Minerals Technology Corporation

Mining and Metallurgical Enterprises

THE GATEWAY TOWERS 115 HENNEPIN AVENUE MINNEAPOLIS, MINNESOTA 55401

Gold Hill Maps

GOLD HILL PROPERTY
Whatcom County, Washington

Exploration Proposal, July 30, 1965

Rec'd 8/9/65 Spokane, Wash.
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Gold Hill Property - Whatcom County, Wash.

Summary of Information

Two Ag, Pb, Zn ore shoots are indicated in old adits with a gross grade of about $40.00 per ton (1964 prices), a width of 5 feet or more, representing about 220 tons per vertical foot. If the two shoots have a vertical extent of 300 feet, then there are over 60,000 tons in these two ore shoots alone.

The two indicated ore shoots are 1000 feet apart horizontally and some 400 feet vertically. Both appear to be part of the fault fracture zone although the lower ore shoot may be in a subsidiary fracture of the main zone. There is a good chance that other ore shoots may occur in subsidiary fractures or along the main zone in the 800 feet of unexplored ground between the two shoots. In addition, the favorable structure southwest of the lower ore shoot is completely untested. The upper adit apparently extends a thousand feet or so beyond the upper ore shoot. The structure below this is also unexplored.

If 60,000 tons of ore of the indicated grade exist in the two ore shoots, a plant of 100 tons per day capacity should return capital costs plus a modest profit. If ore in excess of this amount, or if the price of silver should increase significantly, or both, then this could be a very profitable mining venture.

At the present time the property is about 12 miles from a road. A highway (North Cross State Highway) is now under construction that will pass about 3 miles from the property. This highway should reach the area in 1966, and not later than 1967. It is this road, plus the higher price of silver now, as compared with the time the old adits were driven, which gives the property an attractiveness it did not have previously.

The property should have some exploratory work carried out upon it to check the indicated ore shoots and to provide a better idea of the tonnage potential and ore controls. Such a program would cost between 20 and 30 thousand dollars. If the initial program is successful, then additional exploration would be necessary.

D. H. Yardley

D. H. Yardley,
Reg. Prof. Engineer
(Mining)

Memorandum on "Gold Hill" Property

Whatcom County, Washington

by

D. H. Yardley, PE

During August of 1963, I visited the Gold Hill property and spent a full day in examining the showing there. I was accompanied by Mr. D. Gebbers and Mr. E. Pariseau. Because of the short time available to me, plus a lack of adequate plan maps or survey control, I did not reach definite conclusions regarding the structural relations of the various showings. Later, a report on a study of the Gold Hill ores carried out at the University of Washington in 1937 was obtained. A copy is attached.

In June of 1964, Mr. W. Pariseau (a graduate of the University of Washington in Mining Engineering), at my request, carried out a compass and hand level survey to provide some geometric and topographic data. This work is incorporated in the map of the general mine area. (Fig. B)

General Impressions

The main mineralized zone is along a strong fault fracture system in argillitic rocks. There is some diorite, probably a dike. Some detailed geologic mapping will be required to clarify the geologic setting.

Two adits exist, about 400 feet apart in elevation. The lower (B adit) followed one ore shoot, an assay plan of which is attached. The indicated shoot has a length of 205 feet, average width of 5.5 feet. The grade averages Silver 20.4 oz. per ton, Lead 4.4%. No assays are given for Zinc or Gold. It is noteworthy that the thesis by Mr. Sylliasen shows substantial zinc values.

Insofar as the ore shoot reported in the upper (A adit) tunnel, no assay plan isavailable. Mr. Wm. Pariseau saw one once and the indicated position (Fig. B) is based on his recollection. This can be checked at relatively low cost.

The portal of the upper adit is nearly filled by a sand run a few feet from the entrance and did not appear safe to enter. Beyond the sand run the adit is in rock and was open for the limited distance I could see. There should be no particular difficulty in repairing the portal so that check sampling can be carried out.

The entrance to the lower adit is completely caved. It appears that there could be as much as 50 feet (Hor. Dist.) which has caved in.

Both the upper and lower adits appear to be driven on fissure veins in the fracture zone. There is a possibility that the lower adit is driven on a tension fracture subsidiary to the main zone. Other such fracture or fissure may well exist.

The fault fracture system appears to be strong and continuous and could be the locus of substantial ore shoots in addition to the two indicated ones.

The fracture system extends uphill from the upper adit for at least 1000 feet. Mineralization, evidence of faulting and drag folding can be seen. The zone is roughly parallel to a creek and can be traced along the steep slope along the creek. The side slope along the creek is subject to ravel so that only a few feet of sand ravel and weathered rock exist over the zone. Trenches could be dug with hand tools. The old maps indicate that a few trenches or pits once existed, but I saw ~~evidence of~~ only one, several hundred feet north east of the up-dip projection of the upper adit ore shoot. The others were filled by ravel.

A grab sample of sand and fault gouge taken across 6 feet about 400 feet up hill from the upper adit returned 3.5 oz. Ag. This was not in the ore shoot zone.

Apparently that portion of the structure south west from the lower adit is completely untested. Possibly some geochemical work may prove useful in this mantled area.

The existence of a strong structure, the two indicated ore shoots, the University of Washington thesis, improved metal prices and the road construction all support a conclusion that this prospect justifies an exploration program.

Buildings

A log structure about 75'x20' exists. A part of this building can be put in adequate condition for a small crew.

Road

A road is being constructed to pass along the adjoining valley of Granite Creek; to connect the Gold Hill property to this road will require

about 3 miles of road work. I have not seen the route, but at the property only bulldozer work would be required. Mr. Pariseau informs me that about one quarter mile will require some rock work. If ore is found in mineable quantities, operating plans would require road access.

At the present time, one can drive to Ross dam about 12 miles from the property and walk in along a fairly good trail.

Ore Possibilities

The assay plan of the ore shoot in the lower adit indicates a length of 205 feet, average width of 5.5 feet, average Ag 20.4 oz./T, average Pb. 4.4%; Gross Value (Ag at $1.30 per oz., Pb at 14¢/lb.) = $26.50 + $12.30 = $38.80 per ton.

Assuming 10 cubic feet per ton, the indicated ore in the lower adit is 115 tons per vertical foot. If the shoot has a vertical extent of 300 feet the ore potential is about 35,000 tons. This is an amount of ore which would be of interest as a target. There, drilling should test if this much, or more, exists in this ore shoot. Such drilling would be below the adit as only about 75' of backs occur above the adit level.

No assay plan is available for the upper adit which is the longest of the two adits. Mr. Wm. Pariseau saw the assay plan some years ago and insofar as he can recall, the indicated ore shoot was located as shown on the sketch map. He also recalls that the grade was somewhat higher than in the lower adit with occasional very rich samples.

Fortunately, this upper adit can be reopened and check sampled. Assuming that width, grade and length are similar to the lower adit ore, one can visualize 110 tons or so per vertical foot in the upper adit shoot. If a vertical extent of 300 feet exists, then there could be 35,000 tons of ore in the upper shoot. Drill tests could check this.

One can visualize 70,000 tons of $38 (gross value) ore as a distinct exploration target for these two ore shoots.

In addition to the above, there is a good possibility of additional ore shoots.

If 60,000 tons exists, it should amortize the cost of a plant to mine it with a modest profit. If more ore exists, then the property will be distinctly attractive.

The first objective is to prove or disprove the existence of enough ore to return plant and development costs.

The chance that this much ore exists, with chances for additional ore, is good and therefore an exploration program should be initiated.

Any development and mining would have to await completion of the road along Granite Creek.

A. H. Yardley

90' from portal checked again that by (rcy) B tunnel (lower adit)

"Gold Hill" Property — Computations of Assay Averages by W. Yardley

Sample No.	Influence Length	Width	Sq. Ft.	% Pb	Oz. Ag.	Sqft. % Pb	Sq. Ft. Oz.
1	16'	6'	96	0.14	10.20	13.44	979.2
2	16'	7'	112	3.16	9.20	353.92	1030.4
3	9'	6'	54	7.76	21.63	419.04	1168.0
4	6.5'	3'	19.5	7.49	11.78	146.06	229.7
5	4'	5'	20	8.11	18.35	162.20	367.0
6 & 7	2.5'	8'	20	11.92	28.86	238.40	577.2
8	3.5'	6'	21	7.14	20.78	149.94	436.4
9	5'	6'	30	3.28	9.66	98.40	289.8
10	5'	6'	30	6.62	17.79	198.60	533.7
11	5'	5'	25	7.51	18.71	187.75	467.8
12	5'	6'	30	9.17	43.12	275.10	1293.6
13	5'	5.5'	27.5	2.55	40.98	70.13	1126.9
14	5'	6'	30	0.40	44.77	12.00	1343.1
15	7.5'	6'	45	6.21	81.96	279.45	3688.2
16	10'	5'	50	3.75	20.50	187.50	1025.0
17	10'	5'	50	4.91	26.87	245.50	1343.5
18	10'	4.5'	45	9.61	27.20	432.45	1224.0
19	10'	6'	60	6.03	19.87	361.80	1192.2
20	10'	5.5'	55	0.28	0.18	15.40	9.9
21	10'	6'	50	4.54	20.39	272.40	1223.4
22	10'	5'	50	1.17	7.91	58.50	395.5
23	10'	5'	60	2.63	9.89	131.50	494.5
24	10'	4.5'	45	3.32	14.17	149.40	637.6
25	10'	5'	50	4.70	18.21	235.00	910.5
26	10'	4'	40	5.59	18.91	223.60	756.4
Totals	205'	137'	1115			4917.48	22,743.5

Ave. % Pb = 4.41% Ave. Oz. Ag/T = 20.40 Ave. Width = 5.5'

225' from portal

Figures checked with those of W. Washington (rcy) April 1963. [illegible]

The Proposed Exploration Program

General

The program is to consist of 3 phases. The minimum expenditure is that for phase 1 which shall be carried to completion. Provided that phase 1 does delineate ore potential then phase 2 shall be initiated. In turn, phase 3 shall be carried out only if phase 2 provides justification for the expenditure.

Phase No. 1 (details of cost estimate are attached)

This shall consist of:

(1) Necessary equiping and rehabilitation of camp
(2) Trail repair
(3) Reopening and timbering of portal of upper adit
(4) Scaling and safety timbering
(5) Geology mapping
(6) Sampling
(7) Trenching
(8) Drilling of Diamond Drill Hole 1 to 6

The estimated cost of Phase No. 1 is $ 25,915.00

Phase No. 2

This phase will consist primarily of tunnel work along the vein structure, some cross cutting and some short drill holes from underground. The tunnel work and drilling would be by contract.

Two alternatives were considered for phase 2; tunnel or drill from surface. The drilling considered consists of holes 7 through 14 (Fig. 2 and B), a total footage of about 2800 feet. At a base rate of $8.00 per foot, this would be $22,400.00, not including costs for supervision, transport, assays, etc. The tunnel work selected consists of 675 feet at $35.00 per foot - $23,625.00, not including supervision, assays, etc.

The tunnel approach was selected because of the following advantages:

1. The vein structure can be followed without the between-hole gaps inherent in a drill program.
2. Any ore shoots encountered could be thoroughly sampled and could be outlined easily by short drill holes from cross cuts.
3. Ore shoots can be checked above the adit by raising.

(4) A tunnel provides a better exposure of the geology and mineralogy, more reliable samples, and a much greater sample density than drill holes alone.

(5) The indicated ore shoot in the lower adit could be mapped and check sampled.

(6) Short drill holes could be drilled to test for parallel zones as compressed air would be available in the tunnel.

(7) If mineable ore is found the tunnel could serve for ventilation and provide means for quick development.

(8) Any drifting in ore would provide some ore. Hand cobbing might produce some direct shipping material. This would help defray expenses and would also provide metallurgical information.

(9) There is no guarantee that core recovery would be satisfactory in drilling this material.

Based on the considerations noted above, adit and tunnel work was selected for Phase No. 2.

Phase No. 2 shall consist of:

(a) Adit to connect to lower tunnel - 130 feet

(b) Drift on structure - 470 feet

(c) Cross cutting - 100 feet

(d) Probe drill holes - 400 feet

Note: See Fig. B for location

Total tunnel work, 700 feet @ $35.00 -	$ 24,500.00
Probe drill holes, 400 feet @ 5.00 -	2,000.00
Office expense -	400.00
Supervision, Geology mapping, consulting -	2,500.00
Sampling and assaying -	750.00
Transport costs -	500.00
Miscellaneous -	500.00
Total estimated cost of Phase 2	$ 31,150.00

Phase No. 3

Phase No. 3 is to be carried out only if justified by successful results of the previous exploration in the upper portal area or in the area between the A and B adits. It consists of extending the phase 2 tunnel 1000 feet, cross cutting, raising and probe drilling. It should be noted that to drill about 200 feet below the upper ore shoot would require drill holes of about 1000 feet each. Four such drill holes would cost about $32,000.00, not including sampling, supervision, etc.

The cost of Phase No. 3 is estimated as follows:

(a) Drifting and cross cutting, 1100 feet @ $35.00 -	$ 38,500.00
(b) Probe drill holes, 500 feet @ $ 5.00 -	2,500.00
(c) Raising (only if ore shoot encountered), 100 feet @ $20.00 -	2,000.00
Supervision, Geology mapping, consulting -	2,300.00
Office expense -	500.00
Sampling, assaying -	800.00
Transport costs -	600.00
Miscellaneous -	500.00
Total estimated cost of Phase No. 3 -	$ 47,700.00

Summary of Estimated Costs

Phase No. 1	$ 25,915.00
Phase No. 2	31,150.00
Phase No. 3	47,700.00
	$104,765.00

Phase No. 1 - Cost Estimates

Repair of kitchen area and part of remainder of log structure to provide office and sleeping room. Area to be rehabilitated ≃ 20 x 50 feet.

Roofing paper @ $4.00/100 sq. ft.	$ 60.00
Plywood for flooring, tables, doors, etc., @ $5.00 per 4x8' panel, ½"	120.00
Tubular foldaway cots and mattresses, 5 @ $20.00	100.00
Lumber, 500 board feet, mixed	100.00
Nails, mixed	20.00
Stove pipe	5.00
Cement - stove base	10.00
Windows, 6x3', sliding, 2 @ $40.00	80.00
Screening	15.00
Total repair materials -	$ 510.00
Kitchen and cooking utensils	105.00
Fire extinguisher	25.00
First Aid kit	25.00
Camp blankets, 60x80", 10 @ $4.00	40.00
Sheet blankets, 5 @ $1.00	5.00
Gas lanterns, 3 @ $13.00	40.00
Tubs, 2 @ $6.00	12.00
Basins, 3 @ $1.00	3.00
Total -	$ 255.00
Total cost - rehabilitation and equiping of camp - - -	$ 765.00

Phase No. 1 - Cost Estimate

Tools and Materials

Hammers, 3 @ $3.00	$ 10.00
Brace and bit, 1 set	12.00
Saws, carpenter - 2 @ $4.00	8.00
Saws, buck - 2 @ $6.00	12.00
Axes, 3	18.00
Hatchets, 2	7.00
Picks, 2	10.00
Shovels, 4	25.00
Grubhoes, 2	12.00
Sledges, 7 lb., 2 @ $6.00	12.00
Scaling bars, light, 2	5.00
Rock chisels, 3 @ $1.50	4.50
Spikes, timber	10.00
Claw bar	4.00
Sample bags, 150, 10x18 @ 30¢	45.00
Crack hammer, 2 lbs., 2 @ $5.00	10.00
Nails, mixed	10.00
Plastic pipe, 1", 1000' @ 10¢ (water supply)	100.00
Chain saw for mine timber, 7 h.p., 21"	200.00
Carbide lamps, carbide	20.00
Heavy canvas tarps, sample collection, 5x7, 4 @ $2.50	10.00
Drafting equipment and paper	75.00
Survey, rental of equipment	100.00
Brunton compass	60.00
Explosives	50.00
Total -	$ 850.00

