of all the hand specimens and polished sections of ore samples, none have given any indication of the role played by gold. Not one single piece of free gold was found which would indicate occurrence or genetic preference. For this reason several fire assays were run on the more abundant minerals to find out which minerals if any, carried the gold and silver. The samples were crushed, rolled, screened and the liberated mineral particles separated under a binocular microscope. Arsenopyrite, pyrite, spalerite, and galena, were the only minerals which revealed themselves well to this treatment, other minerals were too small or too scarce. The results of these assays are:

(ounces per ton)

	Gold	Silver
Pyrite.........	trace.....	4.6
Arsenopyrite...	0.53.....	5.1
Sphalerite.....	0.12.....	18.2
Gelena.........	0.08.....	2.1

The fact that gold shows a strong preference for arsenopyrite is also carried out by the facts contained in smelter returns. As the arsenic content goes up, the gold content also increases proportionately.

The silver assays may not be entirely accurate owing to the intimate relationship of tetrahedrite and spalerite. It is quite likely that the silver-bearing tetrahedrite remained interlocked with the sphalerite because of the coarse grind used to liberate the mineral particles. The sphalerite therefore probably contained minute amounts of tetrahedrite causing an unusually high silver assay for the sphalerite.

PARAGENESIS

The mineral sequence for this suite of ore samples was determined chiefly from crystal growth and relationship as observed under the microscope. This refers in particular to the size and shape of the individual crystals, as well as the regularity and outline of the crystal boundaries. In observing these factors, it is evident that the mode of formation was predominately replacement. This view is substantiated by the veinlets which cut across well formed grains, unmatching vein walls, smooth but irregular boundaries, and well developed crystal forms in many minerals. This position is further strengthened by an inspection of the vein in situ, wherein many residual fragments may be seen left by replacement.

In correlation with the single-solution conditions indicated by wall rock alteration, the emanetions began with a tourmaline-quartz emplacement and ended with a vugfilling millerite occurrence, thus running the temperature scale from high to low, with the greatest activity in the mesothermal range. After the heavy tourmalization came the first indications of a long quartz period. Quartz emplacement remains important throughout the later stages, and its presence in vugs as well as veinlets cutting both early minerals like pyrite and late minerals such as galena, makes its paragenesis long and extensive.

Pyrite is the first sulphide mineral to replace the quartz. This relationship can be observed in all sections by the smooth crystal boundaries, and well developed crystal forms which have developed in the quartz groundmass. Closely following the pyrite replacement came the deposition of arsenopyrite aggregates which attacked and developed largely in and about the pyrite occurrences, thus forming large clusters of interlocking pyrite and arsenopyrite crystals.

Sphalerite is well developed in crystal form and often can be observed invading the arsenopyrite. The common occurrence of chalcopyrite within the confines of the sphalerite has been identified as an exsolution process. There is a very even distribution of these inclustions, and the sharp boundaries of the grains show no enlargement. Other criteria of possible replacement are entirely missing, and it is probable that the chalcopyrite precipitated out of the solid solution when this state became untenable because of a lowering of temperature. This places its occurrence at the end of sphalerite emplacement, and the exsolution processes were discontinued shortly after the last ZnS developed.

Galena and tetrahedrite were the last of the ore minerals to win replacement. Both can be found replacing the sphalerite, but the relation to each other is not discernable. The association of the tetrahedrite, plus the unbroken cleanliness of galena and high silver values of sphalerite, indicates the fact that the galena was the last mineral deposited.

