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REPORT ON SHEEP CREEK MINES LTD.

NELSON MINING DISTRICT

by

F.R. THOMPSON FOR J.A.C. ROSS

April 30, 1970

plus

674417

Portion of Bulletin 31 B.C.D.M.

GEOLOGY OF THE SHEEP CREEK CAMP

REPORT

on

SHEEP CREEK MINES LTD. CLAIMS

SALMO, B.C.

NELSON MINING DISTRICT

Submitted to

J.A.C. ROSS & ASSOCIATES LTD.

1720 - 1055 West Hastings Street

Vancouver, 1, B.C.

by

FRED R. THOMPSON, P.Eng.
6524 Wellington Place
West Vancouver, B.C.

Vancouver, B.C. April 30th, 1970.

INTRODUCTION

The writer was retained by Mr. J.A.C. Ross to prepare a report on a group of claims in the Sheep Creek Gold camp. The claims are part of the holdings of the Sheep Creek Mine, operated by Sheep Creek Gold Mines Ltd. from 1934 to 1951.

The writer was employed by Sheep Creek Gold Mines Ltd. and its successor company, Sheep Creek Mines Ltd., from June 1934 to June 1955. Employment was at the Sheep Creek property through to August 1941, from July 1945 to February 1948, and from September 1949 to closure in April 1951.

This report will describe the Sheep Creek operations, past and possible future.

SOURCE OF INFORMATION

Mr. Ross supplied the writer with the working plans of the Sheep Creek Mine. The plans and sections on the 40' = 1" scale are up-to-date.

Geological and production information are from the report "The Geology of the Sheep Creek Camp" by W.H. Mathews, Bulletin No. 31, B.C. Department of Mines.

Reference was made to Department of Mines Annual Reports.

Brief discussions were held with J.S. McIntosh, F.J. Hemsworth and E.F. Hallbauer. The former were employed in engineering and operating at the mine, and Hallbauer was the mechanical superintendent from 1942 on and one of the first employees hired in 1933.

SUMMARY

There is 5000 feet of geologically favourable structure on the claim group south of the 57 vein of the Sheep Creek Mine.

From 1935 to 1956 the mine paid dividends amounting to $2,700,000. From 1935 through 1950 the mine produced 597,000 tons of ore averaging 0.41 ounces of gold per ton.

The existing workings contain 44,000 tons of vein material grading 0.31 ounces of gold per ton.

Operating costs for an operation on the basis of the Sheep Creek operation are probably $27.00 per ton on existing costs. This cost figure would suggest a break-even grade of 0.70 ounces of gold per ton. Few ore shoots in the camp produced appreciable tonnages of material of such grade.

RECOMMENDATION

That with a favourable gold price cost ratio, a study be undertaken to assess the value of the property, cost of re-opening the mine and re-examination of the workings.

For purpose of the study, a grade figure of 0.30 ounces per ton be used.

A favourable study on this basis would suggest production and development proceed on the existing reserve and workings.

The plunge of the structure is climbing to the south which suggests that cross-cutting to the south should be on 7 level. There is no assurance of locating a major vein in the ground to the south. On the other hand, the possibility cannot be ruled out. In any revival of the operation, development of the ground to the south must be on a high priority.

GENERAL

The Sheep Creek camp is in the Nelson Mining Division. By road it is 9 miles from Salmo and 35 miles from Trail or Nelson.

The Queen and Yellowstone veins were located in 1896 and first claims staked were on these veins. Production from the camp is first recorded in 1899. A number of mines operated until 1916 and one of these was the Queen Mine, operating on the Yellowstone and Queen veins.

Activity in the camp was revived with the building of a small mill at the Reno Mine in 1928. This mill burned and the Reno company acquired the old Motherlode mill on Sheep Creek, with the Nugget and Motherlode Mines. In this period of operation four companies had mills on Sheep Creek, e.g. Reno, Gold Belt, Kootenay Belle and Sheep Creek. The Ore Hill Mine had a small mill on Coon Creek.

Sheep Creek Mines Ltd. started milling in May 1935. The mill operated to capacity through 1942 and on a reduced basis from 1942 to closure at the end of the summer of 1950.

Some leasing has taken place where ore remnants were available. Probably the most successful was the operation of Russell Thompson on the Kootenay Belle property.

OWNERSHIP AND PROPERTY

Mr. J.A.C. Ross owns outright the following Crown granted claims and fractional claims:

Name	Lot No.
Success	10089
Strugle	10172
Ore Hill	2073
Dixie	10264
Ore Hill No. 3	10265
Standard	10267
Last Dollar Fr.	10269
Pat Fractional	12213
Royal Ann Fr.	14009
Royal Ann	14010
Royal Ann No. 1	14011
Vernon	14020
Margaret Fraction	14696
Bruhn No. 2	14697
Henry Fraction	14916
Queen Ann No. 1	15235
Queen Ann Fr.	15236
Queen	1076
Niagara	1077
Lewiston	1078
Burlington Fraction	1079
Pat	5706
Bullion	8325
Edward VII	9077
Alexandra	9078
Placer Fraction	9079
Silver Tip Fraction	14019
Marie Fraction	10007
Victoria Fraction	10008

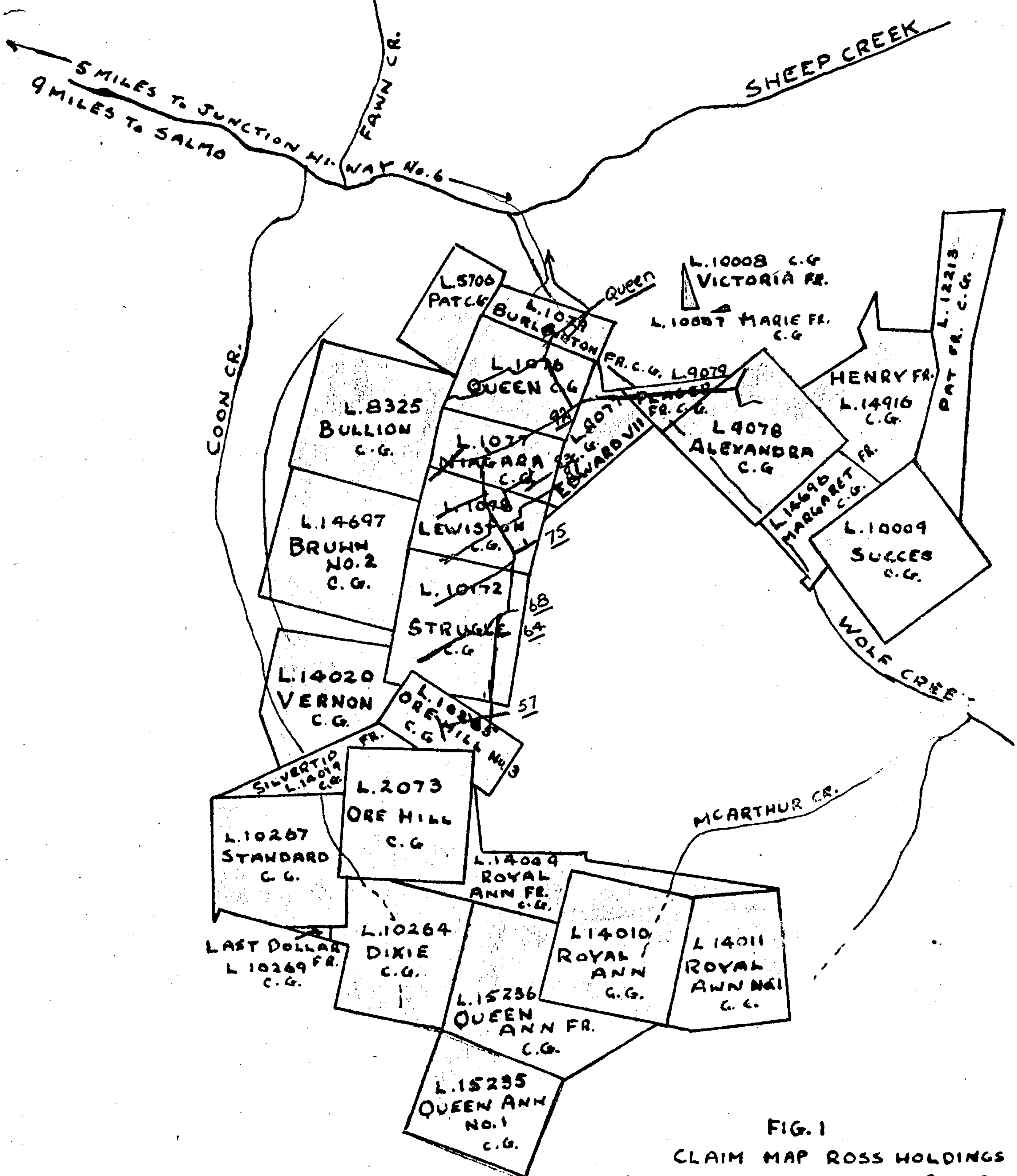


FIG. 1

CLAIM MAP ROSS HOLDINGS

SOUTH END SHEEP CREEK CAMP

1500'-1"

MARCH 1970

The location of the claims in relation to the watershed is illustrated in Fig. 1.

The eastern boundary of the claims in relation to veins developed or partially developed is illustrated in Fig. 2.

The Chief Gold Commissioner, in a letter dated March 4th, 1970, confirmed that these claims were currently held. No further action was taken in verification of ownership.

Buildings remaining on the property are in various stages of repair. Near the shaft are the headframe, hoist and compressor house, shop and the mill building.