Cost Estimate - Labor

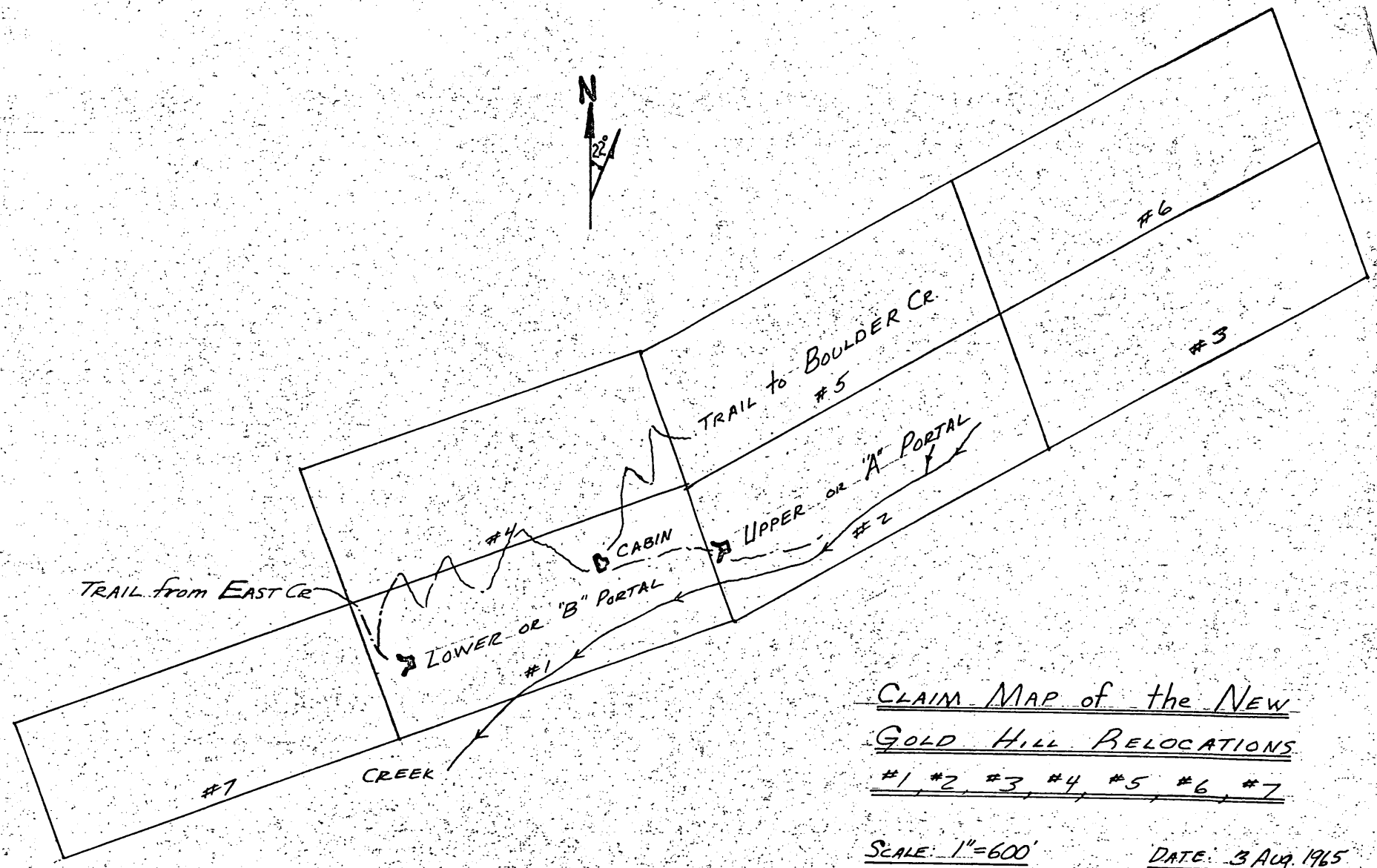
Rehabilitation of cabin, 7 man days	$ 210.00
Rock work on trail to upper ~~cabin~~ adit, 2 man days	60.00
Prepare helicopter landing site, 2 man days	60.00
Portal repair, place safety timbers in adit, scale adit, 18 man days	540.00
Cut and transport timbers, 5 man days	150.00
Trenching, 10 man days	300.00
Prepare drill site, upper adit, 5 man days	150.00
Prepare drill site, lower adit, 4 man days	120.00
Channel sampling, "A" adit, 12 man days	360.00
Other trenching and sample cutting, 5 man days	150.00
Contingencies - weather, etc., 8 man days	240.00
Total man days, 78 (13 weeks of 6 days)	
Use 3 men for 4 weeks, including travel time, Use 1 man for 3 weeks, estimate paid time, 90 @ $30.00	2700.00
Add 1 cook, 4 weeks	500.00
Total labor	$ 3200.00

Supervision and Consulting

One Geologist-Mining Engineer (4 man weeks, including travel time and planning)	$ 1500.00
One Fd. Assistant, 4 weeks	600.00
Supervisory	$ 2100.00

Miscellaneous costs

Assays, Ag, Pb, Zn, Au	$ 500.00
Preliminary Met. tests	300.00
Tpn. Geol., Assistant, crew	800.00
Helicopter service	750.00
Pack horse	100.00
Insurance	100.00
Contingencies	450.00
	$ 3000.00

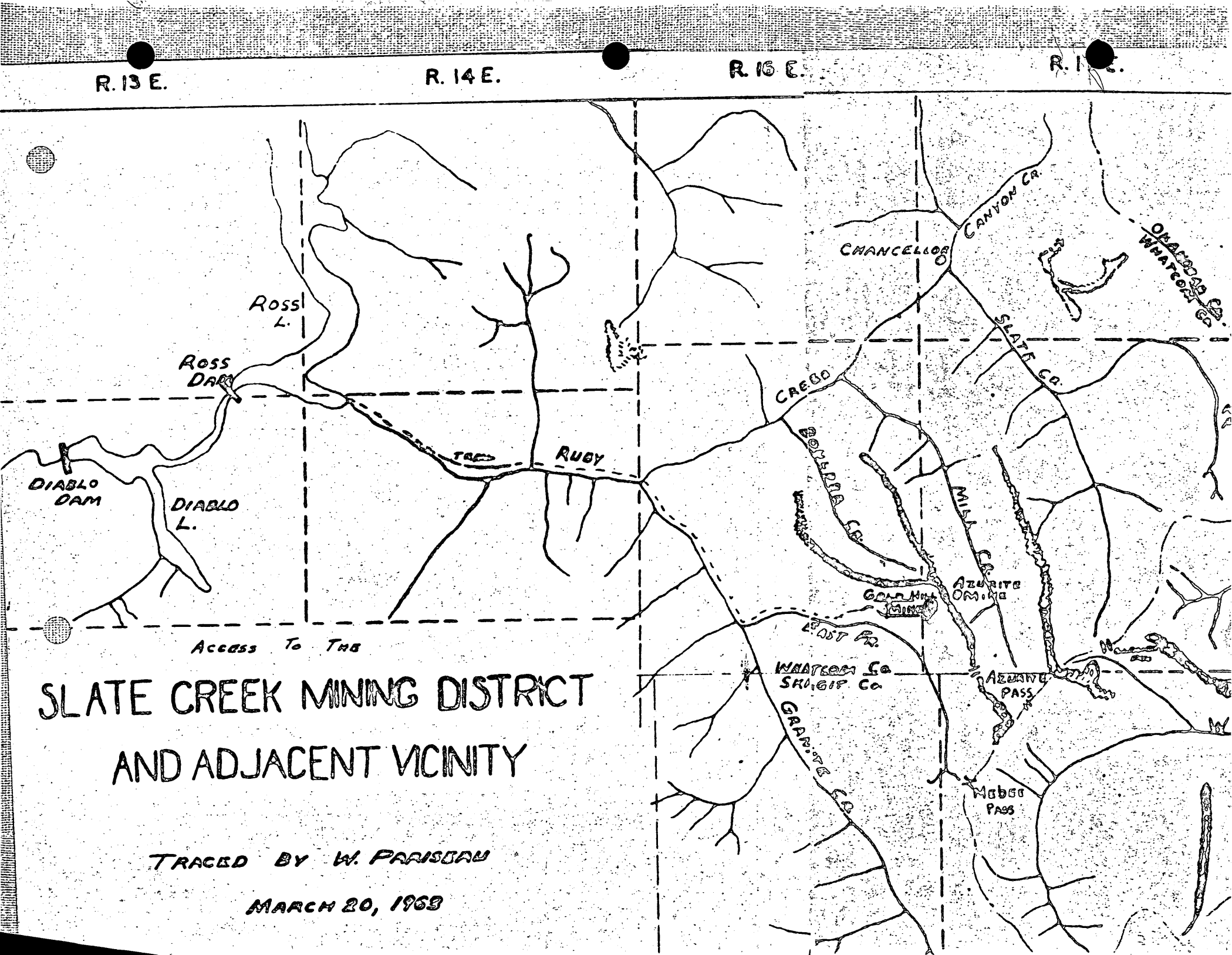


CLAIM MAP of the NEW GOLD HILL RELOCATIONS #1, #2, #3, #4, #5, #6, #7

SCALE: 1" = 600'

DATE: 3 Aug. 1965

BY: BILL PARISEAU


R. 13 E.
R. 14 E.
R. 15 E.
R. 16 E.
ROSS L.
ROSS DAM
DIABLO DAM
DIABLO L.
TRAIL
RUBY
CREEK
CHANCELLOR
CANYON CR.
OKANOGAN CO.
WHATCOM CO.
SLATE CO.
BOMBERA CR.
MILL CR.
AZURITE MINE
EAST FK.
WHATCOM CO.
SKAGIT CO.
AZURITE PASS
GRANITE CR.
HABER PASS
ACCESS TO THE
SLATE CREEK MINING DISTRICT
AND ADJACENT VICINITY
TRACED BY W. PARISEAU
MARCH 20, 1968

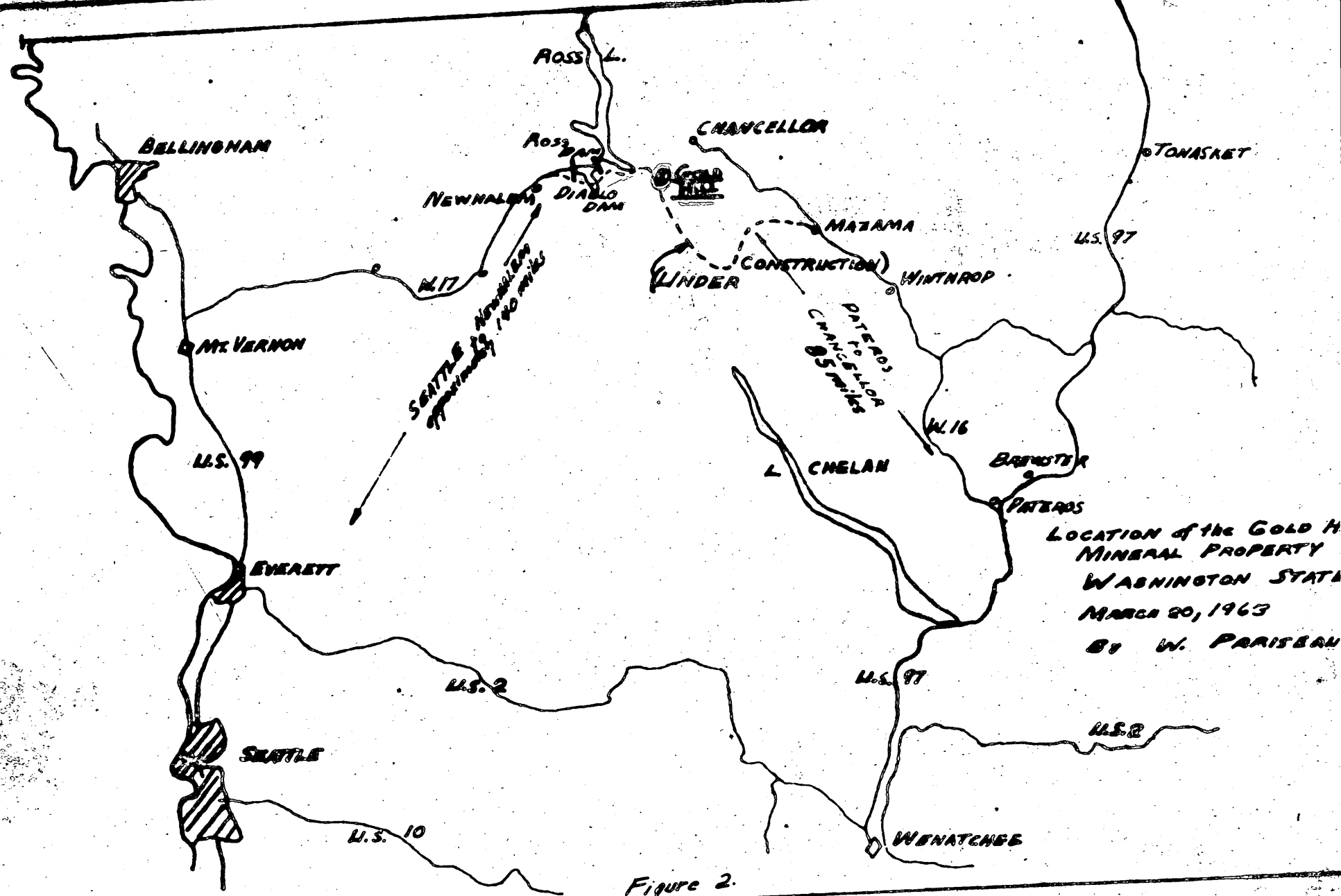

ROSS L.
ROSS DAM
DIABLO DAM
NEWHALEM
CHANCELLOR
MAZAMA
WINTHROP
TONASKET
U.S. 97
BELLINGHAM
MT. VERNON
W. 17
SEATTLE to Newhalem approximately 140 miles
UNDER CONSTRUCTION
PATERSON to CHANCELLOR 85 miles
W. 16
L. CHELAN
BREWSTER
PATERSON
U.S. 99
EVERETT
U.S. 2
U.S. 97
U.S. 2
SEATTLE
U.S. 10
WENATCHEE
LOCATION of the GOLD H
MINERAL PROPERTY
WASHINGTON STATE
MARCH 20, 1963
BY W. PARISEAU

Figure 2.

Gold Hill Property

The property consists of 7 unpatented mining claims, named the New Gold Hill, numbers 1 to 7. Claims 1 to 3 have been held for several years and the assessment work carried out and recorded. Claims 4 to 7 were staked during July of 1965.

The location of the property is stated by Syliassen (p. 2, University of Washington Thesis report) as Section 30, Twp. 36N, R17 East. Because the claims have not been surveyed and because there are some differences between Forest Service and other maps, this may not be the correct description. However, if the claims are not in Section 30, they are very close to it.

The property is on the west slope of the Cascade Mountains, about 23 miles south of the Canadian boundary. It is in the Slate Creek Mining District in the Mount Baker National Forest in Whatcom County, Washington.

A sketch map of the claim layout and a sketch map of the general location are attached.

H. S. Yardley

TREATMENT OF A GOLD-SILVER-LEAD-ZINC ORE FROM THE GOLD HILL MINE WHATCOM COUNTY

by

CLIFFORD THEODORE SYLLIAASEN

A thesis submitted for the degree of

BACHELOR OF SCIENCE IN

MINING AND METALLURGICAL ENGINEERING

UNIVERSITY OF WASHINGTON

1937

317962

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TREATMENT OF A GOLD-SILVER-LEAD-ZINC ORE FROM THE GOLD HILL MINE WHATCOM COUNTY

INTRODUCTION

OBJECT

In the summer of 1936 while employed by the Seattle Light Department at the Diablo Power House, the writer became acquainted with Mr. August Peterson, manager of the Gold Hill Operating Company, and obtained his permission to visit the company's property in eastern Whatcom County for the purpose of gathering material for this thesis.

The Gold Hill mine was visited for three days in the last week of September, 1936. During the stay at the mine various specimens were obtained which have been used in making a study of the petrology of the vicinity and the mineralogy of the Iron Mountain vein. The writer also obtained a lot of ore weighing 150 pounds. This ore has been used in fulfilling an important object of the thesis, which is to find a suitable method of concentrating the ore from the Iron Mountain vein by flotation.

ACKNOWLEDGMENTS

This thesis is made possible by the cooperation and assistance of certain men to whom the writer owes a debt of grati-

tude: to Dean Milnor Roberts, of the College of Mines, for his suggestions, criticism, and assistance in the preparation of this paper; to Mr. Peterson for his encouragement and placement of mine facilities at the writer's disposal; to Mr. Olav Drange, the mine foreman, for his very able cooperation during the writer's stay at the mine; and to Mr. B. H. Bennetts, of Bennetts' Chemical Laboratory, Tacoma, for the maps and ore that the writer received from him.

LOCATION OF THE GOLD HILL MINE

The Gold Hill mine is situated at an elevation of approximately 4500 feet on the western slope of the Cascade Mountains, three miles from the divide and twenty-three miles south of the International Boundary. The claims are all in section 30, township 36 north, range 17 east. This location lies in the Slate Creek Mining District, which is within the Mount Baker National Forest.

At present the only means of reaching the mine is by trail. The region is approached from the Puget Sound side by the Rockport branch of the Northern Pacific Railroad from Burlington in Skagit County. From Burlington the route up the Skagit Valley to Rockport is thirty-six miles by train and about the same by highway. From Rockport a railroad owned and operated by the Light Department of the City of Seattle extends up the Skagit Valley about thirty miles to Diablo at the dam of that name. Boats on Diablo Lake make one or more trips

daily across the lake and up the Skagit River six miles to the Ruby damsite just below the junction of Ruby Creek with Skagit River. From the Ruby damsite a trail leads to the Gold Hill mine, a distance of approximately seventeen miles.

The district can also be approached from the east side of the Cascade Mountains. From Ventura in Okanogan County, an automobile road leads to Barron in Whatcom County, which is connected to the Azurite Mine by a tractor road. The Gold Hill mine can be reached by trail from the Azurite mine.