Paragensis Table

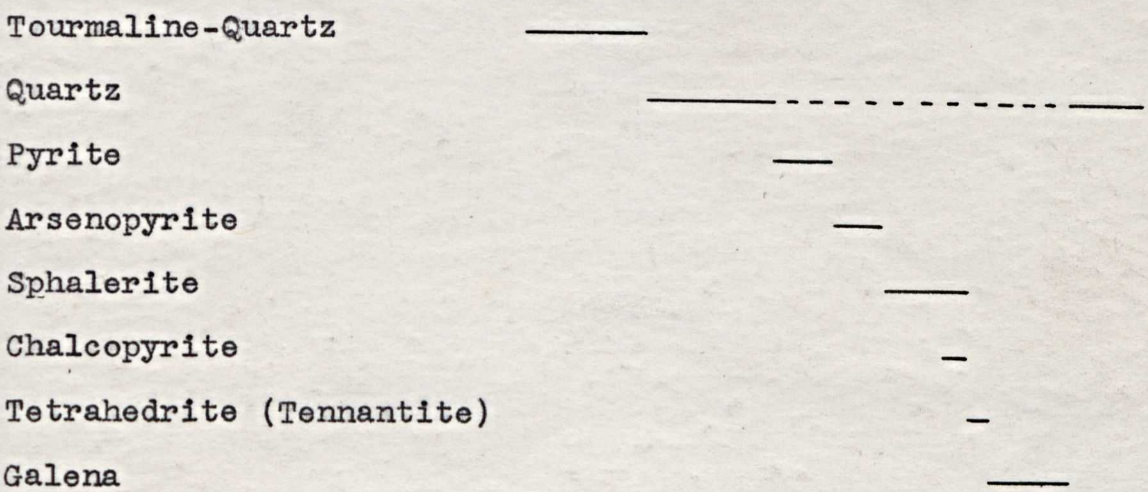


PLATE IV

SKETCHES OF POLISHED SECTION SURFACES

PLATE IV

1. Arsenopyrite replacing the pyrite which has developed in the quartz groundmass.

2. Sphalerite replacing both pyrite and arsenopyrite.

3. Blebs of chalcopyrite which have exsolved from the sphalerite. The sphalerite has, in turn, developed at the expense of the arsenopyrite.

4. Tetrahedrite replacing sphalerite.

5. Well developed galena crystals replacing arsenopyrite.

6. Late quartz veinlets cutting arsenopyrite and galena.

Explanation of Symbols

Qtz........Quartz (black)

Py.........Pyrite (yellow)

Asy........Arsenopyrite (rose)

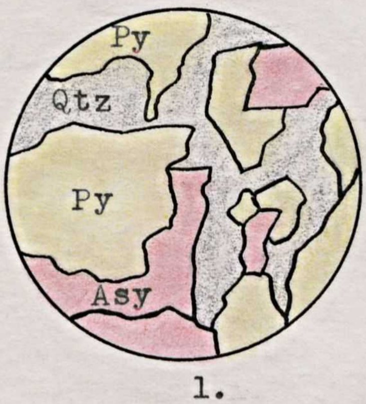
Sph........Sphalerite (brown)

Te.........Tetrahedrite (deep red)

Ga.........Galena (blue)

PARAGENESIS

Sketches of Polished Section Surfaces



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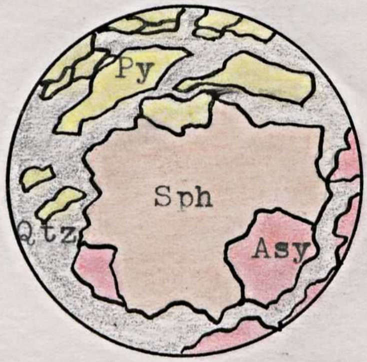

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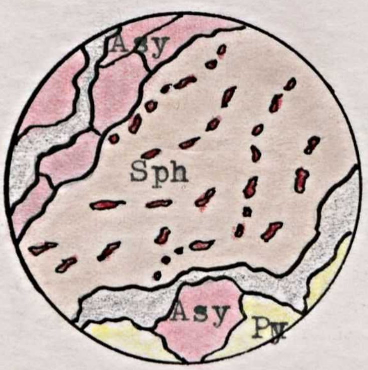

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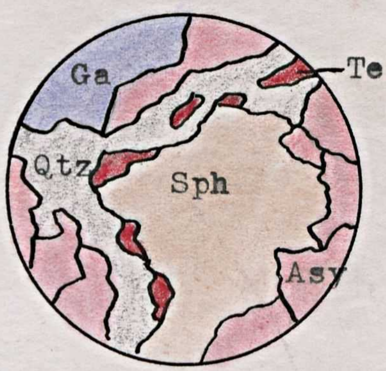

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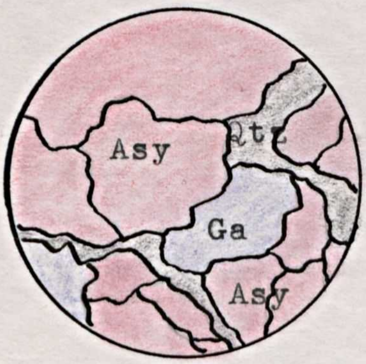


5.

6.

PETROLOGY AND WALL ROCK ALTERATION

At the intersection of the shaft and the new Lilly adit, an eleven foot crosscut has been driven into the granitic foot wall. Examination of the wall rock along this abandoned cut disclosed a clear view of the successive zones of alteration which have resulted from the attacks of the ore-bearing solutions emanating along these fractures. Short auger holes in the wall rock at other sites along the main drift have verified the continuity of the effect throughout the lateral extent of the present development.