GEOLOGY

The geology of the Sheep Creek camp is described in detail in British Columbia Department of Mines publication Bulletin 31 by W.H. Mathews.

British Columbia Department of Mines publication Bulletin 41, by Fyles & Hewlett, is the most recent work covering the area.

The underlying sediments in the camp are of Lower Cambrian and older series, probably Pre-Cambrian. Granite intrusives outcrop to the south, west and northwest of the camp.

Mathews describes the members of the formation as follows:

Formation	Member	Lithology	Thickness (ft.)
Laib group		Argillite	200
		Grey limestone	150
		Limey argillite	300-500
		Limestone & argillite	100-300
		Limestone	0-60
Reno	Upper Reno	Impure dark quartzite	125
	Lower Reno	Argillaceous quartzite	450
Quartzite Range Formation	Upper Navada	Massive white quartzite	20-160
	Lower Navada	Thin bedded & argillaceous quartzite	100-140
	Upper Nugget	Massive white quartzite	135-375
	Middle Nugget	White & dark quartzite, argillite	175-300
	Lower Nugget	Argillite, dark argillaceous quartzite	150-225
	Upper Motherlode	Massive white quartzite	370-450
	Middle Motherlode	Argillite, grey grit, green schist	50
	Lower Motherlode	Massive white quartzite	500-700
Three Sisters		Grey grit, white quartzite grit & green schist	500

The sediments strike N to N 10° E and are folded into an anticline, syncline and anticline. These are referred to as the Western anticline, Central syncline and Eastern anticline.

A quartz porphyry sill swarm, on the eastern limb of the Central syncline, at or close to the Laib Reno contact, has been traced for 5¼ miles in the camp. Acid and basic dykes are found in the mine workings, and are both pre and post vein faulting.

Four fault systems are recognized: Northeasterly trending faults with a right hand slip, northwesterly trending faults with a left hand slip, northerly trending faults and flat faults.

Vein development occurs in the northeasterly trending faults and production in the camp has been from these faults. Vein development in the northwesterly trending faults has not produced ore.

Northerly trending normal faults, post ore, are found in the workings of the Sheep Creek Mine. The Weasel Creek fault is traced on the surface for several miles. The fault is on the east limb of the Eastern anticline and has not been located underground due to the minimum work carried out on this limb of the anticline.

Flat lying faults of generally less than 15° dip to either east or west are found in some of the workings. Where observed, the hangingwall block has moved westward. Movement on the faults is generally only a few feet, however a displacement of about 200 feet seems to offer the best explanation for the difference in geology between 6 and 8 levels of the Ore Hill Mine.

As stated previously, production has come from the northeasterly trending faults. Further production has been limited, to date, to the sections of the vein faults crossing competent beds in the Western anticline and in the western limb of the Eastern anticline. The vein faults carry through the argillite as narrow to thin seams, in many areas difficult to distinguish.

Vein filling is of white brittle quartz with minor sulphide content. Pyrite is the more plentiful sulphide but in places sphalerite, galena, scheelite, wolframite and pyrrhotite may be present. Gold deposition appears to be associated with the sulphide mineralization.

In the Sheep Creek Mine, sphalerite was considered an indication of better than average ore. In the Reno Mine, the better values occurred where pyrrhotite was present.

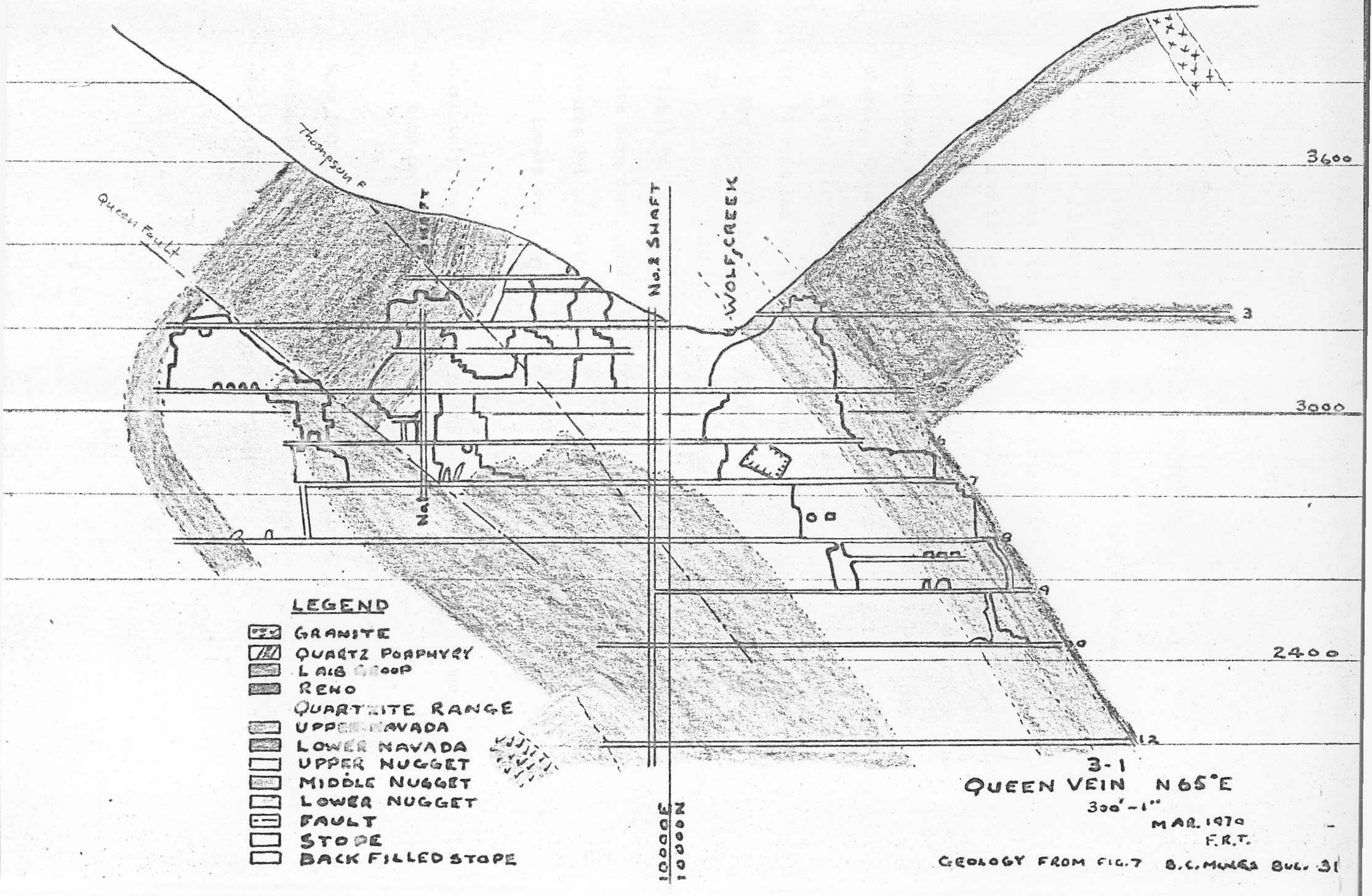
In the Western anticline work has been carried out on 28 veins in roughly parallel northeasterly trending vein faults; in the western limb of the Eastern anticline in 15 veins, and in the eastern limb of the Eastern anticline 4 veins.

Ore shoots in the veins are not found in a pattern. They are developed in sections with competent rock on both walls, but all the sections with competent rock on both walls do not develop ore shoots. The vertical range of ore shoots varies. In the Western anticline the Reno vein shows a vertical range of 1500 feet; the Gold Belt 3040 vein 1590 feet. No other vein has yielded ore through a vertical range of more than 1200 feet. Ore shoots are not confined to one formation. The Reno vein was most productive in the Reno formation, possibly due to alteration and complex folding in that formation. The Queen vein was productive to a minor degree in Reno and Navada. In general, the Nugget formation and, in particular, the Upper Nugget has been most productive. Factors that may influence localization of ore shoots are the attitude of the beds and vein slips. Mathews states "The localization of ore shoots within a vein depends on a combination of factors that influence the width of vein filling and the deposition of gold. No general statement can be offered to explain fully the localization of ore shoots in veins of the Sheep Creek camp."

Geology of 7 level of the Sheep Creek Mine is outlined on Fig. 2. 7 level was chosen as it represents the maximum development of any level in the mine and includes a section from the Western anticline, through the syncline and into the west limb of the Eastern anticline.

The geology on the Queen vein section, Fig. 3-1, is representative of the conditions found in the mine. The influence of the Thompson and Queen faults, in providing a greater length of favourable formation on a level, is illustrated.

The vertical range of ore shoots in veins of the Western anticline has an apparent plunge to the south of 10°. Minimum work has been done below this apparent floor. Mathews suggests there is no physical change in the veins, or attitude of the beds to preclude ore shoots at greater depth. Work on the Queen vein at depth was discontinued due to failure to develop sizeable ore shoots on 10 level or 9 level east, and the lack of an ore shoot on 12 level east. The locating of granite in quantity in a drill hole to the west on 12 level was an additional factor. Work on the ore shoots in the stopes of the upper levels was discontinued when vein width narrowed and was not compensated for with an increase in grade.



3-1

QUEEN VEIN N 65°E

300'-1"

MAR. 1970

F.R.T.

GEOLOGY FROM FIG. 7 B.C. MINES BUL. 31

DEVELOPMENT AND PRODUCTION

The Queen vein was pumped out and examined in early 1934. On the basis of a report by H.H. Yuill development work was started on 7 level east. Subsequently, the mine west of the Queen fault was developed and in May 1935 the treatment plant was placed in operation.