SLATE CREEK MINING DISTRICT

HISTORY OF THE DISTRICT

The first discoveries in the Slate Creek District were made in the late seventies by a man named Rowley.[2] During the first season about 2500 men went into the area and over $100,000 in gold dust was taken out. The camp was short lived, however, because the placer ground was limited, the cost of reaching the district was enormous, and the trip was extremely hazardous. At that time the only approach to the district was from British Columbia.

After the district had been abandoned for about twelve years prospectors again went in. Not succeeding at mining placer gold they turned to prospecting for veins. Pressing south, near the source of Slate Creek they found gold in the creek that carried particles of quartz. Since outcrops do not exist in that vicinity the men started to dig. As a result

several veins were located, some of which were fairly rich. One of the first to be located was the Eureka group of lode mining claims, which was staked in 1893. In 1895 the owners incorporated under the name of Eureka Mining Company of Anacortes. These claims were situated on the eastern slope of Slate Creek Mountains. Many other veins were located, stamps were brought in, mainly over the eastern route, and operations were started. By this time two more approaches to the camp had been made. From the south it was reached by railroad and wagon road to Marblemount, whence a trail led to the district, a distance of about fifty miles. From the eastern side of the Cascade Mountains it was approached by boat up the Methow River and then by trail over the summit of the mountains.

However, the activity was again doomed to be short lived. It was soon found that the ore was mainly base in character rather than free milling as first supposed. This fact coupled with the lack of transportation facilities caused the activity to cease in 1908. During the first few years of this century the railroads had their attention attracted to the ore showings in the district, but their engineers found the great majority of prospectors searching for free gold, which does not make railroad tonnage; hence no road was constructed into or even toward the district.

In 1915 new locations were made and activity in the district was again renewed, chiefly because it was understood that a railroad was soon to be built. In the early part of 1916 the Methow Valley Railroad was financed, but apparently some-

thing went wrong as it never was constructed. Soon again the district fell into obscurity.

In the last few years operations have again been started and this time, from all appearances, the district will continue to be a producer. The Azurite mine has a road which connects the mine with Twisp in Okanogan County and has recently completed a cyanide mill. The Gold Hill mine should soon have a road under construction, which will connect the mine with the site of the Ruby Dam. The length of this road will be about twenty miles. On the western side of the Cascade Mountains, transportation for the district has been partially realized by the City of Seattle in its Skagit River power development.

TOPOGRAPHY AND GEOGRAPHY

Slate Creek Mining District, situated in the very heart of the higher Cascades, has a very rugged topography. The mountain sides are precipitous and the canyons deep. There are numerous glaciers and consequently an everlasting water supply. The creeks abound with water falls, waiting to be used for the production of power.

The higher peaks rise above the timber line, but in the canyons and to an elevation of about 5000 feet there is an abundance of timber, ample for the demands of the mining industry.

The mountainous and highland areas are deeply cut by valleys that contain strongly flowing streams. These drainage creeks are Ruby Creek, which runs in a southwesterly direction into the Skagit River; Slate Creek, rising along the summit of

the Cascades and running about nine miles west, joining Ruby Creek; Mill Creek about four miles south of Slate Creek, and then Boulder and Granite Creeks, with about four miles between each, all running in a westerly direction into Ruby Creek.

The mountains are Benson Mountain, between the north and middle forks of Slate Creek; Slate Creek Mountains, north of Slate Creek and east of Ruby Creek; Mill Creek Mountains, between Slate and Mill Creeks; Boulder Mountains, between Mill and Boulder Creeks; Granite Mountains, between Boulder and Granite Creeks; and Canyon Mountains west of Ruby Creek. The altitudes of these mountains range from 5000 to 7500 feet above sea level.

The rainfall and snowfall are excessive in the winter months, making travel very difficult if not impossible at times. Snow, either in large amounts or traces, lies on the ground from six to seven months of the year at the higher elevations. However, if proper preparations are made mining operations can be carried on throughout the year as the actual temperatures are not severe.

HISTORICAL GEOLOGY

The geology of this region is complex and a satisfactory explanation of all the factors involved has not yet been offered by any geologist. However, the more salient facts will be pointed out.

The following review of the geological history of the Cascade Mountains in northern Washington is largely based upon the work of I. C. Russell.[5]

The Cascade Range was originally a peneplain, known as the Cascade Plateau. The large masses of granitic rock that today are so prominent in the features of the mountains were intruded beneath this peneplain. The older metamorphics, such as the slates, schists, gneissic granites, and quartzites are remains of this period. Following this period, during the Paleozoic or post-Paleozoic ages, an uplift occurred and dissection by streams, which resulted in the main structural features of the present range. The work of glaciers occurred after the uplift. At present the results of glaciation are shown by the gouged-out valleys and glacial lakes.

PETROLOGY

What is thought to be one of the oldest stratified rocks in the northern Cascades is a series of dark, fine grained slates, which are exposed throughout the district. These slates are but slightly metamorphosed and have the appearance of shales rather than slates. The major cleavage of this formation runs almost north and south. At the eastern end of the district a series of metamorphic rocks is exposed which includes quartzites, schists, and gneisses.

The igneous rocks of the district include masses of extremely hard, compact, and usually gray to black intruded granite, sometimes altered to gneiss. Light granites are also found in the area. Dikes are abundant and probably represent the most recent stages of igneous activity. They usually have an approximately vertical position, are light in color, and for the most part are diorites and syenites.

ORE DEPOSITS

The ore deposits of the district are fissure veins, running usually in an east-west direction. The veins are large, remarkably regular with the exception of those in Slate and Crater Mountains, and for the most part can be traced by their outcrops for long distances; sometimes for several thousand feet. In Slate and Crater Mountains the ore occurs in lenses due to the shifting of the sides of the fissure before the deposition of the minerals. The ore is base, although in parts of the district enough free gold existed to cause the area to be mistaken for a free milling district during the early part of the present century.

Several different ores are represented in the district. North of Boulder Mountains the metal content is chiefly copper, silver, and gold, with some zinc. The characteristic ores, each occurring separately or in association with the others, are bromide or chloride of silver in a copper silicate, pyrrhotite which carries gold in high values, and chalcopyrite. South of Boulder Mountains the metal content is mainly lead, zinc, and silver, with some gold and copper. Most of the veins contain argentiferous galena, sphalerite, and pyrite. The gangue of the vein material consists largely of quartz and calcite.

THE GOLD HILL MINE

PRESENT DEVELOPMENT OF THE MINE

The Gold Hill mining property is not as yet producing. Development has been somewhat hindered by the lack of transportation facilities as all supplies and equipment must be taken in by packhorse. However, Mr. Peterson expects to have a road started in the near future that will connect the mine with the Ruby damsite.

The present development includes a drift driven 1500 feet along the Iron Mountain vein at an elevation of 4757 feet, known as tunnel A, and another drift, known as tunnel B, now being driven on the No-See-Um vein at an elevation of 4337 feet. Tunnel B, which is to be the main operating level, will intersect the Iron Mountain vein at a distance of about 400 feet from its portal.

ORE DEPOSITS

The Gold Hill property contains three main lodes, namely, the Iron Mountain vein, the Genevieve vein, and the Gouge vein, all striking in a north-east to easterly direction. Another lode called the Virginia strikes northward, but it is considerably smaller than the three others. There are also several stringers of varying widths, which for the most part are as well defined on the surface as are the main veins. At present the only main body which has been opened to any extent is in the Iron Mountain vein, ranging in width from two to seven feet. This body is a well defined fissure vein occurring in a

badly altered gray to black granitic rock.

MINERALOGY OF THE IRON MOUNTAIN VEIN

The chief minerals deposited in the Iron Mountain vein are galena, sphalerite, and pyrite, associated with a gangue consisting of quartz and calcite. Other sulfides present in much smaller quantities are chalcopyrite and pyrrhotite. In general pyrite and galena are the most abundant constituents, with sphalerite in excess of chalcopyrite and pyrrhotite.

The pyrite occurs both massive and finely disseminated throughout the gangue in considerable amounts. It also occurs both in euhedral and anhedral forms; this fact coupled with study of the mineral replacements shows that the pyrite was introduced to the vein in two distinct generations, the euhedral first and the anhedral at a later period.

Wall-rock alteration consists of pyritization and the deposition of calcite.

The chief value of the ore lies in the fact that the galena in addition to being argentiferous also carries some gold and it is quite possible that the sphalerite also is slightly argentiferous. No free gold is in evidence, the small amount being in very intimate association with the sulfides; the bulk with the pyrite. Assays of the pyrite show that the gold is associated only with the anhedral or later generation of pyrite.

Oxidation has affected the vein to only a slight extent, the primary minerals extending to within a few feet of the surface. For this reason extensive enrichment at depth could

not be expected.

Due to the minerals and mineral association indicating deposition under conditions of moderate temperature and pressure, pyritization of wall rocks, smooth walls, and fairly regular strike and dip, the vein would be classed as a mesothermal deposit. Also the presence of the high temperature mineral pyrrhotite indicates a low mesothermal vein or some gradation towards hypothermal deposition. In other words, it seems safe to predict that the vein will continue to a good mining depth.

It is probable that the character of the ore will change with depth. Such has been the case in neighboring districts, Monto Cristo being one example. The pyrite and sphalerite will probably increase with depth, with increase in gold and zinc, and a decrease in silver and lead.

PARAGENESIS

The vein consists of quartz replaced and invaded by various sulfides and calcite. The order of origin was first pyrrhotite followed in order by euhedral pyrite, sphalerite, anhedral pyrite, chalcopyrite, calcite, and galena last.

The above order is based on the following facts, determined by the study of various thin sections and polished sections of the ore.

1. Micro-brecciated quartz was replaced and invaded by sulfides and calcite.

2. Sphalerite replaced euhedral pyrite.

3. Anhedral pyrite replaced sphalerite.

4. Chalcopyrite replaced both early and later pyrite.

5. Calcite replaced quartz and itself is not replaced by any mineral except galena.

6. Galena replaced both early and later pyrite, sphalerite, and calcite.

It will be noticed that no mention is made of pyrrhotite in the above list. The reason is that this mineral occurs in such small quantities that no associations could be determined. However, pyrrhotite being a high temperature mineral was very probably introduced with the quartz or soon afterward.

TREATMENT OF THE ORE

ORE FOR TESTS

For use in making flotation tests three lots of ore were secured. The first lot weighing 150 pounds, which will be called lot number one, was secured during the summer of 1936 and the other two lots were secured in April 1937. The two latter lots weighed only approximately 3000 grams each and were received from Mr. Bennetts. These two lots were composed of samples sent to Mr. Bennetts for assaying and were intended to represent a fair sample of the average mine-run ore. One lot was composed of samples from tunnel A, which will be called lot number two, and the other from samples of tunnel B, which will be known as lot number three.

CRUSHING AND GRINDING

All of 150-pound lot of ore was first crushed in a 8 by 6 inch Dodge crusher to a maximum size of three-fourths inch. The second step was to crush the Dodge product in a 3 by 6 inch Sturtevant roll-jaw crusher to a maximum size of three-eighths inch. This product was then crushed in an 8 by 6 inch Sturtevant roll to pass four-mesh. From this product an 1800-gram sample was taken with a Jones splitter; on this sample a screen analysis was run. The ore was cut in two parts with a Jones splitter. One of these halfs was ground in a small rod mill for three hours in final preparation for flotation tests. The size of this final product was 82 percent minus 200-mesh.

The two smaller lots as received were 100 percent minus 60-mesh. These lots were both ground separately in a small ball mill for one and one-half hours. The size of lots numbers two and three after grinding was 87 percent minus 200-mesh and 92 percent through 200-mesh respectively.

TABLE 1.

Screen analysis of lot number one after passing through rolls.

	Mesh	Weight grams	Percent	Cumul. percent
On	6	6.5	0.363	0.363
	8	9.5	0.530	0.89
	10	59.0	3.290	4.18
	14	149.0	8.328	12.50
	20	146.0	8.155	20.66
	28	233.0	13.010	33.67
	35	250.0	13.960	47.63

TABLE 1 (Continued)

Mesh	Weight grams	Percent	Cumul. percent
48	160.0	8.940	56.57
65	101.0	5.640	62.21
80	110.0	6.150	68.36
100	179.0	10.000	78.36
150	69.0	3.850	82.21
200	88.0	4.910	87.12
Thru 200	229.0	12.800	99.92
Total	1789.0	99.923	

TEST PROCEDURE

The properties of this ore are such that the only feasible method of concentration is by the flotation process.

The writer has spent considerable time in making flotation tests on the ore, the object of which has been to determine the reagents that will produce a good recovery of the minerals that contain the important metals in the ore, namely, silver, lead, and zinc. A total of twenty-four tests was made; of this number the best thirteen tests are described herein.

In making flotation tests the usual procedure was to practice selective flotation in a rougher cell, and produce two concentrates. By depressing the sphalerite and pyrite a galena concentrate was first produced. Then followed reactivation and flotation of the sphalerite, leaving the pyrite in the tailing. In a few tests a bulk concentrate was produced.

Fairly good recoveries of galena and its contained silver were obtained, with somewhat lower recoveries of sphalerite in most cases. However, all of these recoveries should easily be

raised with further experimentation.

The grade of the rougher concentrates produced should easily be raised to smelter specifications by one or more cleaning operations.

For the purpose of shortening the descriptions of tests numbers six to thirteen some of the constant factors have been left out. Unless otherwise stated under each test the following data are common to all tests:

The amount of ore used was 500 grams.

The flotation machine used was the Denver Sub-A.

The speed for all periods was constant at 1738 r.p.m.

The pulp dilution used was five to one.

FLOTATION TEST NO. 1

Ore	Lot No. 1
Size	82% minus 200-mesh
Machine	Denver Sub-A, laboratory size
Reagents	Aerofloat #25, American Cyanamid Co.

Mixing period

pH	7.5
Duration	5 minutes
Speed	1475 r.p.m.
Pulp dilution	5 to 1
Reagents	None

Frothing period

Duration	30 minutes
Speed	1475 r.p.m.
Pulp dilution	5 to 1
Reagents	Aerofloat #25

Froth

Character	Elastic
Persistence	High
Texture	Coarse
Quality	Viscous
Mineralization	High

TABLE 2. Results.

Sample	Weight grams	Silver oz/ton	Lead %	Zinc %
Head	500	44.78	12.65	4.36
Concentrate	136	137.46	41.4	10.3
Tailing	364	3.66	1.93	2.18

Ratio of concentration is 3.69 to 1.

Percent recovery

Silver	94.5%
Lead	88.4%
Zinc	63.5%

FLOTATION TEST NO. 2

Ore Lot No. 1.

Size 82% minus 200-mesh

Machine Denver Sub-A, laboratory size

Reagents

Coal tar creosote
Cresylic acid, G.N.S., no. 29.
Pine oil, Yarmor "P" S.D.

Mixing period

pH	7.4
Duration	5 minutes
Speed	1475 r.p.m.
Pulp dilution	3 to 1
Reagents	Coal tar creosote, 0.2 lb./ton

Frothing period

Duration	25 minutes
Speed	1475 r.p.m.
Reagents	
	Cresylic acid, 0.25 lb./ton
	Pine oil, 0.15 lb./ton
Froth	
Character	Effervescent
Persistence	Low
Texture	Coarse
Quality	Tender
Mineralization	Heavy

TABLE 3. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	44.78	12.65	4.36
Concentrate	91	214.8	49.7	11.2
Tailing	409	4.82	4.46	2.78

Ratio of concentration is 5.52 to 1

Percent Recovery

Silver	90.1%
Lead	71.5%
Zinc	46.8%

FLOTATION TEST NO. 3

Ore — Lot No. 1.

Size — 82% minus 200-mesh

Machine — Denver Sub-A, laboratory size

Reagents

Coal tar creosote
Sodium Aerofloat, American Cyanamid Co.
Pine oil, Yarmor "P" S.D.
Cresylic acid, G.N.S. no. 29.

Mixing period

pH	7.2
Duration	5 minutes
Speed	1475 r.p.m.
Pulp dilution	5 to 1
Reagents	
	Coal tar creosote, 0.2 lb./ton
	Sodium Aerofloat, 0.2 lb./ton

Frothing period

Duration	25 minutes
Speed	1475 r.p.m.
Reagents	
	Pine oil, 0.15 lb./ton
	Cresylic acid, 0.25 lb./ton

Froth

Character	Effervescent
Persistence	Low
Texture	Coarse
Quality	Tender
Mineralization	Heavy

TABLE 4. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	44.78	12.65	4.36
Concentrate	99	208.24	46.5	13.4
Tailing	401	3.96	4.24	2.09

Ratio of concentration is 5.01 to 1

Percent Recovery

Silver	92.6%
Lead	74.5%
Zinc	75.8%

FLOTATION TEST NO. 4

Ore — Lot No. 1

Size — 82% minus 200-mesh

Machine — Denver Sub-A, laboratory size

Reagents

Reagent #301, American Cyanamid Co.
Sodium aerofloat, American Cyanamid Co.
Aerofloat #25, American Cyanamid Co.