At point A, one foot from the vein, the silicified clay-like products are clearly visible to the unaided eye, and at point B, six feet from the vein, a graditional greenish montmorillonite coloration is imparted to the altered plagiclase feldspars. The effect of this phenominon then begins to fade, and at a point 11 feet from the vein the only observable alteration products are the lack-lustre, and vaguely brownish appearing halos enclosing the dark minerals.

At each of these three representative sections along the wall a fresh sample of the country rock was taken, and thin sections were then prepared for the author by the Thin Section Laboratory of Butte, Montana. The examination of these thin sections under a polarizing microscope reveals in greater detail the complexity of these chemical and mineralogical changes.

Sample 3 (Vein plus 11 feet), which was taken very close to the outside boundary of alteration, proved to be very hard in comparison to the more friable rock found nearer the vein.

Under the microscope the darker minerals show very little of the effects of alteration, and since they are generally among the first to react to mineralogical changes, this sample has been considered to lie in or near the fresh rock zone. This rock is also the only one of its type found in the immediate vicinity of the Lilly mine. It is the intrusive quartz monzonite host rock in which the fissure vein lies, and upon which solutions have worked alteration effects.

Under a hand lens the fresh rock is light grey, and has a granitoid texture. Fine-grained orthoclase and tabular plagioclase crystals 1 to 2 mm. in length occur in approximately equal amounts, and together make up 75% of the rock. Milky quartz (15 to 20%) is also fine grained and difficult to recognize, while a scattering of darker biotite and hornblende crystals make up the remainder of the rock.

Under a microscope the rock exhibits a hypautomorphic granular texture, and by applying Johanssens system of classification, the rock can be definitely identified as Adamellite. The plagoclase is of the andesine variety ($Ab_{60}An_{40}$) and makes up 25 to 30% of the rock. Orthoclase is frequently perthitic, and makes up the largest constituent, amounting to 30 to 40%. Quartz ranges from 30 to 35%, and the dark minerals, primarily biotite and magnetite make up the remaining 5 to 10%. Accessory minerals identified in all sections include apatite, zircon, and rarely sphene. Even under the microscope alteration products are scarce in this zone; however, very irregular rims of green pleiochoric chlorite are beginning to make inroads into the dark biotite.

Sample 2 (vein plus 6 feet) lies well within the zone of alteration, yet the texture and type names remain the same, with little variation in the percentage comparison of the mineral types. Definite rims of chlorite are observed around the darker biotite minerals, and the much larger plagoclase feldspars striations have lost some of their clarity and brilliance owing to brown clay mineral alteration products clouding the surface. The plagoclase measured here, as in all crystals in all sections, is andesine.

Orthoclase was also marked by the brown clay minerals which formed in blotches on almost all crystals. This product seemed diagnostic of orthoclase and while it appeared much like quartz under the crossed nickols the kaolin coating stands out in bold relief under transmitted light.

Sample 1 (vein plus 1 foot) shows the most advanced effects of the alteration processes. At this point the rock is very close to the boundary between a leuco-adamellite (less than 5% dark minerals) and an adamellite (more than 5% dark minerals). These darker minerals consistently ranged between 4 and 6% of the total rock, whereas in the fresher outer zone the darker minerals accounted for as much as 10% of the total rock. This change to the lighter leuco form can be compensated for by a correspondingly small increase in the silica content. Although very closely grouped in percentage composition, this increment of silica-bearing minerals verifies the original megascopic conclusion that the mineralogical solutions were strongly acidic in character throughout the earlier toumalitic and later clear quartz phases. Of the darker minerals biotite surrounded by pleiochoric chlorite is the preponderant mineral as before, with some magnetite and hornblende discernable.

Plagioclase feldspars are badly altered, and the high order colors of sericite are everywhere, making measurement of extinction angles all but impossible. Orthoclase also is well mantled with kaolin and sericite, and a definite study of the relations of the individual crystal grains is very difficult to determine owing to the advanced stages of alteration.

This is, of course, a very limited and unsatisfactory basis upon which to make extensive conclusions; however, an application of facts as compared to conditions set forth at Butte, reveals a striking similarity to the general conditions described by Sales and Meyer (8). Fortunately the simplicity of the vein has presented the ideal situation of point to point alteration zoning free from the complexities of fault and fissure systems.