No. 2 shaft was raised from 7 level to surface and in 3 sections, early in 1935, 1936 and 1937, sinking to 12 level was completed. Cross-cutting to the south started in 1935 and was carried out on 5 and 7 levels. The locating of an excellent ore shoot on 7 level of the 92 vein led to the establishment of 2 level, an adit on the strike of the vein at elevation of 3347 feet.

Main cross-cuts to the south were on 2 level to 68 vein, 5 level to 44 vein, 7 levels to 57 vein. From the Queen vein south, veins were designated as 92, 85, 83, 81, 76, 75, 68, 64, 57 and 44. Figures 3-1 and 3-10, sections on the veins, illustrate the work on main levels and the areas stoped.

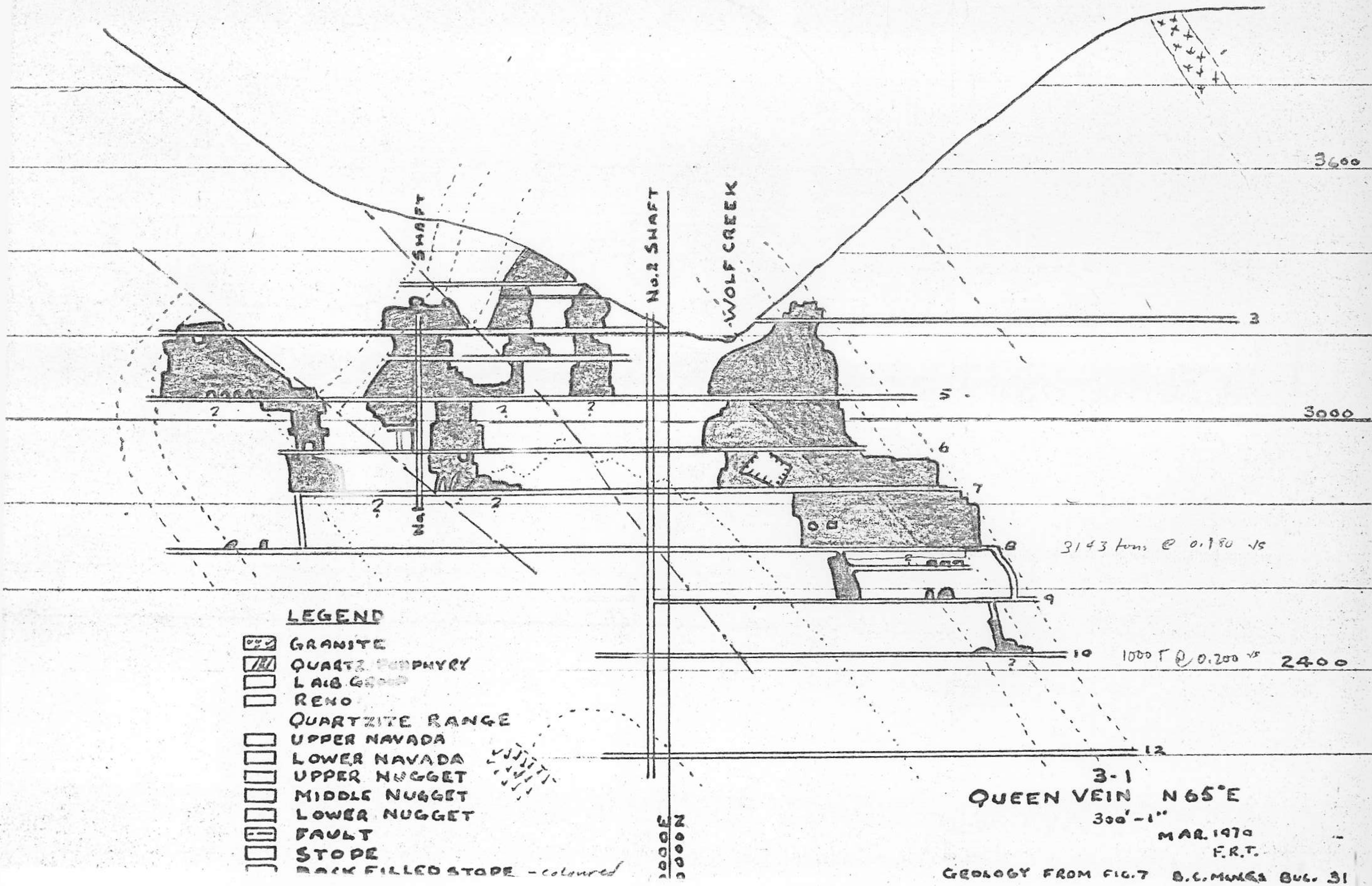
The veins on 9 level south of the 92 vein have not been adequately tested in the west end of the mine. In most cases, work has not been done west of the Thompson fault.

Development work to the south could be most productive. Some 5000 feet of favourable ground is unexplored. Shallow workings on the summit and on the north and south slopes of Mount Waldie suggest the presence of northeasterly vein faults.

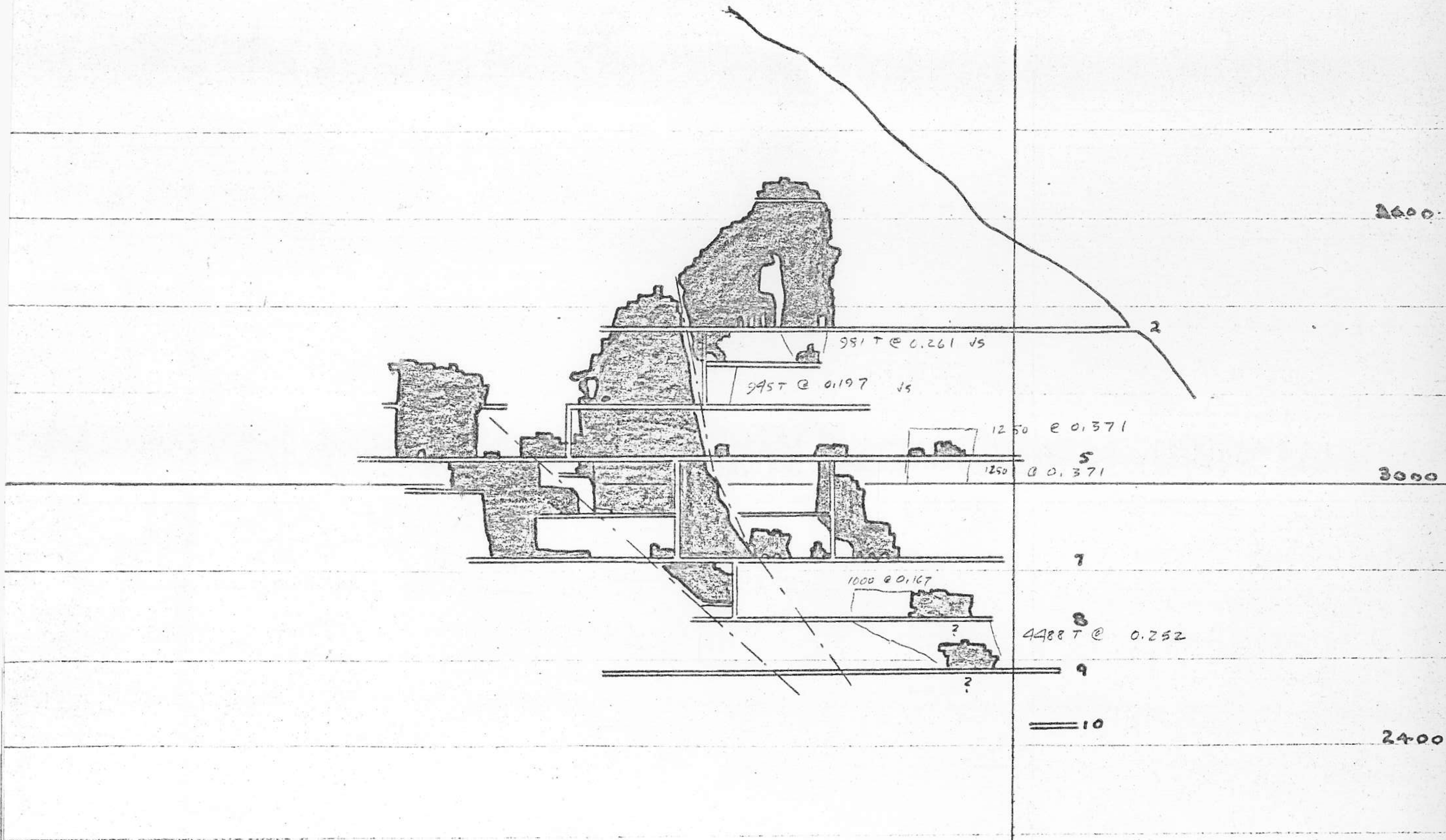
The volume of water now in the mine, based on tonnage mined, sq. ft. of stope wall, and assuming 40% void in back-filled stopes, is 50,000,000 gallons. Most of this volume is above 7 level. Consequently, to open the mine to 7 level is a major operation. Once 7 level was open, it would not be difficult to reach 9 level.

Production figures and amount of development work on the veins are in the following tables. The figures on production are adjusted from the table in Mathews report to correspond with the figure on recovered production. The Queen vein is credited with a total production of 234,500 tons containing 93,725 oz. of gold.