Mixing period

Duration — 5 minutes
Speed — 1475 r.p.m.
Pulp dilution — 5 to 1
Reagents — Reagent #301, 0.2 lb./ ton
Sodium aerofloat, 0.2 lb./ton

Frothing period

Duration — 23 minutes
Speed — 1475 r.p.m.
Reagents — Aerofloat #25, 0.2 lb./ ton
Froth

Character	Elastic
Persistence	High
Texture	Even
Quality	Viscous
Mineralization	Heavy

TABLE 5. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	44.78	12.65	4.36
Concentrate	136	151.36	41.32	13.12
Tailing	364	2.73	2.05	1.1

Ratio of concentration is 3.9 to 1

Percent recovery

Silver	95.4%
Lead	88.7%
Zinc	81.6%

FLOTATION TEST NO. 5

Ore Lot No. 1

Size 82% minus 200-mesh

Machine Denver Sub-A, laboratory size

Reagents

Reagent #301, American Cyanamid Co.
Lime
Sodium aerofloat, American Cyanamid Co.
Barretts No. 4.

Mixing period

Duration	5 minutes
Speed	1475 r.p.m.
Pulp dilution	5 to 1
Reagents	Reagent #301, 0.2 lb/.ton Sodium aerofloat, 0.2 lb./ton Lime, 1.8 lb./ton

Frothing period

Duration	22 minutes
Speed	1475 r.p.m.
Reagents	Barretts no. 4., 0.25 lb./ton
Froth	Character: Elastic Persistence: High Texture: Even Quality: Tender Mineralization: Heavy

TABLE 6. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	44.78	12.65	4.36
Concentrate	104	196.47	52.7	14.38
Tailing	396	3.27	2.03	1.79

Ratio of concentration is 4.77 to 1

Percent recovery

Silver	94.1%
Lead	86.7%
Zinc	71.8%

FLOTATION TEST NO. 6

Ore	Lot no. 1.	
Size	82% minus 200-mesh	
Mixing period	Duration	10 minutes
	Reagents	NaCN, 0.3 lb./ton $ZnSO_4$, 0.0 lb./ton
Frothing period		
	Duration	23 minutes
	Reagents	Aerofloat #25, 0.2 lb./ton
Conditioning period		
	Duration	10 minutes
	Reagents	$CuSO_4$, 2.5 lb./ton
Frothing period		
	Duration	19 minutes
	Reagents	Aerofloat #25, 0.15 lb./ton

Froth

	Lead concn.	Zinc concn.
Character	Elastic	Elastic
Persistence	High	Medium
Texture	Coarse	Fine
Quality	Viscous	Tender
Mineralization	Heavy	Medium

TABLE 7. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	750	44.78	12.65	4.36
Pb concentrate	174	142.31	43.4	3.6
Zn concentrate	63	22.64	6.5	28.2
Tailing	508	2.95	2.48	1.79

Ratio of concentration

Lead concentrate	4.01
Zinc concentrate	9.93

Percent recovery

Silver	78.4%
Lead	84.4%
Zinc	78.2%

FLOTATION TEST NO. 7

Ore — Lot no. 2

Size — 87% minus 200-mesh

Mixing period

Duration — 10 minutes

Reagents

NaCN, 0.3 lb./ton
$ZnSO_4$, 0.9 lb./ton
Reagent #301, 0.2 lb./ton

Frothing period

Duration — 16 minutes

Reagents

Cresylic acid, 0.3 lb./ton
Pine oil, 0.05 lb./ton

Conditioning period

Duration — 10 minutes

Reagents

$CuSO_4$, 1.5 lb./ton
Sodium aerofloat, 0.2 lb./ton

Frothing period

Duration — 15 minutes

Reagents

Cresylic acid, 0.2 lb./ton
Pine oil, 0.05 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Effervescent	Elastic
Persistence	Medium	Medium
Texture	Uneven	Uneven
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 8. Results

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	17.01	8.34	7.9
Pb concentrate	79	88.43	49.6	6.4
Zn concentrate	64	18.56	3.42	36.84
Tailing	364	0.98	1.38	3.2

Ratio of concentration

Lead concentrate	6.92
Zinc concentrate	7.16

Percent recovery

Silver	95.6%
Lead	88.1%
Zinc	70.6%

FLOTATION TEST NO. 8

Ore — Lot no. 2

Mixing period

Duration — 5 minutes

Reagents

NaCN, 0.3 lb./ton
$ZnSO_4$ 0.9 lb./ton
Na_2S, 0.2 lb./ton
Reagent #301, 0.2 lb./ton

Frothing period

Duration — 21 minutes

Reagents

Barretts no. 4, 0.2 lb./ton
Cresylic acid, 0.2 lb./ton

Conditioning period

Duration — 10 minutes

Reagents

$CuSO_4$, 1.5 lb./ton
Sodium aerofloat, 0.2 lb./ton
Lime, 2 lb./ton

Frothing period

Duration — 11 minutes

Reagents — Cresylic acid, 0.25 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Elastic	Elastic
Persistence	High	High
Texture	Coarse	Uneven
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 9. Results

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	17.01	8.34	7.9
Pb concentrate	78	89.69	48.47	7.3
Zn concentrate	56	20.37	3.31	37.67
Tailing	366	1.08	1.36	3.56

Ratio of concentration

Lead concentrate	6.75
Zinc concentrate	7.8

Percent recovery

Silver	95.1%
Lead	88.0%
Zinc	67.2%

PLOTATION TEST NO. 9

Ore Lot no. 2

Mixing period

Duration 5 minutes
Reagents

NaCN, 0.3 lb./ton
$ZnSO_4$, 0.9 lb./ton
Coal tar creosote, 0.25 lb./ton

Frothing period

Duration 22 minutes
Reagents Barretts no. 4., 0.35 lb./ton

Conditioning period

Duration 10 minutes
Reagents $CuSO_4$, 1.5 lb./ton

Frothing period

Duration 17 minutes
Reagents Barretts no. 4, 0.2 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Elastic	Elastic
Persistence	High	Medium
Texture	Coarse	Even
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 10. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	17.01	8.34	7.9
Pb concentrate	71	100.48	45.68	4.18
Zn concentrate	67	12.73	3.82	30.82
Tailing	362	1.36	1.86	4.59

Ratio of concentration

Lead concentrate	6.76
Zinc concentrate	7.92

Percent recovery

Silver	94.05%
Lead	86.20%
Zinc	58.00%

FLOTATION TEST NO. 10

Ore Lot no. 2

Mixing period

Duration 10 minutes
Reagents

NaCN, 0.3 lb./ton
$ZnSO_4$, 0.9 lb./ton
Reagent #301, 0.2 lb./ton
$NaSiO_2$, 0.5 lb./ton

Frothing period

Duration 19 minutes
Reagents

Cresylic acid, 0.2 lb./ton
Aerofloat #25, 0.05 lb./ton

Conditioning period

Duration 10 minutes
Reagents

$CuSO_4$, 1.5 lb./ton
Sodium aerofloat, 0.2 lb./ton
Lime, 1.8 lb./ton

Frothing period

Duration 18 minutes
Reagents

Cresylic acid, 0.2 lb./ton
Barretts no. 4, 0.1 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Elastic	Elastic
Persistence	High	Medium
Texture	Uneven	Even
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 11. Results

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	17.01	8.34	7.90
Pb concentrate	74	104.30	48.36	6.15
Zn concentrate	59	10.14	3.25	34.40
Tailing	367	0.83	1.16	3.87

Ratio of concentration

Lead concentrate	6.57
Zinc concentrate	7.52

Percent recovery

Silver	96.50%
Lead	89.75%
Zinc	64.10%

FLOTATION TEST NO. 11

Ore — Lot no. 3

Mixing period

Duration — 5 minutes

Reagents

NaCN, 0.2 lb./ton
$ZnSO_4$, 0.6 lb./ton
Reagent #301, 0.1 lb./ton
Amyl Zanthate, 0.1 lb./ton

Frothing period

Duration — 16 minutes

Reagents

Barretts no. 4, 0.2 lb./ton
Pine oil, 0.05 lb./ton

Conditioning period

Duration — 10 minutes

Reagents

$CuSO_4$, 1.5 lb./ton
Sodium aerofloat, 0.2 lb./ton

Frothing period

Duration — 14 minutes

Reagents — Barretts no. 4, 0.2 lb./ton

Froth

	Lead concn.	Zinc concn.
Character	Elastic	Elastic
Persistence	Medium	Medium
Texture	Uneven	Even
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 12. Results

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	10.22	5.75	3.30
Pb concentrate	51	88.16	47.82	3.64
Zn concentrate	32	9.95	3.17	32.52
Tailing	417	0.86	0.91	1.02

Ratio of concentration

Lead concentrate	9.7
Zinc concentrate	14.2

Percent recovery

Silver	99.10%
Lead	86.80%
Zinc	73.00%

FLOTATION TEST NO. 12

Ore Lot no. 3

Mixing period

Duration 5 minutes

Reagents

NaCN, 0.2 lb./ton
$ZnSO_4$, 0.6 lb./ton
Reagent #301, 0.1 lb./ton
$NaSiO_2$, 0.5 lb./ton

Frothing period

Duration 15 minutes

Reagents

Aerofloat #25, 0.1 lb./ton
Pine oil, 0.15 lb./ton

Conditioning Period

Duration 10 minutes

Reagents

$CuSO_4$, 1.5 lb./ton
Sodium aerofloat, 0.2 lb./ton
Lime, 1.5 lb./ton

Frothing period

Duration 12 minutes

Reagents Cresylic acid, 0.2 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Elastic	Elastic
Persistence	Medium	Medium
Texture	Uneven	Even
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 13. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	10.22	5.75	5.30
Pb concentrate	58	68.63	41.46	0.62
Zn concentrate	38	25.48	4.75	39.70
Tailings	413	0.64	0.73	0.65

Ratio of concentration

Lead concentrate	8.11
Zinc concentrate	14.70

Percent recovery

Silver	92.95%
Lead	89.48%
Zinc	83.51%

FLOTATION TEST NO. 13

Ore Lot no. 3

Mixing period

Duration 5 minutes
Reagents

$NaCN$, 0.2 lb./ton
$ZnSO_4$, 0.6 lb./ton
Reagent #301, 0.2 lb./ton
$NaSiO_2$, 0.5 lb./ton

Frothing period

Duration 16 minutes
Reagents

Barretts no. 4, 0.2 lb./ton
Aerofloat #25, 0.05 lb./ton

Conditioning period

Duration 10 minutes
Reagents

$CuSO_4$, 2 lb./ton
Lime, 1.5 lb./ton
Sodium aerofloat, 0.2 lb./ton

Frothing period

Duration 13 minutes
Reagents Cresylic acid, 0.25 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Elastic	Elastic
Persistence	High	High
Texture	Uneven	Even
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 14. Results

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	10.22	5.75	3.30
Pb concentrate	49	83.66	48.62	3.56
Zn concentrate	31	22.49	4.65	40.51
Tailings	420	0.84	0.81	0.53

Ratio of concentration

Lead concentrate	9.69
Zinc concentrate	14.40

Percent recovery

Silver	91.10%
Lead	88.25%
Zinc	86.40%

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CONCLUSIONS

The Gold Hill mine in southeastern Whatcom County is still in the development stage largely owing to its location high in the Cascade Range, at a distance of about seventeen miles by trail from the Ruby damsite on the Skagit River.

The Gold Hill property contains three principal veins, of which only one has been opened to any extent. This one is a well defined fissure vein of mesothermal deposition. The ore consists largely of galena, sphalerite, and pyrite in a gangue of quartz and calcite.

The characteristics of the ore, as determined by the writer's study, are such that it seemed unnecessary to attempt concentration by any method other than the flotation process. A total of twenty-four flotation tests were made by the writer, from which the following conclusions have been drawn:

1. The logical method of flotation procedure is first to produce a galena concentrate by depressing the sphalerite and pyrite. Then following this, reactivate and float the sphalerite, leaving the pyrite in the tailing. By this method fairly good recoveries of galena and its contained silver were obtained, with somewhat lower recovery of sphalerite in most cases.

2. Some of the gold is obtained in the galena concentrate, but the bulk will remain in the tailing, due to the intimate association of most of the gold with the pyrite. A pyrite

concentrate could be obtained but unless the gold content of the ore increases somewhat with depth, such a procedure would not pay for itself.

3. Some silver occurs with the sphalerite. To save this silver as well as the silver occurring with the galena in the zinc concentrate, it will be necessary to send the concentrate to a hydrometallurgical plant.

4. It is the writer's belief that further experimentation will produce better recoveries of all the metals and also raise the ratios of concentration. Using one of the foregoing fairly successful tests, the results should be improved by careful control of the pH value, finer grinding, changes in the grinding conditions, in the place of addition of reagents, and in the amount of aeration. Testing with other reagents may also produce better results.

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These pages cover a discussion on the flotation of sulfide lead and zinc ores.

10. Weinig, A. J. and L. A. Palmer, The trend of flotation. Colo. School of Mines Quarterly, vol. 24, no. 4, Oct., 1929, pp. 1-150.

This book gives a brief description of the flotation process. It describes at considerable length the practice employed at many of the important mills in the United States and Canada.

Food Costs

Labor, 12 man weeks @ $40.00		$ 480.00
Cook, 4 man weeks		160.00
Supervisory, 8 man weeks @ $40.00		320.00
		$ 960.00
Office expenses		$ 700.00

Drilling (see Figs. 1 and 2)

Footage, 1380 feet @ $8.00		$11,040.00
Supervisory-consulting	$1200.00	
Cook	500.00	
Food	650.00	
Tpn. service	500.00	
Miscellaneous	150.00	
Office	300.00	
	$3300.00	3,300.00
Total Drilling -		$14,340.00
Total Estimated Cost of Phase No. 1		$25,915.00

90' from portal — Checked against the typed — B. Turner

(Lower Adit)

"Gold Hill" Property — Computations of Assay Averages — by [illegible]

Sample No.	Influence Length	Width	Sq. Ft.	% Pb	Oz. Ag.	Soft. % Pb	Sq. Ft. Oz.
1	16'	6'	96	0.14	10.20	13.44	979.2
2	16'	7'	112	3.16	9.20	353.92	1030.4
3	9'	6'	54	7.76	21.63	419.04	1168.0
4	6.5'	3'	19.5	7.49	11.78	146.06	229.7
5	4'	5'	20	8.11	18.35	162.20	367.0
6 & 7	2.5'	8'	20	11.92	28.86	238.40	577.2
8	3.5'	6'	21	7.14	20.78	149.94	436.4
9	5'	6'	30	3.28	9.66	98.40	289.8
10	5'	6'	30	6.62	17.79	198.60	533.7
11	5'	5'	25	7.51	18.71	187.75	467.8
12	5'	6'	30	9.17	43.12	275.10	1293.6
13	5'	5.5'	27.5	2.55	40.98	70.13	1126.9
14	5'	6'	30	0.40	44.77	12.00	1343.1
15	7.5'	6'	45	6.21	81.96	279.45	3688.2
16	10'	5'	50	3.75	20.50	187.50	1025.0
17	10'	5'	50	4.91	26.87	245.50	1343.5
18	10'	4.5'	45	9.61	27.20	432.45	1224.0
19	10'	6'	60	6.03	19.87	361.80	1192.2
20	10'	5.5'	55	0.28	0.18	15.40	9.9
21	10'	6'	50	4.54	20.39	272.40	1223.4
22	10'	5'	50	1.17	7.91	58.50	395.5
23	10'	5'	60	2.63	9.89	131.50	494.5
24	10'	4.5'	45	3.32	14.17	149.40	637.6
25	10'	5'	50	4.70	18.21	235.00	910.5
26	10'	4'	40	5.59	18.91	223.60	756.4
		137'	1115			4917.48%	22,743.5

Ave. Oz. Ag/T = 20.40 — Ave. Width = 5.5'

Checked with Mine Map of Workings (Map) and 1963 [illegible]

225' from Portal

TREATMENT OF A GOLD-SILVER-LEAD-ZINC ORE FROM THE GOLD HILL MINE, WHATCOM COUNTY

by

CLIFFORD THEODORE SYLLIAASEN

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A thesis submitted for the degree of

BACHELOR OF SCIENCE IN

MINING AND METALLURGICAL ENGINEERING

UNIVERSITY OF WASHINGTON

1937

317962

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TREATMENT OF A GOLD-SILVER-LEAD-ZINC ORE FROM THE GOLD HILL MINE WHATCOM COUNTY

INTRODUCTION

OBJECT

In the summer of 1936 while employed by the Seattle Light Department at the Diable Power House, the writer became acquainted with Mr. August Petersen, manager of the Gold Hill Operating Company, and obtained his permission to visit the company's property in eastern Whatcom County for the purpose of gathering material for this thesis.

The Gold Hill mine was visited for three days in the last week of September, 1936. During the stay at the mine various specimens were obtained which have been used in making a study of the petrology of the vicinity and the mineralogy of the Iron Mountain vein. The writer also obtained a lot of ore weighing 150 pounds. This ore has been used in fulfilling an important object of the thesis, which is to find a suitable method of concentrating the ore from the Iron Mountain vein by flotation.