Because no chemical analysis was made of these occurrences, it is difficult to guess the exact chemical nature of these solutions through an analysis of gains and losses in chemical constituents. It is, moreover, within the limits of the previous facts to observe that the mineralogical and chemical changes which accompanied this alteration have resulted in a uniform symmetrical distribution of products, reflecting the intensity of a single continuous acidic solution reacting through a mesothermal range of temperature and physical conditions.

PLATE V

PHOTOGRAPHS OF ALTERATION PRODUCTS

PLATE V

1. Vein plus 6 feet: First noticeable development of clay alteration products on orthoclase (Irregular dark splotches on shallow-white minerals). 60X

2. Vein plus 1 foot: Heavy kaolin development on feldspars. Lighter more transparent edges around biotite (dark mineral) attest to chlorite alteration of dark minerals. Quartz (clean white crystals) show no alteration. 60X

3. Vein plus 11 feet: Plagioclase striations show the clear unaltered appeareance of these feldspars. 30X

4. Vein plus 6 feet: The clarity of the striations on the plagioclase feldspars is impaired by alteration products at the surface. 30X

5. Vein plus 6 feet: The lighter edges around the biotite are chlorite alteration products. 70X

6. Vein plus 11 feet: Biotite crystals show little alteration. At this point, the section still appears clean and unaltered. 70X

Explanation of Symbols

Qtz..............Quartz

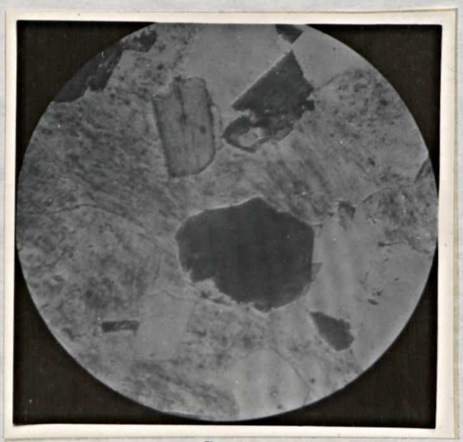
Bi...............Biotite

Pl...............Plagioclase

O................Orthoclase

WALL ROCK ALTERATION

Photographs of alteration products



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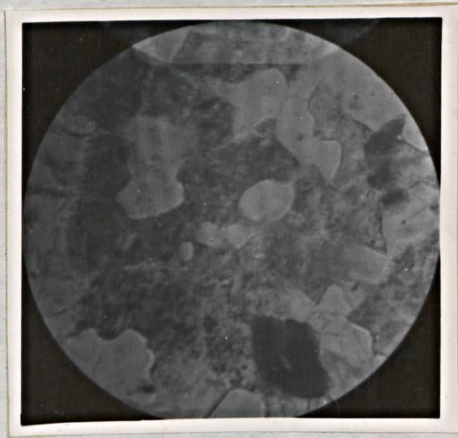

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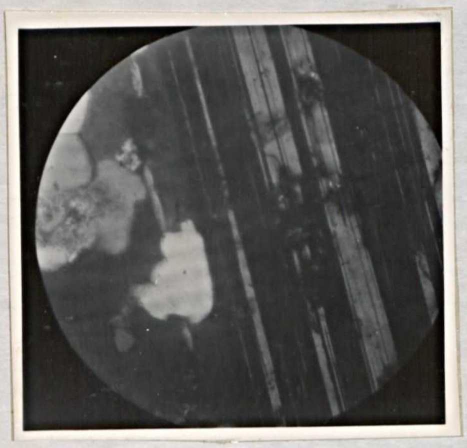

3.

4.

5.

6.

SECONDARY ENRICHMENT

No signs of enrichment were observed within the limits of the vein examined by the author. Surface discoloration is noticeable only from the bottom upward on the opposite side of the hill. Oxide and carbonate minerals are unknown even in vugs and cavities, and pyrite shows no sign of weathering. Iron oxide stains can be found on some of the post-mineral fault gouges, but very little was encountered either in polished or thin section. The siver assays were fairly consistent from the surface into the face, and every indication is that there is no heavy zone of secondary enrichment at the Lilly Mine.

CONCLUSIONS

If worked on a moderate scale, the vein should prove profitable. At present the development work is still insufficient to determine the true nature of the ore body at depth. For this reason caution and fundamental mining principles should be utilized in an effort to develope the facts upon which sound decisions can be made, insofar as the future of the mine is concerned.

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