Vein	Tons Mined	Oz. Au Recovered	Development on Vein	Oz./ton	Oz./ft.
Yellowstone	Nil		500		
Queen	117,305	34,137	7,700	.29	4.43
92	180,500	85,100	5,400	.47	15.76
85	6,000	1,500	1,700	.25	.90
83	56,000	19,200	3,000	.34	6.40
81	167,500	78,500	5,800	.47	13.53
76	6,500	1,600	1,050	.25	1.52
75	30,500	12,800	2,500	.42	5.12
68	16,000	5,400	2,300	.34	2.35
64	2,000	700	250	.35	2.80
57	15,500	5,200	1,490	.34	3.49
44	Nil		150		
Total	597,495	244,137	31,840	.41	7.66
X-Cutting - including 7E & work N & S			20,940		
			52,780		4.63



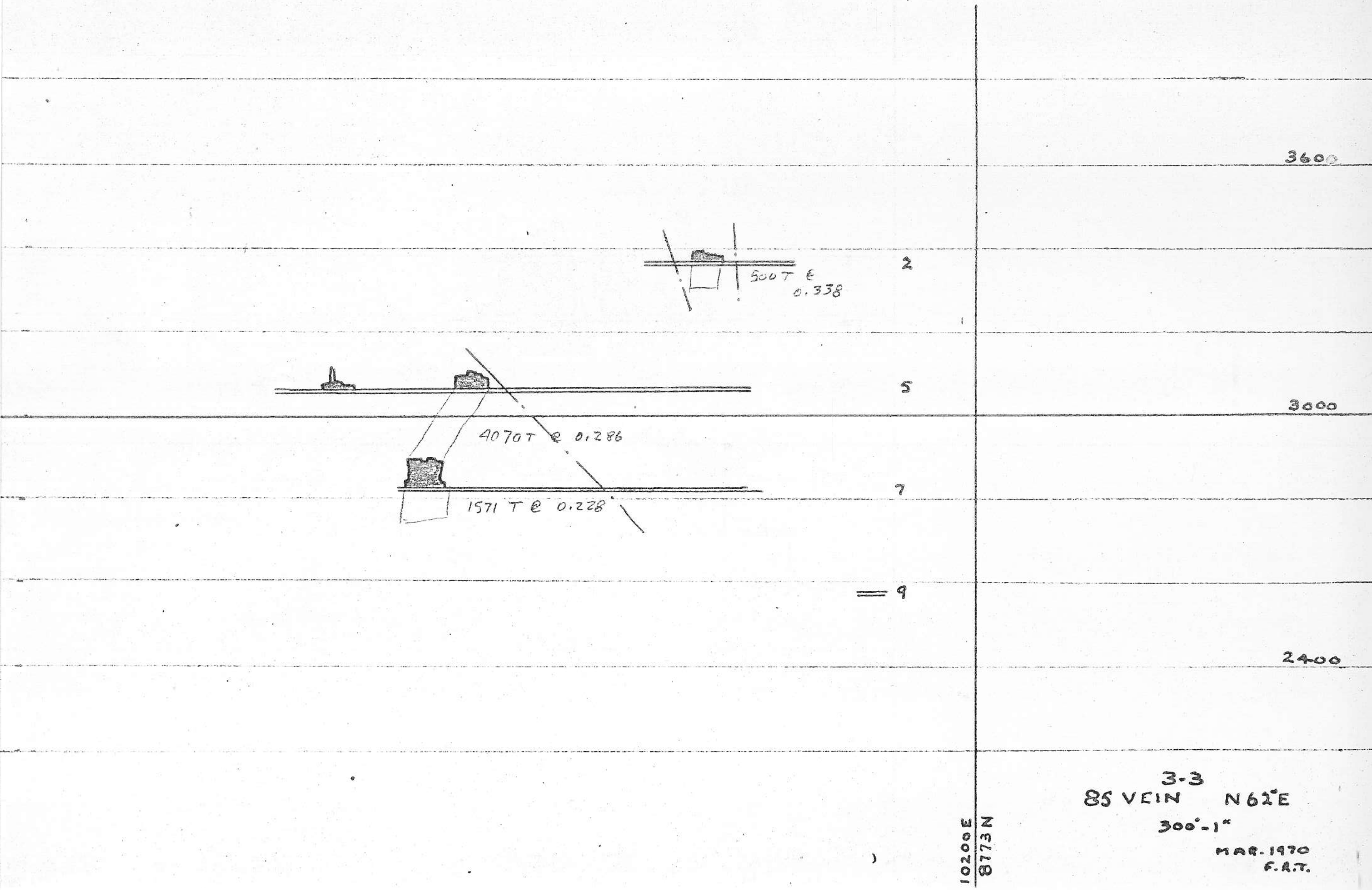
3-1
QUEEN VEIN N65°E
300'-1"
MAR. 1970
F.R.T.
GEOLOGY FROM FIG.7 B.C.MINES BUL. 31



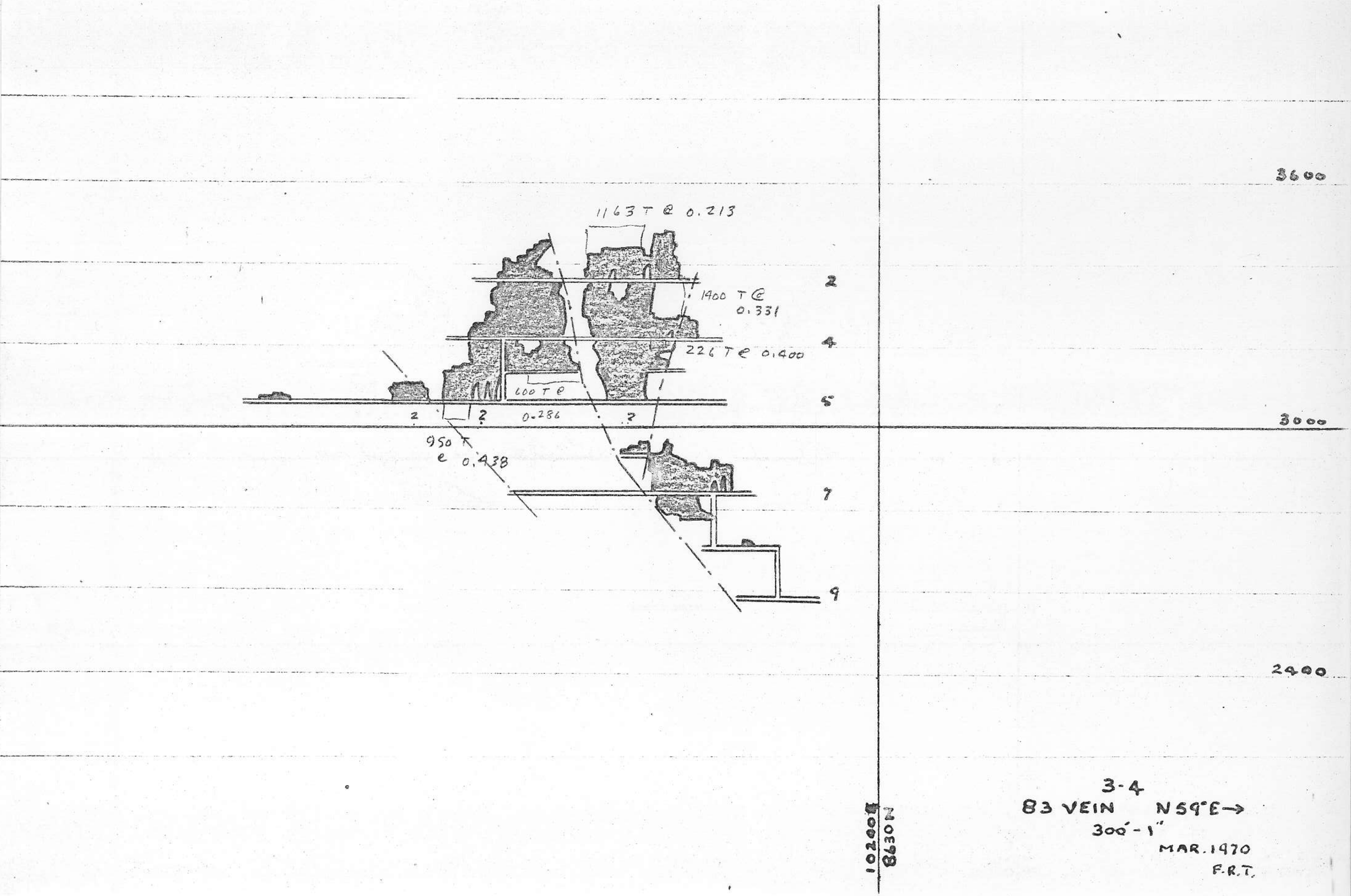
3-2
92 VEIN N56°E
300'-1"
MAR. 1970
F.R.T.