ACKNOWLEDGMENTS

This thesis is made possible by the cooperation and assistance of certain men to whom the writer owes a debt of gratti-

tude; to Dean Wilnor Roberts, of the College of Mines, for his suggestions, criticism, and assistance in the preparation of this paper; to Mr. Peterson for his encouragement and placement of mine facilities at the writer's disposal; to Mr. Olav Drange, the mine foreman, for his very able cooperation during the writer's stay at the mine; and to Mr. B. N. Bennetts, of Bennetts' Chemical Laboratory, Tacoma, for the maps and ore that the writer received from him.

LOCATION OF THE GOLD HILL MINE

The Gold Hill mine is situated at an elevation of approximately 4500 feet on the western slope of the Cascade Mountains, three miles from the divide and twenty-three miles south of the International Boundary. The claims are all in section 30, township 36 north, range 17 east. This location lies in the Slate Creek Mining District, which is within the Mount Baker National Forest.

At present the only means of reaching the mine is by trail. The region is approached from the Puget Sound side by the Rockport branch of the Northern Pacific Railroad from Burlington in Skagit County. From Burlington the route up the Skagit Valley to Rockport is thirty-six miles by train and about the same by highway. From Rockport a railroad owned and operated by the Light Department of the City of Seattle extends up the Skagit Valley about thirty miles to Diable at the dam of that name. Boats on Diable Lake make one or more trips

daily across the lake and up the Skagit River six miles to the Ruby damsite just below the junction of Ruby Creek with Skagit River. From the Ruby damsite a trail leads to the Gold Hill mine, a distance of approximately seventeen miles.

The district can also be approached from the east side of the Cascade Mountains. From Ventura in Okanogan County, an automobile road leads to Barron in Whatcom County, which is connected to the Azurite Mine by a tractor road. The Gold Hill mine can be reached by trail from the Azurite mine.

SLATE CREEK MINING DISTRICT

HISTORY OF THE DISTRICT

The first discoveries in the Slate Creek District were made in the late seventies by a man named Rowley.[2] During the first season about 2500 men went into the area and over $100,000 in gold dust was taken out. The camp was short lived, however, because the placer ground was limited, the cost of reaching the district was enormous, and the trip was extremely hazardous. At that time the only approach to the district was from British Columbia.

After the district had been abandoned for about twelve years prospectors again went in. Not succeeding at mining placer gold they turned to prospecting for veins. Pressing south, near the source of Slate Creek they found gold in the creek that carried particles of quartz. Since outcrops do not exist in that vicinity the men started to dig. As a result

several veins were located, some of which were fairly rich. One of the first to be located was the Eureka group of lode mining claims, which was staked in 1893. In 1895 the owners incorporated under the name of Eureka Mining Company of Anacortes. These claims were situated on the eastern slope of Slate Creek Mountains. Many other veins were located, stamps were brought in, mainly over the eastern route, and operations were started. By this time two more approaches to the camp had been made. From the south it was reached by railroad and wagon road to Marblemount, whence a trail led to the district, a distance of about fifty miles. From the eastern side of the Cascade Mountains it was approached by boat up the Methow River and then by trail over the summit of the mountains.

However, the activity was again deemed to be short lived. It was soon found that the ore was mainly base in character rather than free milling as first supposed. This fact coupled with the lack of transportation facilities caused the activity to cease in 1908. During the first few years of this century the railroads had their attention attracted to the ore showings in the district, but their engineers found the great majority of prospectors searching for free gold, which does not make railroad tonnage; hence no road was constructed into or even toward the district.

In 1915 new locations were made and activity in the district was again renewed, chiefly because it was understood that a railroad was soon to be built. In the early part of 1916 the Methow Valley Railroad was financed, but apparently some-

thing went wrong as it never was constructed. Soon again the district fell into obscurity.

In the last few years operations have again been started and this time, from all appearances, the district will continue to be a producer. The Azurite mine has a road which connects the mine with Twisp in Okanogan County and has recently completed a cyanide mill. The Gold Hill mine should soon have a road under construction, which will connect the mine with the site of the Ruby Dam. The length of this road will be about twenty miles. On the western side of the Cascade Mountains, transportation for the district has been partially realized by the City of Seattle in its Skagit River power development.

TOPOGRAPHY AND GEOGRAPHY

Slate Creek Mining District, situated in the very heart of the higher Cascades, has a very rugged topography. The mountain sides are precipitous and the canyons deep. There are numerous glaciers and consequently an everlasting water supply. The creeks abound with water falls, waiting to be used for the production of power.

The higher peaks rise above the timber line, but in the canyons and to an elevation of about 5000 feet there is an abundance of timber, ample for the demands of the mining industry.

The mountainous and highland areas are deeply cut by valleys that contain strongly flowing streams. These drainage creeks are Ruby Creek, which runs in a southwesterly direction into the Skagit River; Slate Creek, rising along the summit of

the Cascades and running about nine miles west, joining Ruby Creek; Mill Creek about four miles south of Slate Creek, and then Boulder and Granite Creeks, with about four miles between each, all running in a westerly direction into Ruby Creek.

The mountains are Benson Mountain, between the north and middle forks of Slate Creek; Slate Creek Mountains, north of Slate Creek and east of Ruby Creek; Mill Creek Mountains, between Slate and Mill Creeks; Boulder Mountains, between Mill and Boulder Creeks; Granite Mountains, between Boulder and Granite Creeks; and Canyon Mountains west of Ruby Creek. The altitudes of these mountains range from 5000 to 7500 feet above sea level.

The rainfall and snowfall are excessive in the winter months, making travel very difficult if not impossible at times. Snow, either in large amounts or traces, lies on the ground from six to seven months of the year at the higher elevations. However, if proper preparations are made mining operations can be carried on throughout the year as the actual temperatures are not severe.

HISTORICAL GEOLOGY

The geology of this region is complex and a satisfactory explanation of all the factors involved has not yet been offered by any geologist. However, the more salient facts will be pointed out.

The following review of the geological history of the Cascade Mountains in northern Washington is largely based upon the work of I. C. Russell.[5]

The Cascade Range was originally a peneplain, known as the Cascade Plateau. The large masses of granitic rock that today are so prominent in the features of the mountains were intruded beneath this peneplain. The older metamorphics, such as the slates, schists, gneissic granites, and quartzites are remains of this period. Following this period, during the Paleozoic or post-Paleozoic ages, an uplift occurred and dissection by streams, which resulted in the main structural features of the present range. The work of glaciers occurred after the uplift. At present the results of glaciation are shown by the gouged-out valleys and glacial lakes.

PETROLOGY

What is thought to be one of the oldest stratified rocks in the northern Cascades is a series of dark, fine grained slates, which are exposed throughout the district. These slates are but slightly metamorphosed and have the appearance of shales rather than slates. The major cleavage of this formation runs almost north and south. At the eastern end of the district a series of metamorphic rocks is exposed which includes quartzites, schists, and gneisses.

The igneous rocks of the district include masses of extremely hard, compact, and usually grey to black intruded granite, sometimes altered to gneiss. Light granites are also found in the area. Dikes are abundant and probably represent the most recent stages of igneous activity. They usually have an approximately vertical position, are light in color, and for the most part are diorites and syenites.

ORE DEPOSITS

The ore deposits of the district are fissure veins, running usually in an east-west direction. The veins are large, remarkably regular with the exception of those in Slate and Crater Mountains, and for the most part can be traced by their outcrops for long distances; sometimes for several thousand feet. In Slate and Crater Mountains the ore occurs in lenses due to the shifting of the sides of the fissure before the deposition of the minerals. The ore is base, although in parts of the district enough free gold existed to cause the area to be mistaken for a free milling district during the early part of the present century.

Several different ores are represented in the district. North of Boulder Mountains the metal content is chiefly copper, silver, and gold, with some zinc. The characteristic ores, each occurring separately or in association with the others, are bromide or chloride of silver in a copper silicate, pyrrhotite which carries gold in high values, and chalcopyrite. South of Boulder Mountains the metal content is mainly lead, zinc, and silver, with some gold and copper. Most of the veins contain argentiferous galena, sphalerite, and pyrite. The gangue of the vein material consists largely of quartz and calcite.

THE GOLD HILL MINE

PRESENT DEVELOPMENT OF THE MINE

The Gold Hill mining property is not as yet producing. Development has been somewhat hindered by the lack of transportation facilities as all supplies and equipment must be taken in by packhorse. However, Mr. Peterson expects to have a road started in the near future that will connect the mine with the Ruby damsite.

The present development includes a drift driven 1500 feet along the Iron Mountain vein at an elevation of 4757 feet, known as tunnel A, and another drift, known as tunnel B, now being driven on the No-See-Um vein at an elevation of 4337 feet. Tunnel B, which is to be the main operating level, will intersect the Iron Mountain vein at a distance of about 400 feet from its portal.

ORE DEPOSITS

The Gold Hill property contains three main lodes, namely, the Iron Mountain vein, the Genevieve vein, and the Gouge vein, all striking in a north-east to easterly direction. Another lode called the Virginia strikes northward, but it is considerably smaller than the three others. There are also several stringers of varying widths, which for the most part are as well defined on the surface as are the main veins. At present the only main body which has been opened to any extent is in the Iron Mountain vein, ranging in width from two to seven feet. This body is a well defined fissure vein occurring in a

badly altered gray to black granitic rock.

MINERALOGY OF THE IRON MOUNTAIN VEIN

The chief minerals deposited in the Iron Mountain vein are galena, sphalerite, and pyrite, associated with a gangue consisting of quartz and calcite. Other sulfides present in much smaller quantities are chalcopyrite and pyrrhotite. In general pyrite and galena are the most abundant constituents, with sphalerite in excess of chalcopyrite and pyrrhotite.

The pyrite occurs both massive and finely disseminated throughout the gangue in considerable amounts. It also occurs both in euhedral and anhedral forms; this fact coupled with study of the mineral replacements shows that the pyrite was introduced to the vein in two distinct generations, the euhedral first and the anhedral at a later period.

Wall-rock alteration consists of pyritization and the deposition of calcite.

The chief value of the ore lies in the fact that the galena in addition to being argentiferous also carries some gold and it is quite possible that the sphalerite also is slightly argentiferous. No free gold is in evidence, the small amount being in very intimate association with the sulfides; the bulk with the pyrite. Assays of the pyrite show that the gold is associated only with the anhedral or later generation of pyrite.

Oxidation has affected the vein to only a slight extent, the primary minerals extending to within a few feet of the surface. For this reason extensive enrichment at depth could

not be expected.

Due to the minerals and mineral association indicating deposition under conditions of moderate temperature and pressure, pyritization of wall rocks, smooth walls, and fairly regular strike and dip, the vein would be classed as a mesothermal deposit. Also the presence of the high temperature mineral pyrrhotite indicates a low mesothermal vein or some gradation towards hypothermal deposition. In other words, it seems safe to predict that the vein will continue to a good mining depth.

It is probable that the character of the ore will change with depth. Such has been the case in neighboring districts, Monto Cristo being one example. The pyrite and sphalerite will probably increase with depth, with increase in gold and zinc, and a decrease in silver and lead.

PARAGENESIS

The vein consists of quartz replaced and invaded by various sulfides and calcite. The order of origin was first pyrrhotite followed in order by euhedral pyrite, sphalerite, anhedral pyrite, chalcopyrite, calcite, and galena last.

The above order is based on the following facts, determined by the study of various thin sections and polished sections of the ore.

1. Micro-brecciated quartz was replaced and invaded by sulfides and calcite.

2. Sphalerite replaced euhedral pyrite.

3. Anhedral pyrite replaced sphalerite.

4. Chalcopyrite replaced both early and later pyrite.

5. Calcite replaced quartz and itself is not replaced by any mineral except galena.

6. Galena replaced both early and later pyrite, sphalerite, and calcite.

It will be noticed that no mention is made of pyrrhotite in the above list. The reason is that this mineral occurs in such small quantities that no associations could be determined. However, pyrrhotite being a high temperature mineral was very probably introduced with the quartz or soon afterward.

TREATMENT OF THE ORE

ORE FOR TESTS

For use in making flotation tests three lots of ore were secured. The first lot weighing 150 pounds, which will be called lot number one, was secured during the summer of 1936 and the other two lots were secured in April 1937. The two latter lots weighed only approximately 3000 grams each and were received from Mr. Bennetts. These two lots were composed of samples sent to Mr. Bennetts for assaying and were intended to represent a fair sample of the average mine-run ore. One lot was composed of samples from tunnel A, which will be called lot number two, and the other from samples of tunnel B, which will be known as lot number three.

CRUSHING AND GRINDING

All of 150-pound lot of ore was first crushed in a 5 by 8 inch Dodge crusher to a maximum size of three-fourths inch. The second step was to crush the Dodge product in a 3 by 6 inch Sturtevant roll-jaw crusher to a maximum size of three-eighths inch. This product was then crushed in an 8 by 5 inch Sturtevant roll to pass four-mesh. From this product an 1800-gram sample was taken with a Jones splitter; on this sample a screen analysis was run. The ore was cut in two parts with a Jones splitter. One of these halfs was ground in a small rod mill for three hours in final preparation for flotation tests. The size of this final product was 82 percent minus 200-mesh.

The two smaller lots as received were 100 percent minus 60-mesh. These lots were both ground separately in a small ball mill for one and one-half hours. The size of lots numbers two and three after grinding was 87 percent minus 200-mesh and 92 percent through 200-mesh respectively.

TABLE 1.

Screen analysis of lot number one after passing through rolls.

	Mesh	Weight grams	Percent	Cumul. percent
On	6	6.5	0.363	0.363
	8	9.5	0.530	0.89
	10	59.0	3.290	4.18
	14	149.0	8.325	12.50
	20	146.0	8.155	20.66
	28	233.0	13.010	33.67
	35	250.0	13.960	47.63

TABLE 1 (Continued)

Mesh	Weight grams	Percent	Cumul. percent
48	160.0	8.940	56.57
65	101.0	5.640	62.21
80	110.0	6.150	68.36
100	179.0	10.000	78.36
150	69.0	3.850	82.21
200	83.0	4.910	87.12
Thru 200	229.0	12.800	99.92
Total	1789.0	99.923	

TEST PROCEDURE

The properties of this ore are such that the only feasible method of concentration is by the flotation process.

The writer has spent considerable time in making flotation tests on the ore, the object of which has been to determine the reagents that will produce a good recovery of the minerals that contain the important metals in the ore, namely, silver, lead, and zinc. A total of twenty-four tests was made; of this number the best thirteen tests are described herein.

In making flotation tests the usual procedure was to practice selective flotation in a rougher cell, and produce two concentrates. By depressing the sphalerite and pyrite a galena concentrate was first produced. Then followed reactivation and flotation of the sphalerite, leaving the pyrite in the tailing. In a few tests a bulk concentrate was produced.

Fairly good recoveries of galena and its contained silver were obtained, with somewhat lower recoveries of sphalerite in most cases. However, all of these recoveries should easily be

raised with further experimentation.

The grade of the rougher concentrates produced should easily be raised to smelter specifications by one or more cleaning operations.

For the purpose of shortening the descriptions of tests numbers six to thirteen some of the constant factors have been left out. Unless otherwise stated under each test the following data are common to all tests:

The amount of ore used was 500 grams.

The flotation machine used was the Denver Sub-A.

The speed for all periods was constant at 1758 r.p.m.

The pulp dilution used was five to one.

FLOTATION TEST NO. 1

Ore — Lot No. 1

Size — 82% minus 200-mesh

Machine — Denver Sub-A, laboratory size

Reagents

Aerofloat #25, American Cyanamid Co.

Mixing period

pH	7.5
Duration	5 minutes
Speed	1475 r.p.m.
Pulp dilution	5 to 1
Reagents	None

Frothing period

Duration	30 minutes
Speed	1475 r.p.m.
Pulp dilution	5 to 1
Reagents	Aerofloat #25

Froth

Character	Elastic
Persistence	High
Texture	Coarse
Quality	Viscous
Mineralization	High

TABLE 2. Results.

Sample	Weight grams	Silver oz/ton	Lead %	Zinc %
Head	500	44.78	12.65	4.36
Concentrate	136	137.46	41.4	10.3
Tailing	364	3.66	1.93	2.18

Ratio of concentration is 3.69 to 1.

Percent recovery

Silver	94.5%
Lead	88.4%
Zinc	63.5%

FLOTATION TEST NO. 2

Ore — Lot No. 1.

Size — 82% minus 200-mesh

Machine — Denver Sub-A, laboratory size

Reagents

Coal tar creosote
Cresylic acid, G.N.S., no. 29.
Pine oil, Yarmor "P" S.D.

Mixing period

pH	7.4
Duration	5 minutes
Speed	1475 r.p.m.
Pulp dilution	3 to 1
Reagents	Coal tar creosote, 0.2 lb./ton

Frothing period

Duration	25 minutes
Speed	1475 r.p.m.
Reagents	
	Cresylic acid, 0.25 lb./ton
	Pine oil, 0.15 lb./ton
Froth	
Character	Effervescent
Persistence	Low
Texture	Coarse
Quality	Tender
Mineralization	Heavy

TABLE 3. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	44.78	12.65	4.56
Concentrate	91	214.8	49.7	11.2
Tailing	409	4.82	4.46	2.78

Ratio of concentration is 5.52 to 1

Percent Recovery

Silver	90.1%
Lead	71.5%
Zinc	46.8%

FLOTATION TEST NO. 3

Ore — Lot No. 1.