9200E
9200N

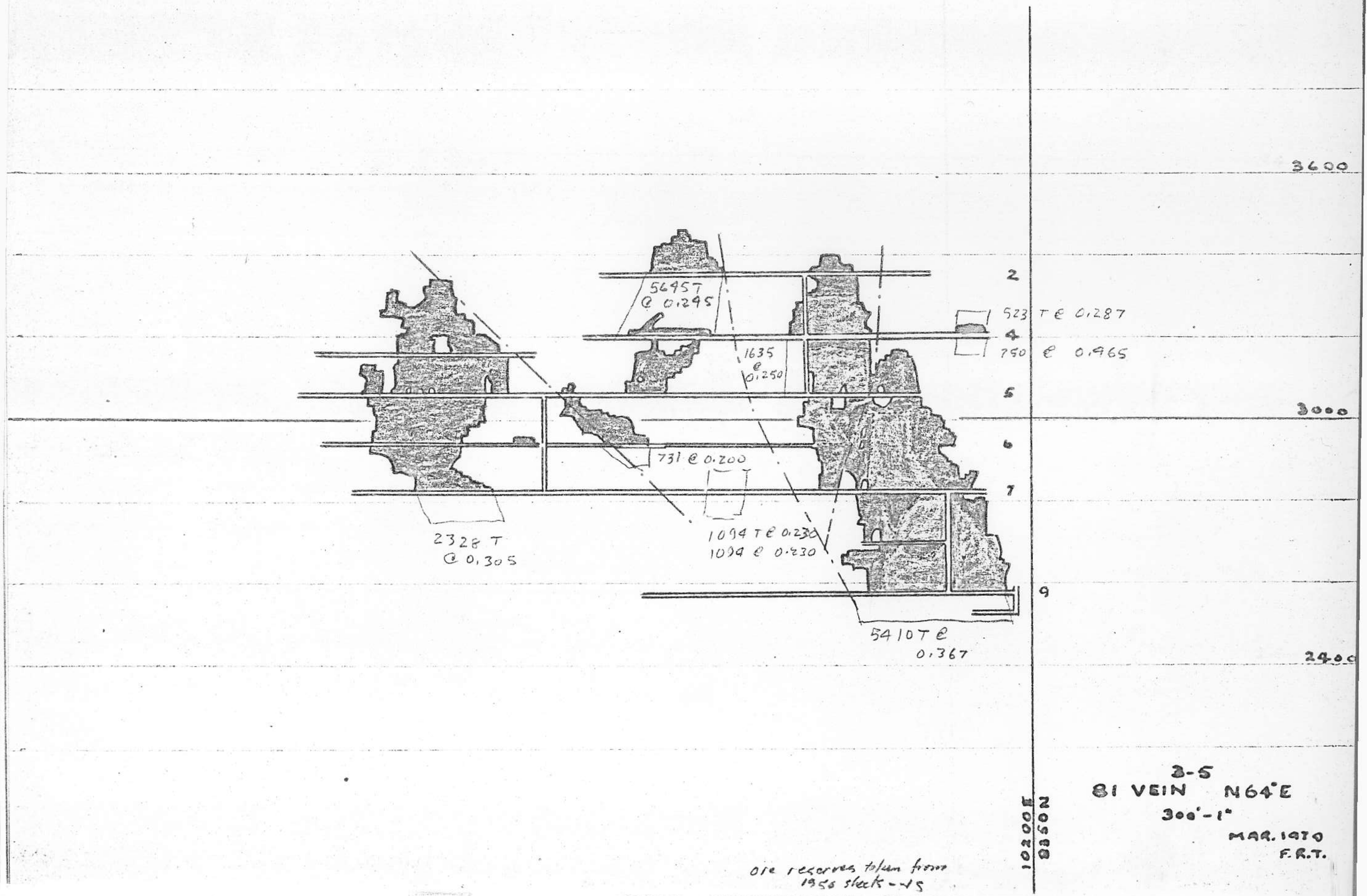
ore reserves taken from 1950 sheets. JS

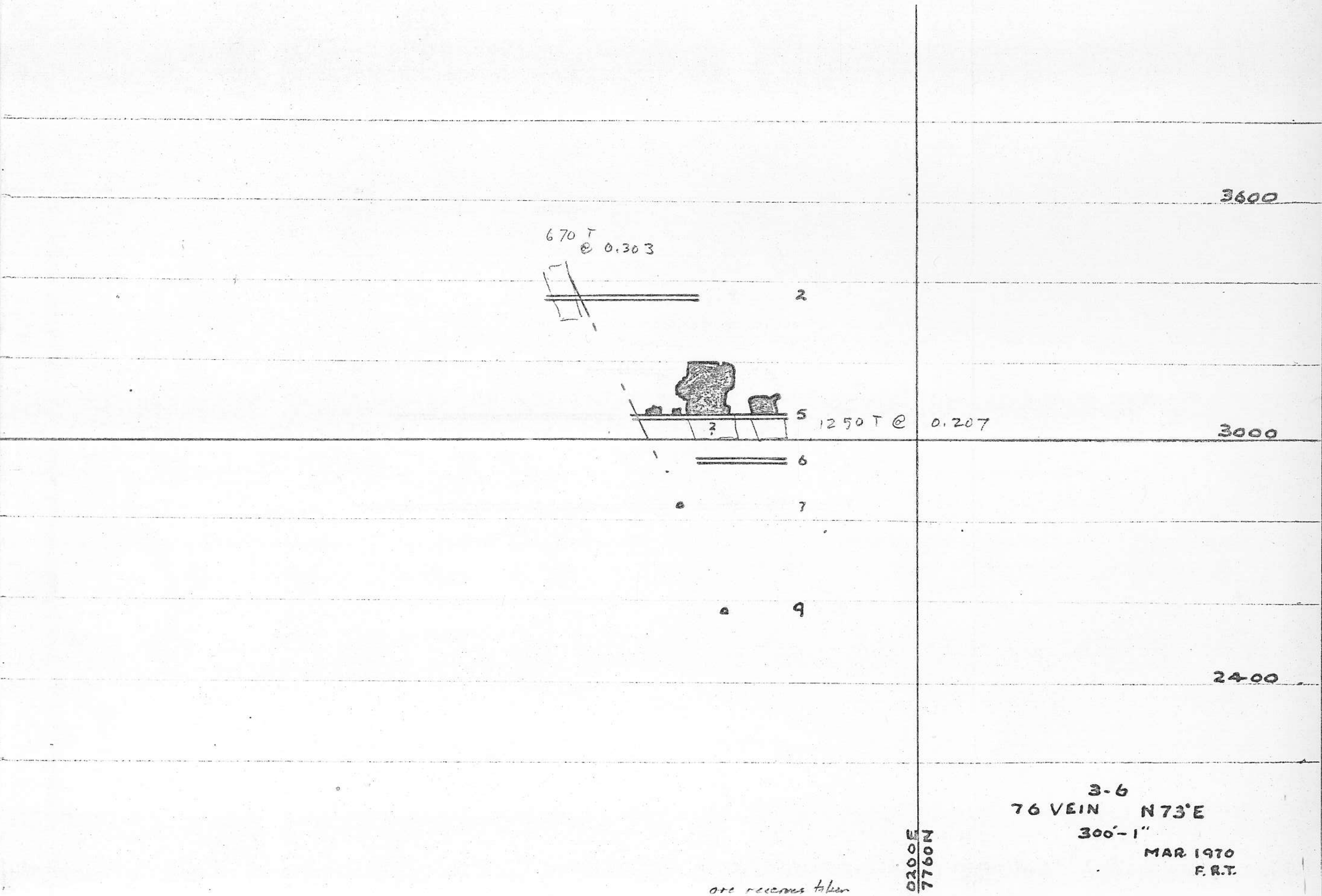


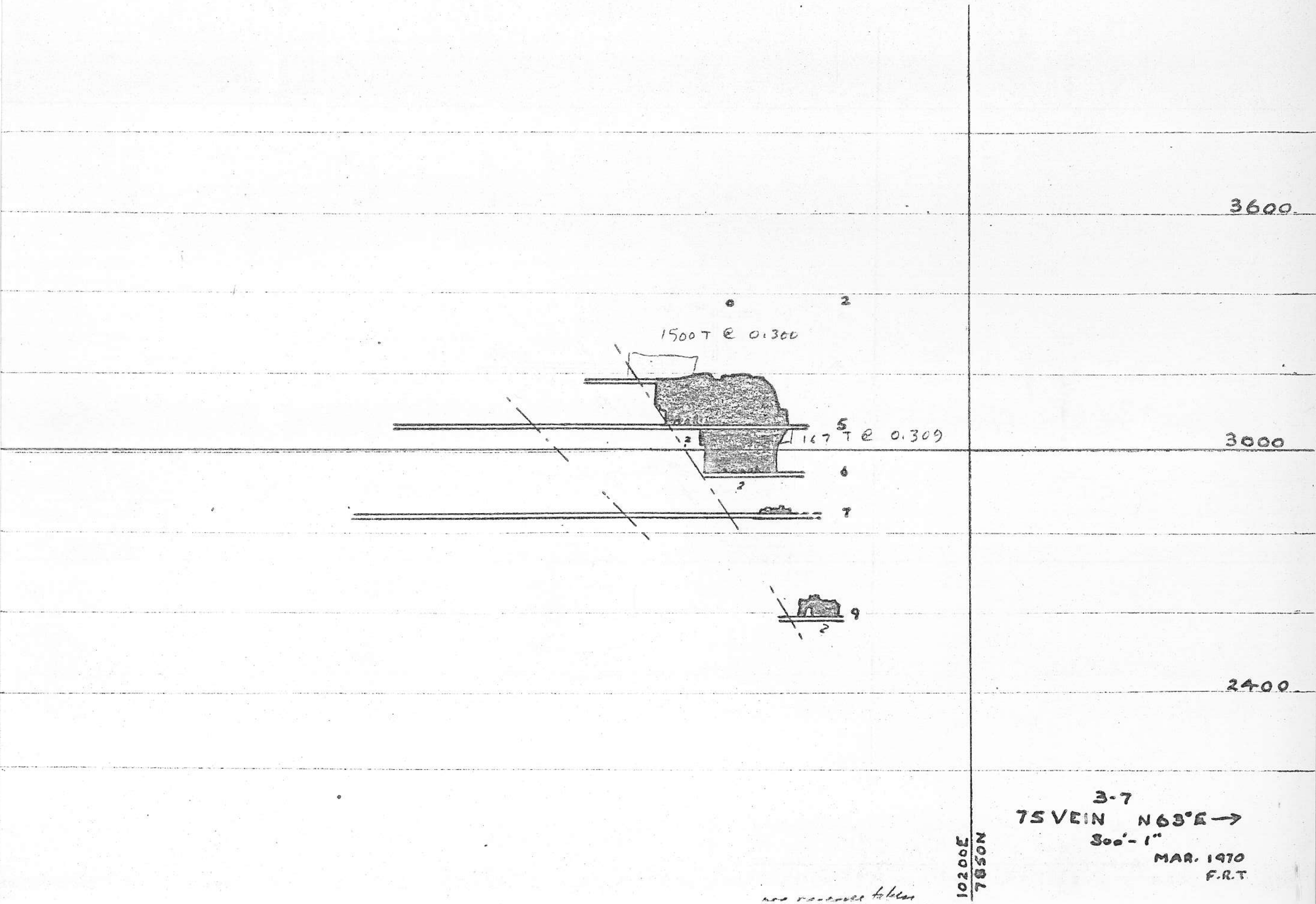
3-3
85 VEIN N62°E
300'-1"
MAR. 1970
F.R.T.



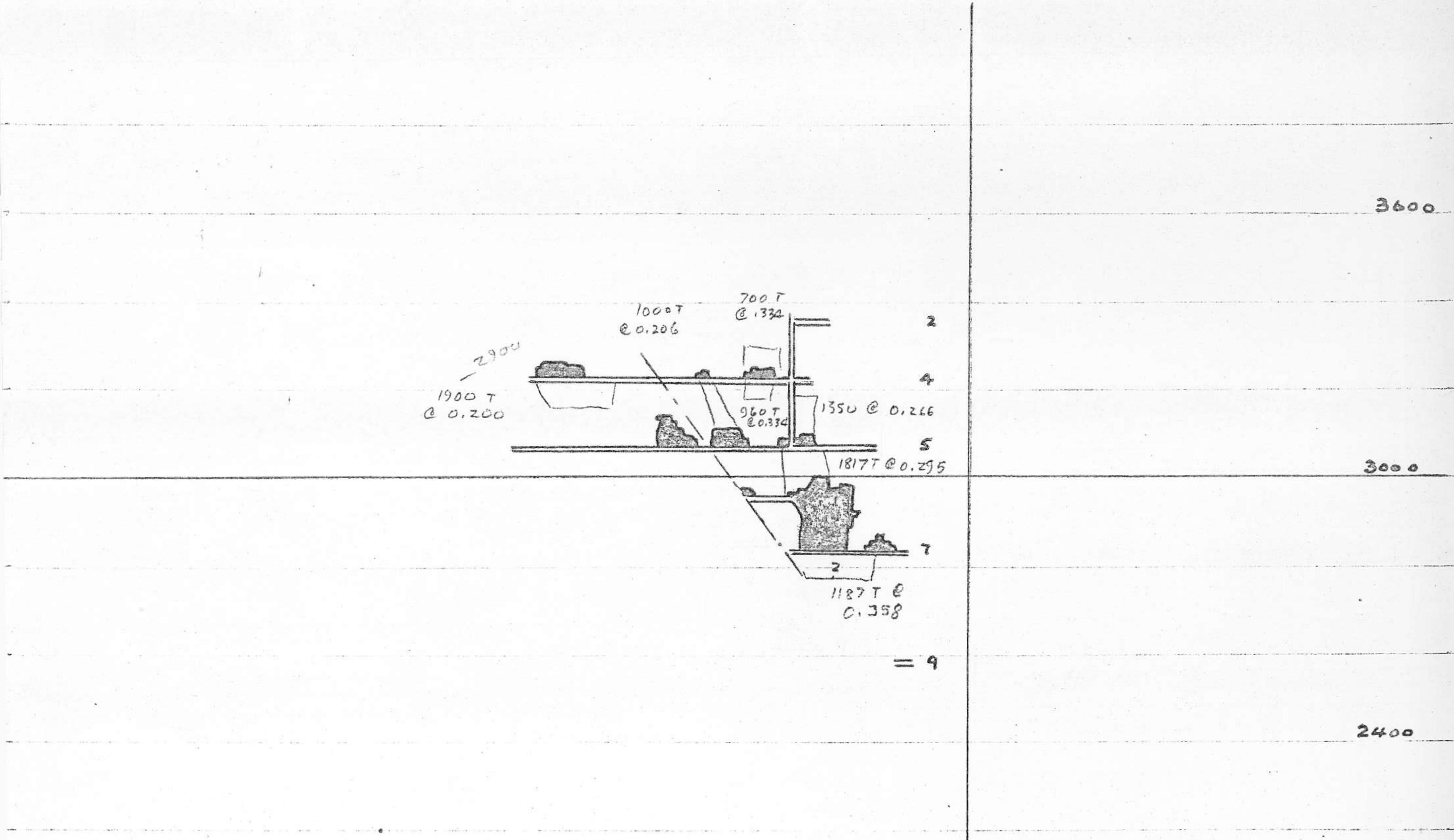
3-4
83 VEIN N59°E→
300'-1"
MAR. 1970
F.R.T.


3600
3000
2400
2
5645T
@ 0.295
523 T @ 0.287
4
750 @ 0.965
1635
@
0.250
5
6
731 @ 0.200
7
2328 T
@ 0.305
1094 T @ 0.230
1094 @ 0.230
9
5410 T @
0.367
10200E
8850N
8-5
81 VEIN N64°E
300'-1"
MAR. 1970
F.R.T.
ore reserves taken from
1956 sheets - JS

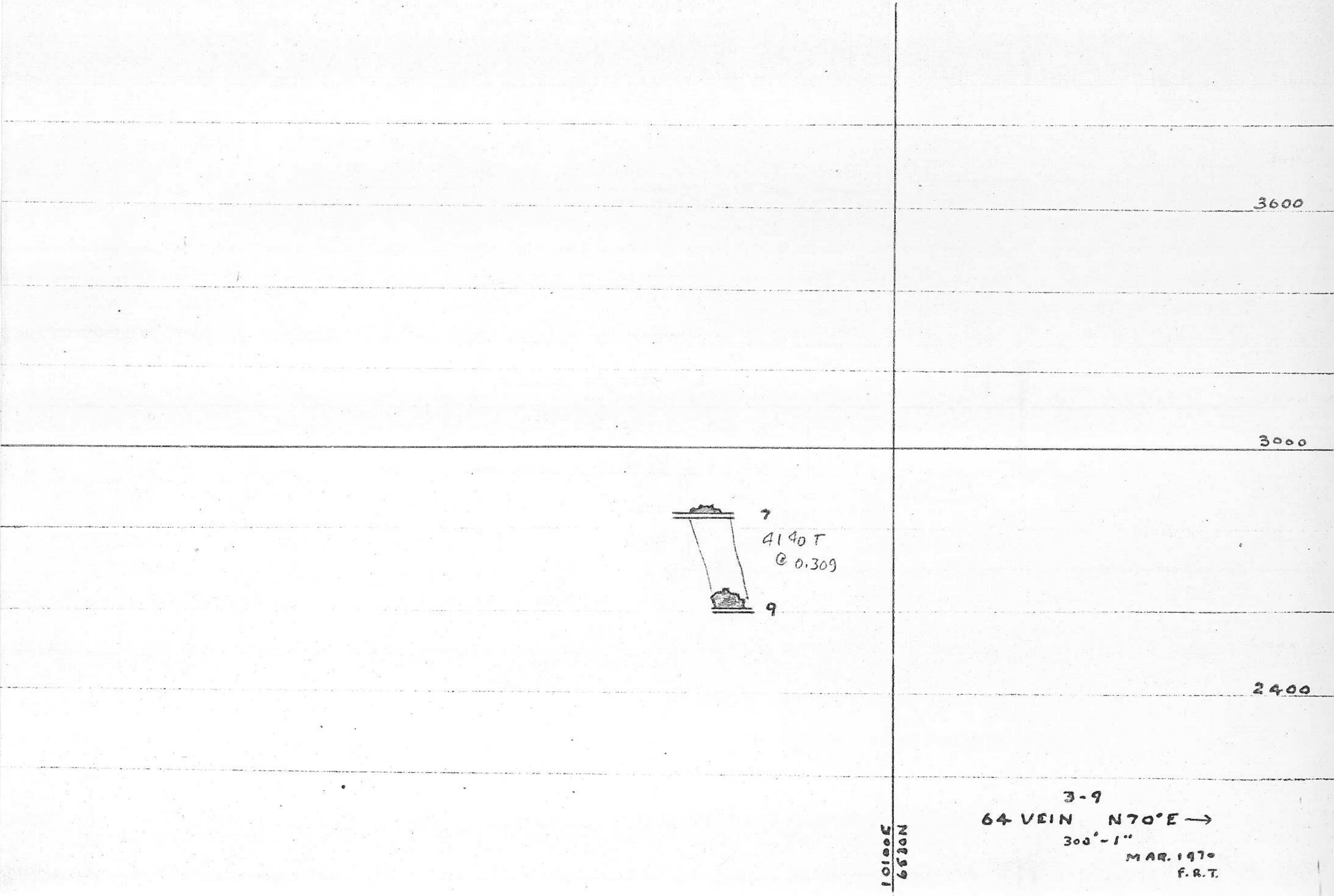

3600
670 T
@ 0.303
2
5
1250 T @ 0.207
3000
6
7
9
2400
3-6
76 VEIN
N73°E
300'-1"
MAR 1970
F.R.T.
0200E
7760N
ore reserves taken



3600.
1500 T @ 0.300
5
167 T @ 0.309
3000
6
7
9
2400
10200E
7850N
3-7
75 VEIN N63°E →
300'-1"
MAR. 1970
F.R.T



3-8
68 VEIN N 60°E →
300'-1"
MAR. 1970



3-9
64 VEIN N70°E →
300'-1"
MAR. 1970
F.R.T.