Size — 82% minus 200-mesh

Machine — Denver Sub-A, laboratory size

Reagents

Coal tar creosote
Sodium Aerofloat, American Cyanamid Co.
Pine oil, Yarmor "F" S.D.
Cresylic acid, G.N.S. no. 29.

Mixing period

pH	7.2
Duration	5 minutes
Speed	1475 r.p.m.
Pulp dilution	5 to 1
Reagents	
	Coal tar creosote, 0.2 lb./ton
	Sodium Aerofloat, 0.2 lb./ton

Frothing period

Duration	25 minutes
Speed	1475 r.p.m.
Reagents	
	Pine oil, 0.15 lb./ton
	Cresylic acid, 0.25 lb./ton

Froth

Character	Effervescent
Persistence	Low
Texture	Coarse
Quality	Tender
Mineralization	Heavy

TABLE 4. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	44.78	12.65	4.36
Concentrate	99	208.24	46.5	13.4
Tailing	401	3.96	4.24	2.09

Ratio of concentration is 5.01 to 1

Percent Recovery

Silver	92.6%
Lead	74.5%
Zinc	75.8%

FLOTATION TEST NO. 4

Ore

Lot No. 1

Size

82% minus 200-mesh

Machine

Denver Sub-A, laboratory size

Reagents

Reagent #301, American Cyanamid Co.
Sodium aeroflost, American Cyanamid Co.
Aeroflost #25, American Cyanamid Co.

Mixing period

Duration 5 minutes
Speed 1475 r.p.m.
Pulp dilution 2 to 1
Reagents

Reagent #301, 0.2 lb./ ton
Sodium aeroflost, 0.2 lb./ton

Frothing period

Duration 23 minutes
Speed 1475 r.p.m.
Reagents Aeroflost #25, 0.2 lb./ ton
Froth

Character	Elastic
Persistence	High
Texture	Even
Quality	Viscous
Mineralization	Heavy

TABLE 5. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	44.78	12.65	4.36
Concentrate	136	181.36	41.32	13.12
Tailing	364	2.75	2.05	1.1

Ratio of concentration is 3.9 to 1

Percent recovery

Silver	95.4%
Lead	88.7%
Zinc	81.8%

FLOTATION TEST NO. 5

Ore — Lot No. 1

Size — 82% minus 200-mesh

Machine — Denver Sub-A, laboratory size

Reagents

Reagent #301, American Cyanamid Co.
Lime
Sodium aeroflost, American Cyanamid Co.
Barretts No. 4.

Mixing period

Duration	5 minutes
Speed	1475 r.p.m.
Pulp dilution	5 to 1
Reagents	
	Reagent #301, 0.2 lb/.ton
	Sodium aeroflost, 0.2 lb./ton
	Lime, 1.8 lb./ton

Frothing period

Duration	22 minutes
Speed	1475 r.p.m.
Reagents	Barretts no. 4., 0.25 lb./ton
Froth	
	Character — Elastic
	Persistence — High
	Texture — Even
	Quality — Tender
	Mineralization — Heavy

TABLE 6. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	44.78	12.65	4.36
Concentrate	104	196.47	52.7	14.38
Tailing	396	3.27	2.03	1.79

Ratio of concentration is 4.77 to 1

Percent recovery

Silver	94.1%
Lead	86.7%
Zinc	71.8%

FLOTATION TEST NO. 8

Ore — Lot no. 1.

Size — 82% minus 200-mesh

Mixing period
- Duration — 10 minutes
- Reagents — NaCN, 0.3 lb./ton; $ZnSO_4$, 0.9 lb./ton

Frothing period
- Duration — 28 minutes
- Reagents — Aerofloat #25, 0.2 lb./ton

Conditioning period
- Duration — 10 minutes
- Reagents — $CuSO_4$, 2.5 lb./ton

Frothing period
- Duration — 19 minutes
- Reagents — Aerofloat #25, 0.15 lb./ton

Froth

	Lead concn.	Zinc concn.
Character	Elastic	Elastic
Persistence	High	Medium
Texture	Coarse	Fine
Quality	Viscous	Tender
Mineralization	Heavy	Medium

TABLE 7. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	750	44.78	12.65	4.36
Pb concentrate	174	142.31	43.4	3.6
Zn concentrate	68	22.64	6.5	28.2
Tailing	508	2.95	2.48	1.79

Ratio of concentration

Lead concentrate	4.01
Zinc concentrate	9.95

Percent recovery

Silver	78.4%
Lead	84.4%
Zinc	78.2%

FLOTATION TEST NO. 7

Ore Lot no. 2

Size 87% minus 200-mesh

Mixing period

Duration 10 minutes

Reagents

NaCN, 0.3 lb./ton
$ZnSO_4$, 0.9 lb./ton
Reagent #301, 0.2 lb./ton

Frothing period

Duration 16 minutes

Reagents

Cresylic acid, 0.3 lb./ton
Pine oil, 0.05 lb./ton

Conditioning period

Duration 10 minutes

Reagents

$CuSO_4$, 1.5 lb./ton
Sodium aerofloat, 0.2 lb./ton

Frothing period

Duration 15 minutes

Reagents

Cresylic acid, 0.2 lb./ton
Pine oil, 0.05 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Effervescent	Elastic
Persistence	Medium	Medium
Texture	Uneven	Uneven
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 8. Results

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	17.01	8.34	7.9
Pb concentrate	79	88.43	49.5	6.4
Zn concentrate	64	18.56	3.42	36.84
Tailing	354	0.98	1.38	3.2

Ratio of concentration

Lead concentrate	6.92
Zinc concentrate	7.16

Percent recovery

Silver	95.6%
Lead	88.1%
Zinc	70.6%

FLOTATION TEST NO. 8

Ore Lot no. 2

Mixing period

Duration 5 minutes

Reagents

NaCN, 0.3 lb./ton
$ZnSO_4$ 0.9 lb./ton
Na_2S, 0.2 lb./ton
Reagent #301, 0.2 lb./ton

Frothing period

Duration 21 minutes

Reagents

Barretts no. 4, 0.2 lb./ton
Cresylic acid, 0.2 lb./ton

Conditioning period

Duration 10 minutes

Reagents

$CuSO_4$, 1.5 lb./ton
Sodium aeroflost, 0.2 lb./ton
Lime, 2 lb./ton

Frothing period

Duration 11 minutes

Reagents Cresylic acid, 0.25 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Elastic	Elastic
Persistence	High	High
Texture	Course	Uneven
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 9. Results

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	17.01	8.34	7.5
Pb concentrate	78	89.69	48.47	7.3
Zn concentrate	56	20.37	3.31	37.47
Tailing	366	1.08	1.36	3.56

Ratio of concentration

Lead concentrate	8.75
Zinc concentrate	7.8

Percent recovery

Silver	95.1%
Lead	88.0%
Zinc	67.2%

FLOTATION TEST NO. 9

Ore — Lot no. 2

Mixing period

Duration — 5 minutes

Reagents

NaCN, 0.3 lb./ton

$ZnSO_4$, 0.9 lb./ton

Coal tar creosote, 0.25 lb./ton

Frothing period

Duration — 22 minutes

Reagents — Barretts no. 4., 0.35 lb./ton

Conditioning period

Duration — 10 minutes

Reagents — $CuSO_4$, 1.5 lb./ton

Frothing period

Duration — 17 minutes

Reagents — Barretts no. 4, 0.2 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Elastic	Elastic
Persistence	High	Medium
Texture	Coarse	Even
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 10. Results.

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	17.01	8.34	7.9
Pb concentrate	71	100.48	45.68	4.18
Zn concentrate	67	12.73	3.92	30.82
Tailing	362	1.36	1.86	4.59

Ratio of concentration

Lead concentrate — 6.76

Zinc concentrate — 7.92

Percent recovery

Silver — 94.05%

Lead — 86.20%

Zinc — 58.00%

FLOTATION TEST NO. 10

Ore — Lot no. 2

Mixing period

Duration — 10 minutes

Reagents

NaCN, 0.3 lb./ton
$ZnSO_4$, 0.9 lb./ton
Reagent #301, 0.2 lb./ton
$NaSiO_2$, 0.5 lb./ton

Frothing period

Duration — 19 minutes

Reagents

Cresylic acid, 0.2 lb./ton
Aerofloat #25, 0.05 lb./ton

Conditioning period

Duration — 10 minutes

Reagents

$CuSO_4$, 1.5 lb./ton
Sodium aerofloat, 0.2 lb./ton
Lime, 1.8 lb./ton

Frothing period

Duration — 18 minutes

Reagents

Cresylic acid, 0.2 lb./ton
Barretts no. 4, 0.1 lb./ton

Froth

	Lead conct.	Zinc conct.
Character	Elastic	Elastic
Persistence	High	Medium
Texture	Uneven	Even
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 11. Results

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	17.01	8.34	7.90
pb concentrate	74	104.30	48.36	6.15
Zn concentrate	59	10.14	3.25	34.40
Tailing	367	0.83	1.16	3.87

Ratio of concentration

Lead concentrate	6.57
Zinc concentrate	7.52

Percent recovery

Silver	96.50%
Lead	89.75%
Zinc	64.10%

FLOTATION TEST NO. 13

Ore — Lot no. 3

Mixing period

Duration — 5 minutes

Reagents

NaCN, 0.2 lb./ton
$ZnSO_4$, 0.6 lb./ton
Reagent #301, 0.2 lb./ton
$NaSiO_2$, 0.5 lb./ton

Frothing period

Duration — 16 minutes

Reagents

Barretts no. 4, 0.2 lb./ton
Aerofloat #25, 0.05 lb./ton

Conditioning period

Duration — 10 minutes

Reagents

$CuSO_4$, 2 lb./ton
Lime, 1.5 lb./ton
Sodium aerofloat, 0.2 lb./ton

Frothing period

Duration — 13 minutes

Reagents — Cresylic acid, 0.25 lb./ton

Froth

	Lead const.	Zinc const.
Character	Elastic	Elastic
Persistence	High	High
Texture	Uneven	Even
Quality	Tender	Tender
Mineralization	Heavy	Medium

TABLE 14. Results

Sample	Weight grams	Silver oz./ton	Lead %	Zinc %
Heads	500	10.22	5.75	3.30
Pb concentrate	49	83.66	48.62	3.56
Zn concentrate	31	22.49	4.65	40.51
Tailings	420	0.84	0.81	0.53

Ratio of concentration

Lead concentrate	9.69
Zinc concentrate	14.40

Percent recovery

Silver	91.10%
Lead	88.25%
Zinc	86.40%

CONCLUSIONS

The Gold Hill mine in southeastern Whatcom County is still in the development stage largely owing to its location high in the Cascade Range, at a distance of about seventeen miles by trail from the Ruby damsite on the Skagit River.

The Gold Hill property contains three principal veins, of which only one has been opened to any extent. This one is a well defined fissure vein of mesothermal deposition. The ore consists largely of galena, sphalerite, and pyrite in a gangue of quarts and calcite.

The characteristics of the ore, as determined by the writer's study, are such that it seemed unnecessary to attempt concentration by any method other than the flotation process. A total of twenty-four flotation tests were made by the writer, from which the following conclusions have been drawn:

1. The logical method of flotation procedure is first to produce a galena concentrate by depressing the sphalerite and pyrite. Then following this, reactivate and float the sphalerite, leaving the pyrite in the tailing. By this method fairly good recoveries of galena and its contained silver were obtained, with somewhat lower recovery of sphalerite in most cases.

2. Some of the gold is obtained in the galena concentrate, but the bulk will remain in the tailing, due to the intimate association of most of the gold with the pyrite. A pyrite

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6. Later historical items were obtained from various issues of the Northwest Mining Journal.

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This pamphlet describes the flotation reagents produced by the American Cyanamid Company, their uses, applications, approximate quantities used, and usual points and method of addition.

8. Anderson, A. K., Gold losses in flotation. Can. Min. Jour., vol. 55, no. 6, Toronto, June, 1934, pp. 269-271.

In this article the author explains some of the causes of losses in milling gold ores, and also how to reduce these losses.

9. Gaudin, A. M., Flotation. McGraw-Hill Book Co., Inc., New York and London, 1932, pp. 196-247.

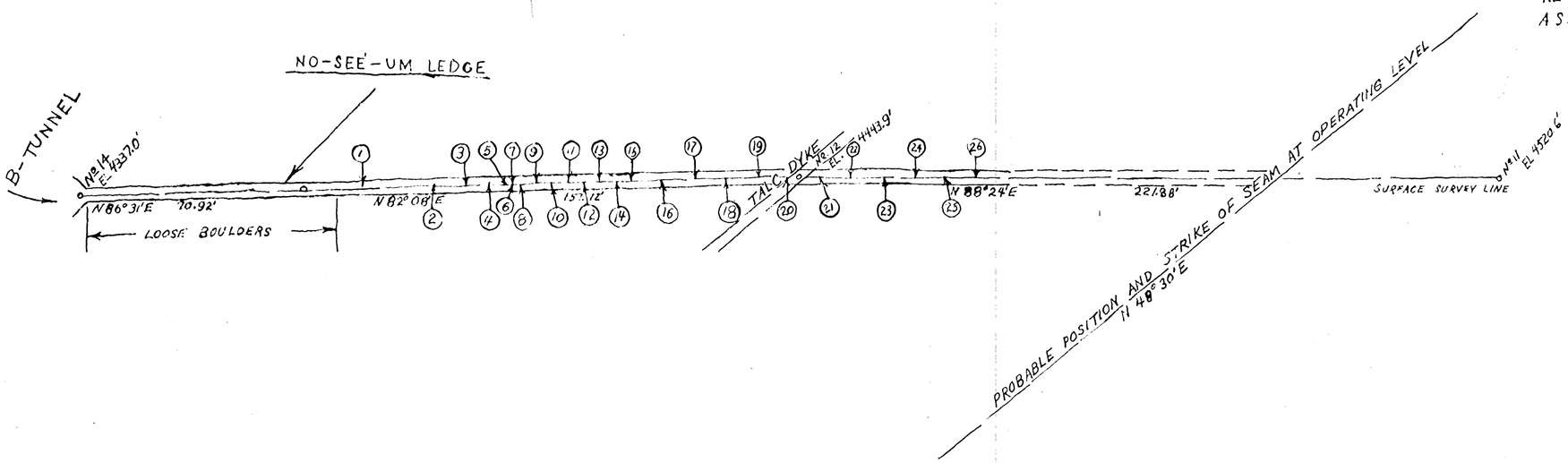
These pages cover a discussion on the flotation of sulfide lead and zinc ores.

10. Weinig, A. J. and L. A. Palmer, The trend of flotation. Colo. School of Mines Quarterly, vol. 24, no. 4, Oct., 1929, pp. 1-150.

This book gives a brief description of the flotation process. It describes at considerable length the practice employed at many of the important mills in the United States and Canada.

B-TUNNEL WIDTHS AND VALUES

DISTANCE FROM PORTAL	WIDTH SAMPLED	GOLD OZS. PER TON	SILVER OZS. PER TON	LEAD %	ZINC %	VALUE PER TON $
(1) 90'	6'	TRACE	10.20	0.14		
(2) 112	7	0.02	9.20	3.16		
(3) 122	6	0.03	21.63	7.76		
(4) 130	3	0.02	11.78	7.49		
(5) 135	5	0.01	18.35	8.11		
(6) 138	4' S.S.	0.02	32.74	13.27		
(7) 138	4' N.S.	0.02	24.98	10.58		
(8) 140	6	0.06	20.78	7.14		
(9) 145	6	0.02	9.68	3.28		
(10) 150	6	0.01	17.79	6.62		
(11) 155	5	0.01	18.71	7.51		
(12) 160	6	0.04	43.12	9.17		
(13) 165	5' 6"	0.04	40.98	2.55		
(14) 170	6'	0.03	44.77	0.40		
(15) 175	6	0.04	81.96	6.21		
(16) 185	5	0.02	20.50	3.75	5.00	
(17) 195	5	0.01	26.87	4.91	5.20	(omitted - w.p.)
(18) 205	4' 6"	0.02	27.20	9.61	3.20	
(19) 215	6'	0.01	19.87	6.03	3.80	
(20) 225	5' 6"	TRACE	0.18	0.29	NIL	
(21) 235	6'	0.01	20.39	4.54	3.00	
(22) 245	5	0.01	7.91	1.17	0.70	
(23) 255	5	0.01	9.89	2.63	0.50	
(24) 265	4' 6"	0.01	14.17	3.32	1.00	
(25) 275	5'	0.01	18.21	4.70	1.30	
(26) 285	4	0.01	18.31	5.59	0.90	



GOLD HILL OPERATING COMPANY

B – TUNNEL

SCALE 1 IN. = 25 FT — MARCH 31, 1937
DRAWN BY — M.S. MADDESS
RETRACED BY — C.T. SYLLUASEN
ASSAYS BY BENNETTS' CHEMICAL LABORATORY

ASSAY MAP OF WORKINGS NEAR GRANITE CREEK WHATCOM COUNTY WASHINGTON

REDRAWN BY W. PARISEAU
MARCH, 1963

LEGEND

ARGILLITES AND CONGLOMERATES	A&C
BASIC IGNEOUS ROCK	BI
ACID IGNEOUS ROCK	AI
SCREE AND TALUS	S&T
GLACIAL MORAINE	GM
VEINS	
SHEARING	

NOTE: Claims not shown W. of P.