Level	Drift + X-Cut on Veins*	Main X-Cut
2	3900	2110
5	8060	5440
7	8830	**8330
9	3260	4020
10	90	1040
	24,140	20,940

* Queen not included
** includes 7N to Yellowstone & 7E to Alexandra & north to Block.

Production for the camp from 1899 to 1951 is reported at 1,721,580 tons containing recoverable gold in the amount of 736,015 ounces. Average per ton is 0.427. Average per ton from the Sheep Creek Mine is 0.41 ounces.

It is reasonable to assume that future production from the camp would be in this area; conservatively say 0.40 ounces per ton.

ORE RESERVES

The last estimate prepared by Sheep Creek was dated January 1st, 1950. With existing costs and the present price for gold the reserve is non-existent. For informative purposes the following is submitted.

Jan. 1, 1950	Tons	Oz./ton
Developed ore - broken	5,596	0.41
Developed ore - unbroken	38,539	0.293
Undeveloped ore - probable	16,597	0.342
Total, including probable	60,732	0.317
Depleted 1950	-15,846	-0.328
Estimate including probable	44,886	0.313
Undeveloped - marginal	14,800	0.201
	59,686	0.285

MINING METHODS

Mining was by the shrinkage method. Stopes on veins south of the Queen were started from one of the main levels. Generally, a sub-level was developed midway to the next main level. Timbered sills were used and chutes of a standard size placed at 20' to 24' centres. When drawing shrinkage rock a timber crew followed the draw down, placing stulls as required and sweeping the footwall.

Ventilation raises were driven from level to level in the stope block, and later were used as a service raise to the stope. Manways, at not more than 100 feet apart, were timbered as the stope advanced.

Stope drilling pattern depended on the width being mined. Normally, in stopes with a vein width of 3 feet, the holes were drilled on foot and hanging with a centre hole in a staggered position. In the wider stopes, three holes abreast were drilled.

Vein quartz and the quartzites were equally abrasive. Using steel bits 15" was the limit that could be drilled in one gauge. Holes ranged down from 2¼" in size, bit gauge being 1/8", and length drilled was from 5 to 6 feet depending on vein width.

Development headings were drilled with an 18 hole round, advance being 5 to 6 feet per round. The brittle rock broke well and was excellent for machine mucking.

Drill steel used in raising and stoping was 1" Q.O. regular carbon steel and, in drift headings, 1-1/8" round. In the last 4 years of the operation the mounted drills were adapted to using the 1" Q.O. steel. Advance per bit was 12" to 17" in the headings.

Testing of the early jack leg machines and tungsten carbide bits was limited but negative on a cost per foot drilled. It is probable that a grade of carbide is now available that would be satisfactory and a reduction in hole size, with faster drilling, allowing for better performance in stoping and in heading work.

Haulage was with Mancha's Little Trammer. Battery charging was centred on 7 level and the trammers moved to the other levels in the cage. Hudson type cars were used in 24 cu. ft. size, and operated with six cars to a train. Track grade was maintained at 0.4% with 18" gauge. 20 lb. rail was used in main cross-cuts and 16 lb. rail on lateral work in the veins.

The shaft operated at three shifts, with a skip and cage in balance. Hoisting of ore and waste required the surface bin to be cleaned twice a day. Where practical, waste was used as backfill in empty shrink stopes. The hoist was a C.I.R. P.E.I. 48" double drum hoist, equipped with post brakes, one drum solid to the shaft, and powered with a 150 H.P. motor.

Ventilation of the mine was controlled with air-operated doors on the levels to divert the air flow through active stopes to the exhaust fan at the portal of 2 level. The fan was reversible and had a capacity of 20,000 c.f.m. On occasion, the flow was inward to exhaust through No. 2 shaft to prevent excess icing in the shaft. Headings were ventilated with auxiliary air-powered or electric fans.

Pumping stations on 8 and 10 level, float controlled, handled the mine water. Volume was estimated at 150 g.p.m. Shaft water below 10 level was handled to the sump with an air-powered pump. Pump line in the shaft was 4" threaded pipe, using regular couplings and flange connections in the stations.

Compressors on the surface, capacity 2200 c.f.m., supplied air to the mine through a 6-inch pipe, with level development using 2 inch and coupled through the ventilation raises from level to level. Working crews at the stopes in the south end of the mine had to be restricted, to the extent of maintaining adequate pressure for drill operations.

TREATMENT PLANT

The treatment plant has been dismantled for a number of years. Should a plant be re-assembled under favourable conditions, the building and foundations may be of value.

The plant was of 150 ton daily capacity, using the counter current decantation method in the cyanide process. Gold recovery was 97% plus.

Crushing plant capacity was 20-25 tons per hour allowing operation on a single shift per day.

Cominco, in recent years, has contracted for waste rock from the dumps in the camp in some volume. Cominco's operation at Trail could be an alternative to the establishment of a treatment plant.

ECONOMIC CONSIDERATIONS

The Sheep Creek camp is credited with dividend payments of more than $5,400,000.

Sheep Creek Gold Mines to 1946 paid dividends of $2,765,625 credited to the operation of the gold mine.

Major producing veins in the Western anticline were:

Reno	261,500 tons	146,725 oz. Au
Queen	234,500 "	93,725 "
92	180,500 "	85,100 "
81	167,500 "	78,500 "

Major producing veins in the west limb of the Eastern anticline were:

Kootenay Belle "A"	204,500 tons	84,300 oz. Au
Motherlode	108,000 "	51,475 "

Undeveloped ground on strike of the Western anticline is north of the Gold Belt Mine and south of the Sheep Creek Mine. There is 5000 feet to be explored south of the Sheep Creek Mine and should the pattern of the camp continue through this ground, 10 veins would be located. Development has shown a vein occurring at a 500' average of strike length on the structure.

Veins on the 4500 feet between the Queen and 57 vein have produced over 700,000 tons averaging 0.40 oz. Au per ton. Veins on the 4800 feet between Gold Belt 3900 and 6600 vein have produced 260,000 tons averaging 0.31 oz. Au per ton. Underground development work would be necessary to determine the actual value of the ground to the south of the Sheep Creek Mine.

If and when a favourable relationship between the cost of services and the price of gold becomes a reality, consideration should be given to re-open the mine. It would be advisable to evaluate costs on the cost per ounce principle; a cost factor below 2/3 ounce value would be attractive. This should be calculated on a grade value of 0.3 oz. per ton.

To re-open the mine, this year, cost of dewatering is estimated as follows:

Supervision - 6 months	$6,600	
Labour (10 men) - 6 months	48,000	
Provision for power supply	20,000	(see note 1)
Provision for hoist	15,000	(see note 2)
Timber, lumber, concrete, etc. (re timber - 90' shaft, new collar, repair headframe & hoist room)	7,000	
Shaft equipment (skips, pipe, power & signals)	15,000	
Pump rental 600 gpm capacity, require for 3 months, head to 10 level 750'	8,000	
Station pumps, 2 @ 150 gpm	5,000	
	$124,600	
20% for contingencies	25,000	
	$149,600	

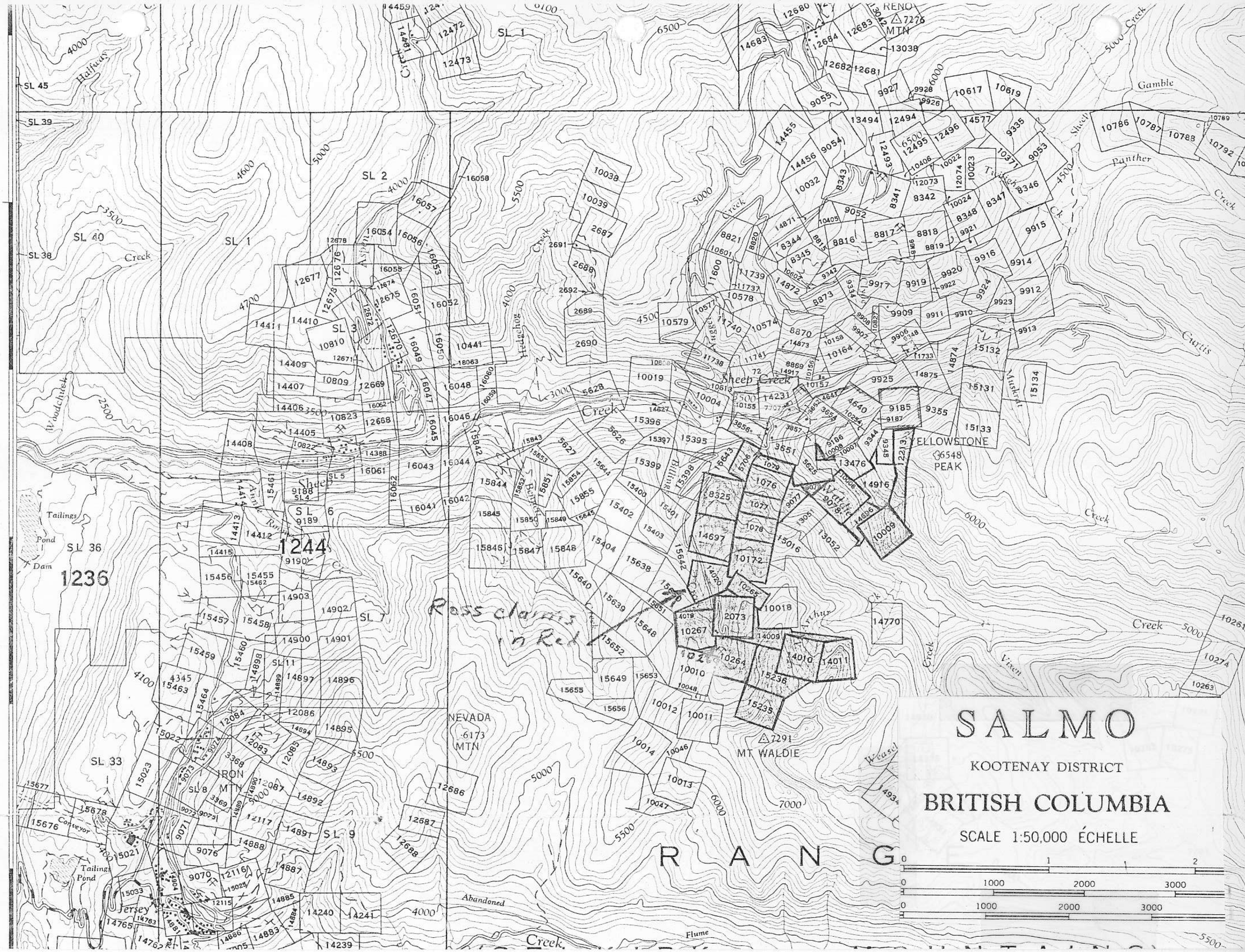
Note 1 - Assuming W.K.P. & L. re-establish sub-station Sheep Creek.