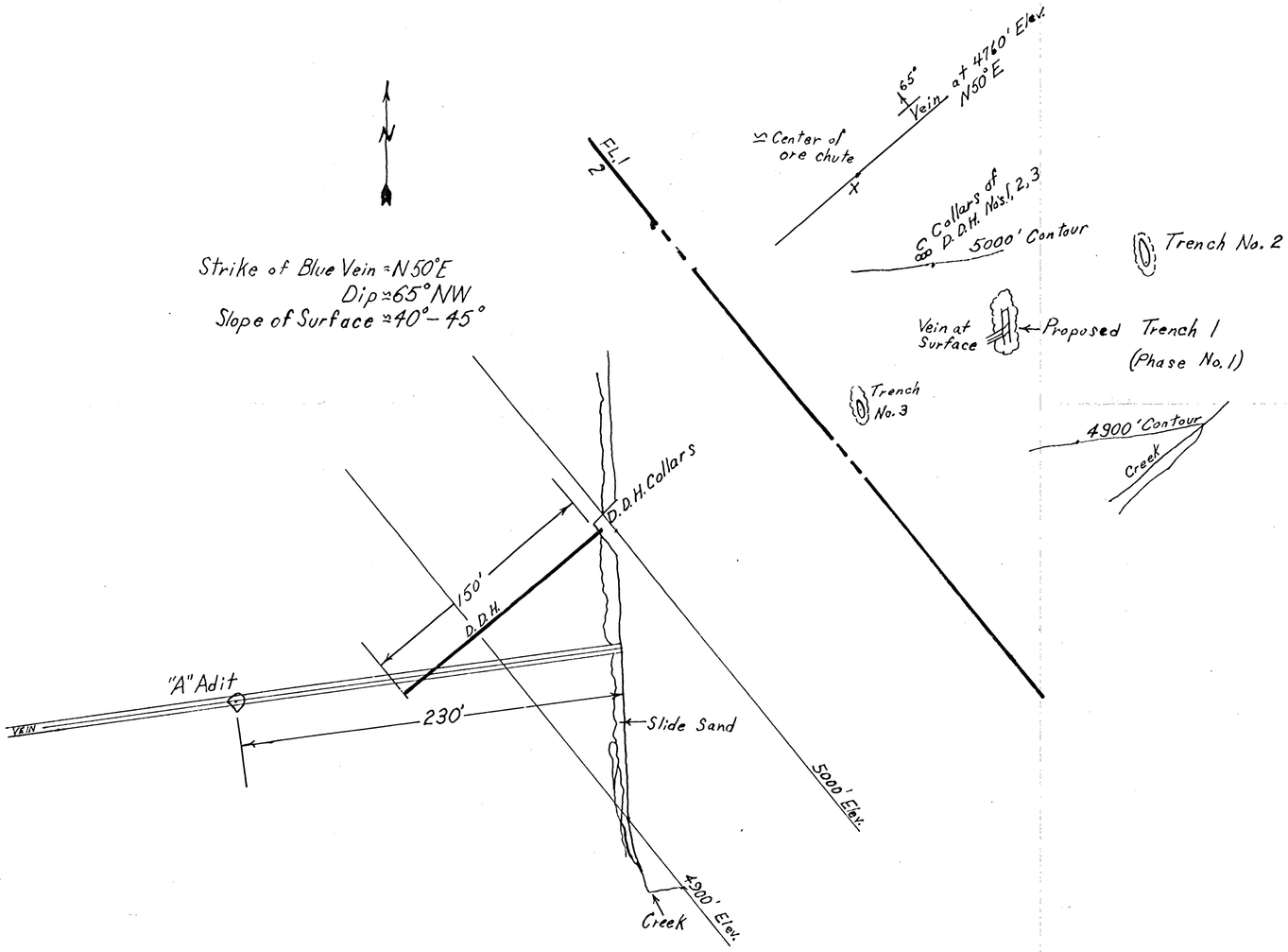
CLAIM MAP WITH SURFACE GEOLOGY OF AZURITE, GOLD HILL AND QUIEN SABE GROUPS OF CLAIMS

SLATE CREEK MINING DISTRICT
WHATCOM CO., WASHINGTON

SCALE 1" = 400' SEPT 21, 1938

GEOLOGY BY PAUL BILLINGSLEY

REDRAWN BY William G. Pariseau
March 20, 1963



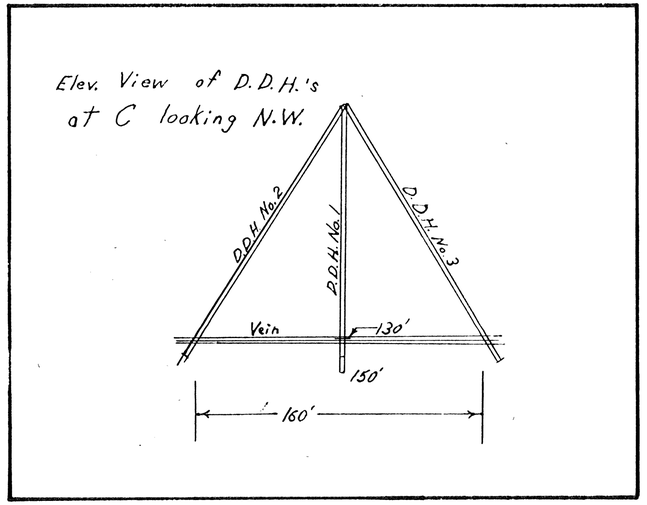
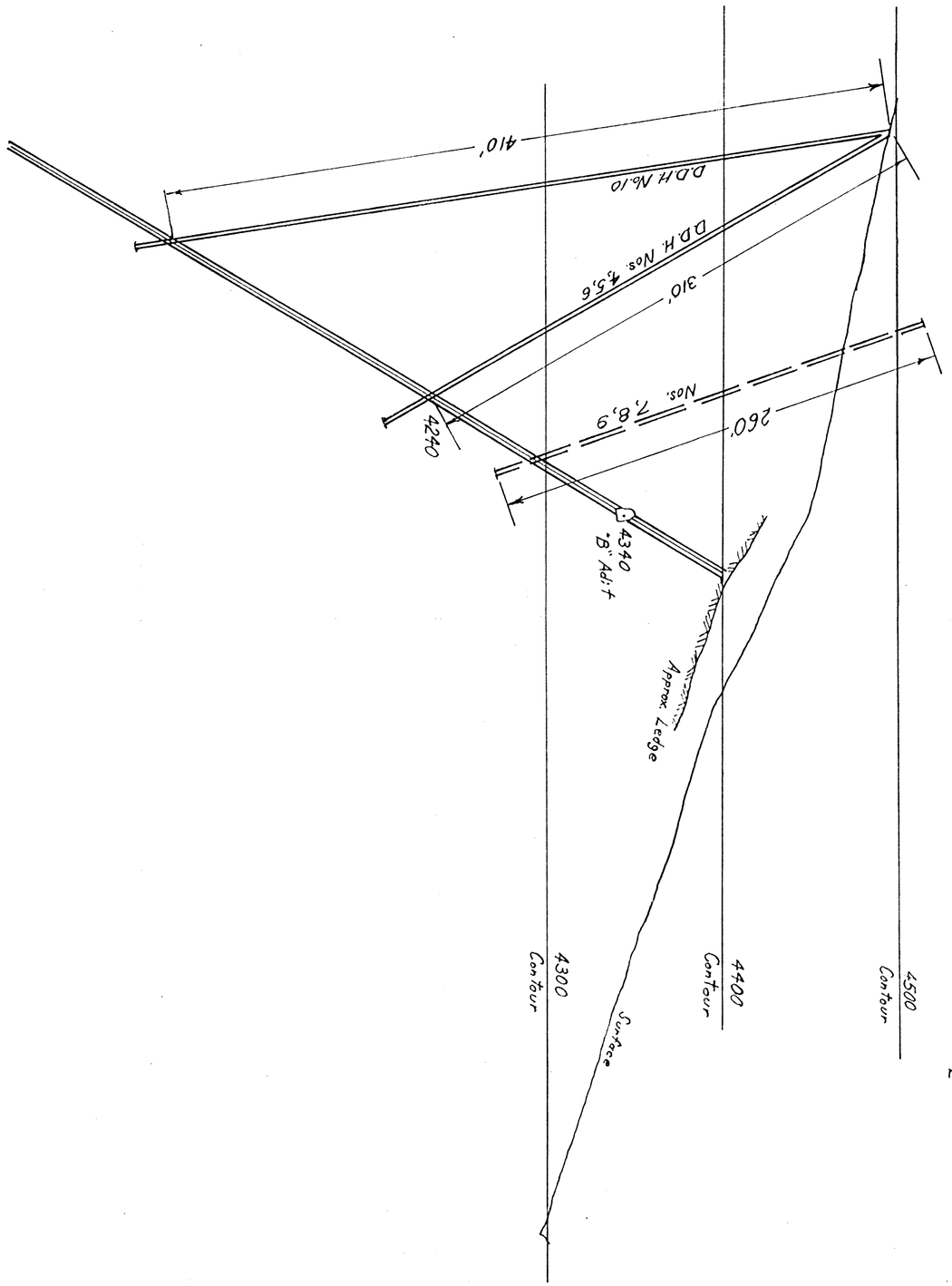


Fig. No. 1
Proposed
D.D.H. Layout Upper Adit ("A" Portal Area) Ore Shoot
Phase No. 2
Scale: 1" = 50'



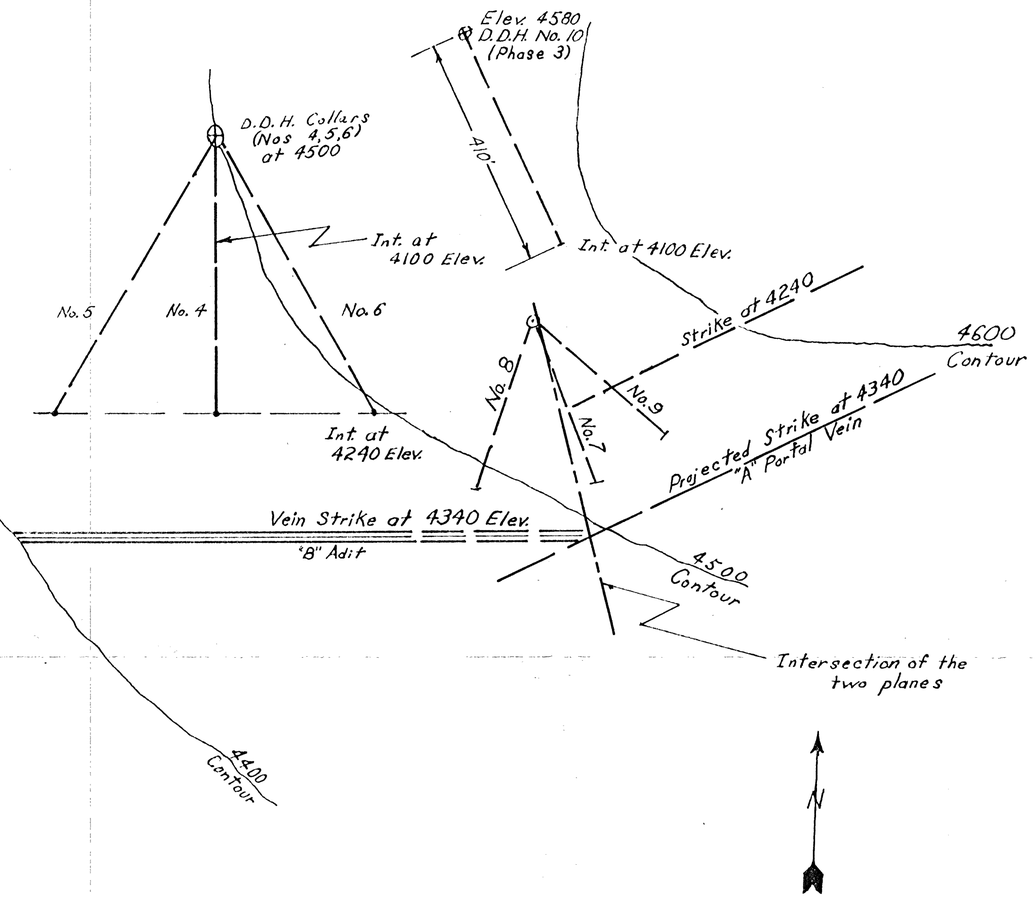
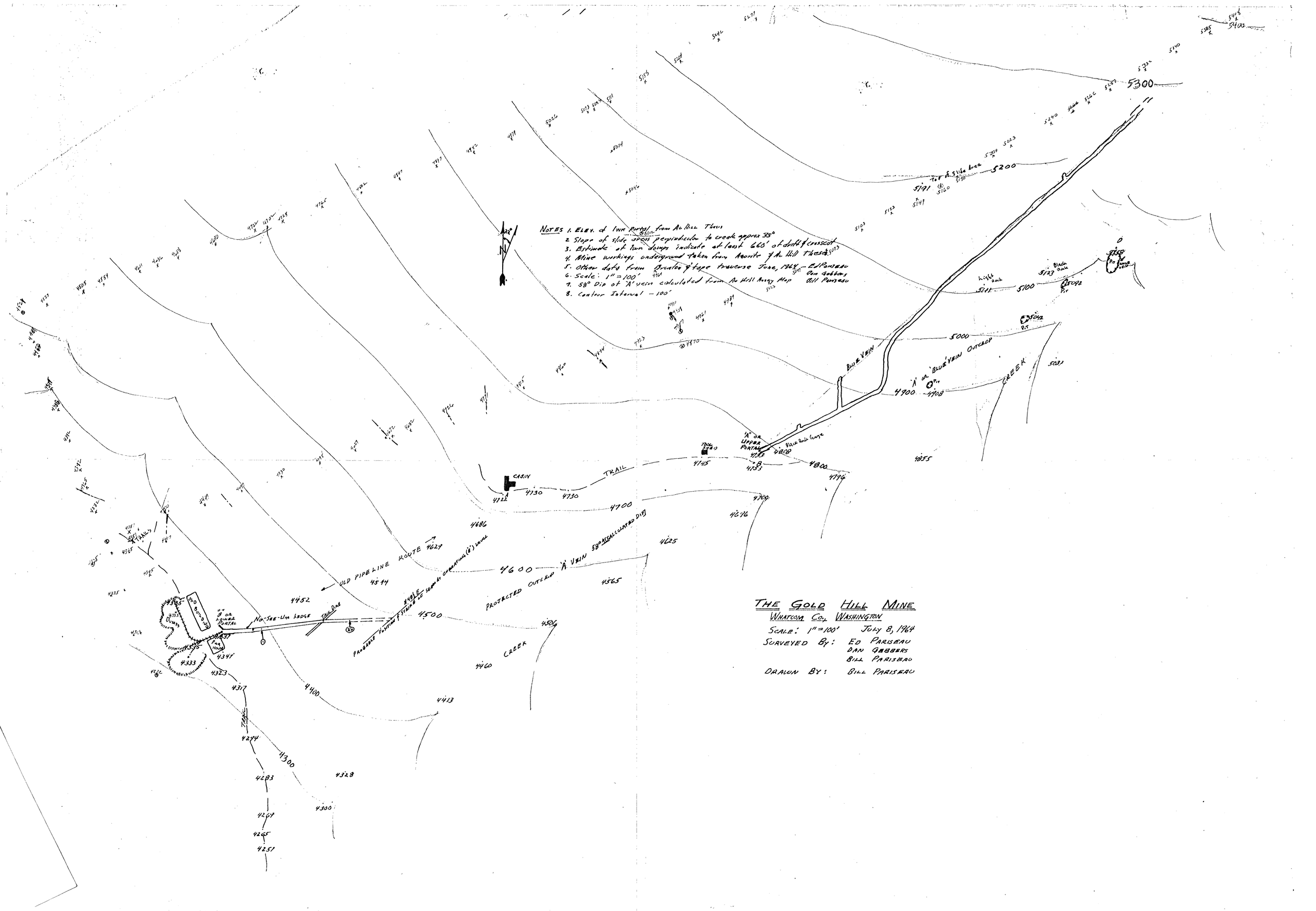
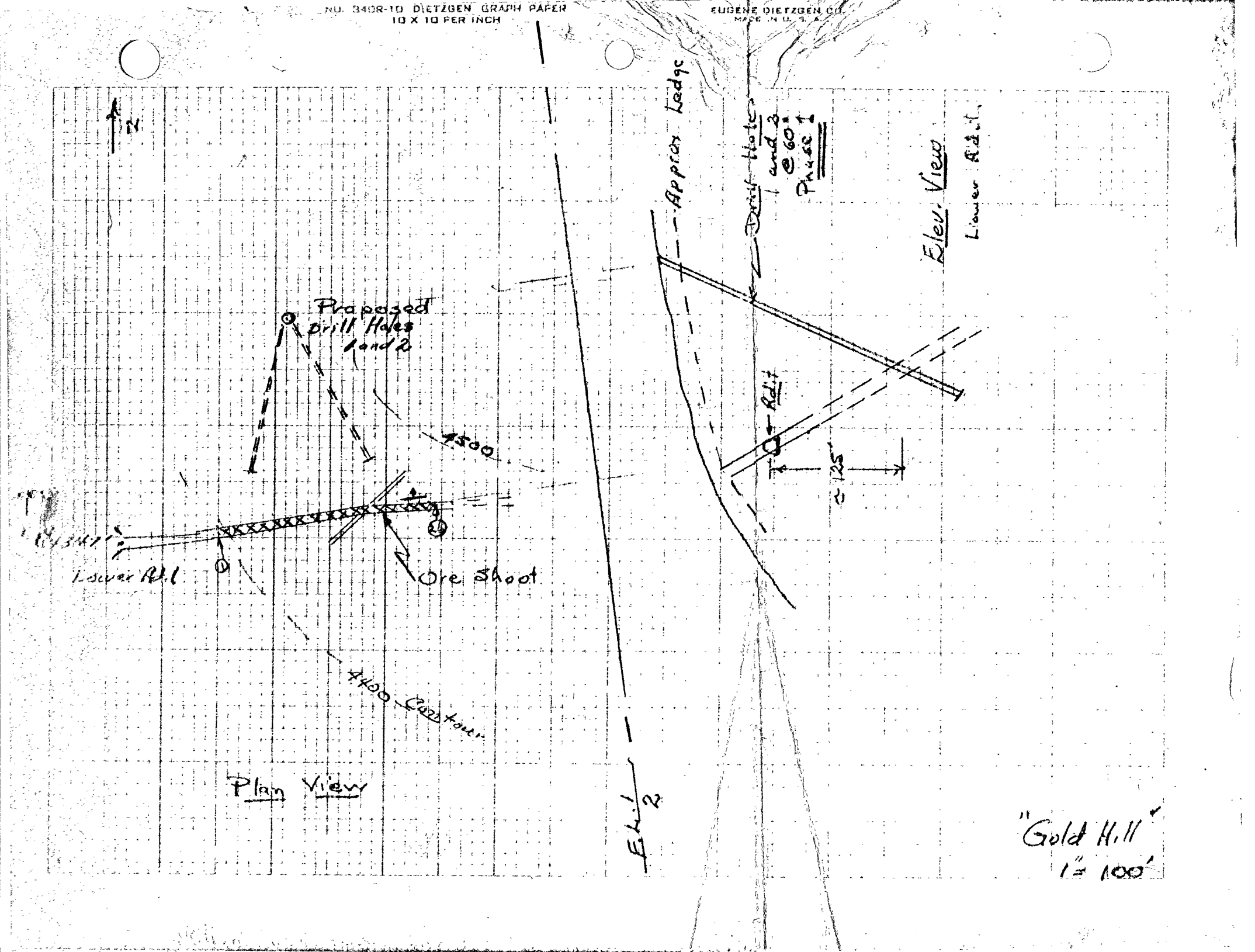
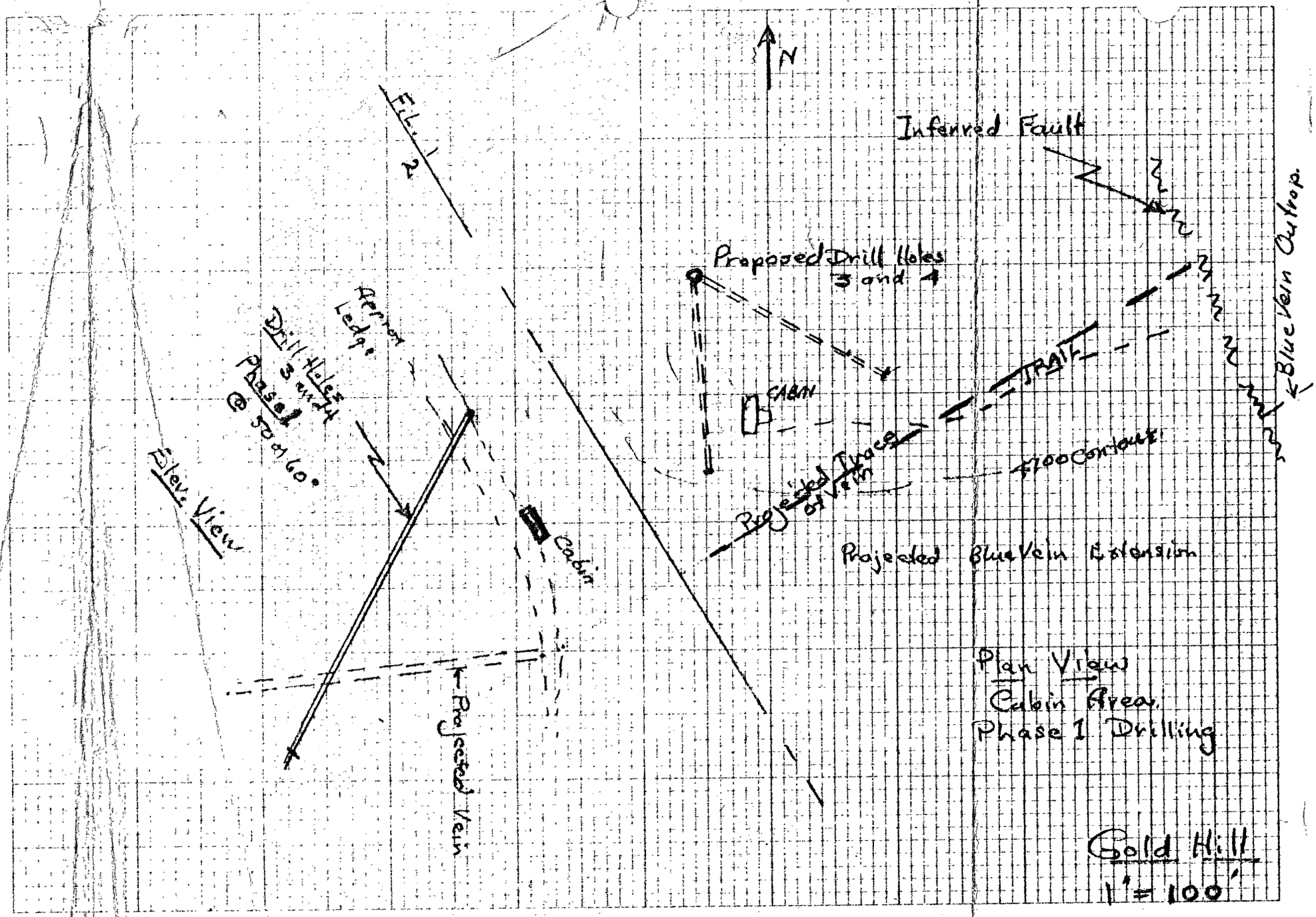


Fig No. 2
Proposed
D.D.H. Layout Lower Adit ("B" Portal Area) Ore Shoot
Phase No. 2
Scale: 1"=50'
Strike of Ore Shoot – Used N 85°E
Used Dip of 60° to N for computation


NOTES 1. ELEV. of Iwn portal from Mt Rice Theis
2 Slope of slide areas perpindicular to creek approx 35°
3. Estimate of Iwn dumps indicate at least 660' of drift & crosscut
4. Mine workings underground taken from Atomic & Mt Hill Theses
5. Other data from Brunton & tape traverse June, 1964 – Ed Parisau
6. Scale: 1" = 100'
7. 58° Dip of 'A' vein calculated from Mt Hill Assay Map
8. Contour Interval – 100'
Dan Gebbers
Bill Parisau
5300
5200
5100
5000
4900
4800
4700
4600
4500
4400
4300
BLUE VEIN
'A' or 'BLUE VEIN' OUTCROP
CREEK
'A' or UPPER PORTAL
CABIN
TRAIL
OLD PIPELINE ROUTE
'A' VEIN 58° (CALCULATED DIP)
PROTECTED OUTCROP
PROBABLE POSITION & STRIKE OF SEAM AT OPERATING (6') LEVEL
No-See-Um Lodge
OLD BUNKHOUSE
DUMPS
LOWER PORTAL
PIPELINE
THE GOLD HILL MINE
WHATCOM CO., WASHINGTON
SCALE: 1" = 100'
JULY 8, 1964
SURVEYED BY: ED PARISEAU
DAN GEBBERS
BILL PARISEAU
DRAWN BY: BILL PARISEAU

NO. 340R-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH
EUGENE DIETZGEN CO.
MADE IN U. S. A.





NO. 340R-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH
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B-TUNNEL WIDTHS AND VALUES

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(1) 90'	6'	TRACE	10.20	0.14		
(2) 112	7	0.02	9.20	3.18		
(3) 122	6	0.03	21.63	7.76		
(4) 130	3	0.02	11.78	7.49		
(5) 135	5	0.01	18.35	8.11		
(6) 138	4' S.S.	0.02	32.74	13.27		
(7) 138	4' N.S.	0.02	24.98	10.58		
(8) 140	6	0.06	20.78	7.14		
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(16) 185	5	0.02	20.50	3.75	5.00	
(17) 195	5	0.01	26.87	4.91	5.20	
(18) 205	4' 6"	0.02	27.20	9.61	3.20	
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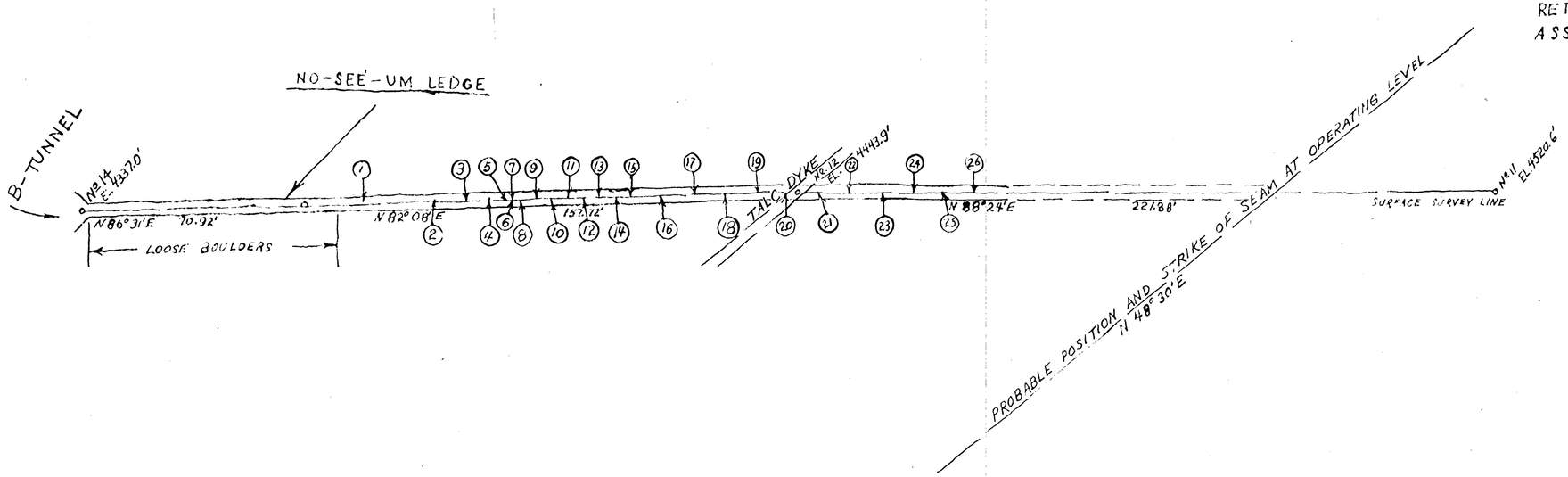
(22) 245	5	0.01	7.91	1.17	0.70	
(23) 255	5	0.01	9.89	2.63	0.50	
(24) 265	4' 6"	0.01	14.17	3.32	1.00	
(25) 275	5'	0.01	18.21	4.70	1.30	
(26) 285	4	0.01	18.31	5.59	0.90	

(omitted - W.H.P.)



GOLD HILL
OPERATING COMPANY
B — TUNNEL

SCALE 1 IN. = 25 FT — MARCH 31, 1937
DRAWN BY — M.S. MADDESS
RETRACED BY — C.T. SYLLIAASEN
ASSAYS BY BENNETTS' CHEMICAL LABORATORY

ASSAY MAP OF WORKINGS
NEAR GRANITE CREEK
WHATCOM COUNTY
WASHINGTON

REDRAWN BY W. PARISEAU
MARCH, 1963

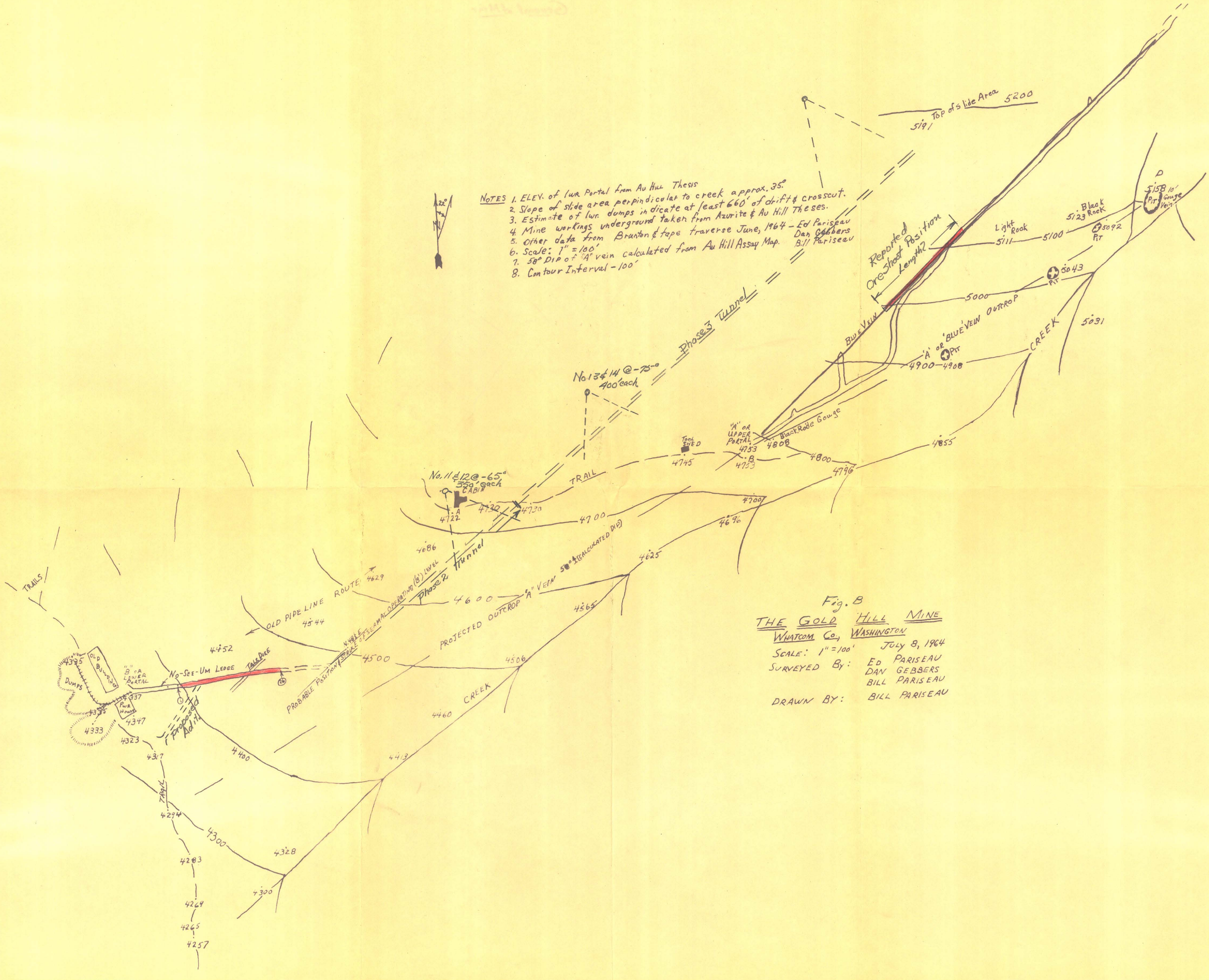


Fig. 8

THE GOLD HILL MINE

WHATCOM Co., WASHINGTON

SCALE: 1" = 100' JULY 8, 1964

SURVEYED BY: ED PARISEAU, DAN GEBBERS, BILL PARISEAU

DRAWN BY: BILL PARISEAU