Note 2 - Hoist previously installed available from Mineral King Mine.

Respectfully submitted,

F. R. Thompson

F.R. Thompson, B.A.Sc., P.Eng.


SALMO
KOOTENAY DISTRICT
BRITISH COLUMBIA
SCALE 1:50,000 ÉCHELLE
Ross claims in Red
RENO MTN
NEVADA 6173 MTN
IRON MTN
MT WALDIE
YELLOWSTONE PEAK
Sheep Creek
Tailings Pond
Jersey
R A N G
1244
1236

V. SHEARER

BRITISH COLUMBIA DEPARTMENT OF MINES

HON. R. E. SOMMERS, *Minister* JOHN F. WALKER, *Deputy Minister*

BULLETIN No. 31

GEOLOGY OF THE SHEEP CREEK CAMP

By W. H. Mathews

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1953

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CHAPTER IV.—VEINS AND MINERALIZATION

SOURCES OF INFORMATION

When the study of the ore deposits of the camp was undertaken, nearly all the ore had been extracted from the parts of the veins so far developed. Isolated pillars and low-grade or narrow parts of the veins remained, but they scarcely provide adequate and representative samples of the material that has constituted ore. Mine records of vein widths and grades have, however, yielded valuable data on the characteristics of the orebodies and to their changes with depth. A general relationship between productivity of different parts of the veins and the adjoining wallrocks is, moreover, readily apparent from a study of the mine workings. A study by M. C. Robinson (unpublished M.Sc. thesis, Queen's University) of fifty-four polished sections constitutes the principal source of information on the relationships of the vein minerals. Further information has been sought in special studies of ore specimens by the writer, by Dr. F. G. Smith and A. D. Mutch of the University of Toronto, and by M. C. Robinson and J. A. Gower.

GENERAL DESCRIPTION

The gold deposits of the Sheep Creek camp consist essentially of quartz veins containing as a rule minor amounts of sulphides. Pyrite is the most abundant sulphide; galena and sphalerite are present, but as a rule it is only where the veins cut limestone that these two minerals oecur in commercial quantities. Nearly all the production of gold has been from those parts of the veins where one or both walls consist of quartzite of either the Nugget or the Navada members of the Quartzite Range formation. Vein fractures cutting argillite are generally devoid of quartz* or are occupied by only a thin band of barren vein matter. The extent of the productive part of any vein along the vein is, therefore, limited by the distribution of the favourable quartzite in its walls. Within the favourable quartzites, oreshoots make np varying proportions of the veins. The upper limit of orebodies is most commonly the ground surface, or in the Western anticline the crest of the quartzite beds, but in places in the southern part of the camp, even within a single type of rock, veins become narrower upward to the point that they cannot be mined economically. In general, vein widths do not diminish downward; on the contrary, vein widths are average or greater than average on the lowest levels of most mines. However, high-grade ore occurs less abundantly in the lower levels, and the proportion of the vein that could be mined profitably diminishes. On the lowest levels on which several veins have been explored no ore was found, or the proportion of ore to submarginal parts of the vein was such that no net profit resulted from exploring and mining the veins on those levels. In the veins that have been explored, oreshoots have been found within a vertical range that is not more than 1,600 feet for any vein. This productive range is found at elevations that from north to south are progressively lower.

PRODUCTION

The year by year production of the Sheep Creek camp and the production attributed to individual veins are set forth in Tables VI and VII, pages 51 and 52.

The total recorded production from 1899 to 1951, inclusive, amounts to 736,015 ounces of gold and 364,793 ounces of silver, from 1,721,580 tons of ore. Lead amounting to 377,568 pounds and zinc amounting to 312,633 pounds were contained in crude ore, gravity concentrates, and flotation concentrates shipped to the smelter. Recovery of lead and zinc was recorded from 188,000 tons of ore, and lead alone from a further 18,000 tons. These figures indicate an average of approximately 2 pounds of lead, and

* Lenses of quartz paralleling the bedding in the wallrocks are relatively common in the more argillaceous strata but not in the quartzites. For completeness it may be noted that these lenses have not been productive and their presence has been revealed only by occasional intersections in the mine workings.

slightly less zinc per ton of ore. In the 1,500,000 tons of ore for which the returns do not indicate any lead or zinc content, it is unlikely that the content of either averaged as much as 2 pounds per ton.

The production of each of thirty-two individual veins is set out in Table VII. Company estimates of tonnages and average grades of ore extracted from various stopes and veins are the sources of information on the production for the veins of the Sheep Creek, Reno, and Gold Belt mines. McGuire (1942) quotes production figures for the individual Kootenay Belle veins for the period March 31st, 1934, to September 1st, 1941, but records are not available prior to or since that time other than for the total production of the mine.

TABLE VI—RECORDED PRODUCTION, SHEEP CREEK CAMP

Year	Motherlode, Nugget, Reno		Queen and Sheep Creek		Kootenay Belle		Gold Belt		Total Production of Camp	
	Ore Milled or Shipped	Gold	Ore Milled or Shipped	Gold	Ore Milled or Shipped	Gold	Ore Milled or Shipped	Gold	Ore Milled or Shipped	Gold
	Tons	Oz.	Tons	Oz.	Tons	Oz.	Tons	Oz.	Tons	Oz.
1900–01[1]	----	----	----	----	----	----	----	----	16,988	5,421
1902–03[1]	----	----	4,663	2,658	----	----	----	----	4,663	2,842
1904–05	----	----	10,924	4,773	415	1,252	----	----	11,339	6,025
1906–07[1]	141	696	15,875	7,512	1,364	1,515	----	----	17,485	9,912
1908–09[1]	7,148	9,326	20,086	11,543	3,148	1,947	----	----	30,456	22,935
1910–11[1]	8,964	7,177	26,709	14,372	31	236	----	----	35,857	22,337
1912–13[1]	42,041	23,924	18,474	6,095	----	----	----	----	60,503	30,164
1914–15[1]	22,892	10,273	19,350	10,608	----	----	----	----	42,446	21,125
1916–17	----	----	2,060	860	----	----	----	----	2,060	860
1918–19[1]	----	----	56	8	----	----	----	----	93	18
1920–21	15,577	4,873	----	----	----	----	----	----	15,577	4,873
1922–23	5,645	2,293	----	----	28	170	----	----	5,673	2,463
1924–25[1]	----	----	----	----	----	----	----	----	4	15
1926–27	----	----	27	65	149	380	----	----	176	445
1928–29	2,008	1,807	1,756	229	282	538	----	----	4,046	2,574
1930–31	21,614	17,530	----	----	----	----	----	----	21,614	17,530
1932–33[1]	24,055	14,861	1,850	150	915	1,308	----	----	27,102	16,953
1934–35[1]	66,812	37,507	28,197	9,081	17,924	7,374	318	640	113,255	54,606
1936–37[1]	88,729	50,895	109,216	40,417	63,464	12,822	----	----	163,327	115,757
1938–39[1]	66,538	28,410	109,286	53,647	100,904	38,154	67,682	21,006	344,792	142,672
1940–41[1]	52,016	18,535	110,129	52,312	73,481	22,427	118,868	32,759	354,408	126,041
1942–43	1,949	2,062	85,680	35,572	28,760	10,293	70,145	25,404	186,534	74,331
1944–45	1,713	585	37,688	14,855	248	107	1	14	39,650	15,561
1946–47	1,303	685	48,029	13,924	564	148	----	----	49,895	14,857
1948–49	362	184	53,424	19,126	748	652	154	45	54,688	20,019
1950–51	110	97	15,846	5,203	468	261	170	116	16,594	5,677

SUMMARY

	Ore	Gold	Silver	Lead	Zinc
	Tons	Oz.	Oz.	Lb.	Lb.
Columbia, 1932, 1933	42	31	46	----	----
Fawn, 1915, 1935	74	131	13	----	----
Gold Belt	257,338	79,984	32,761	----	----
Kootenay Belle	292,893	109,937	37,153	----	----
Motherlode, Nugget, Reno[2]	429,667	231,932	184,502	----	----
Ore Hill, 1906, 1914–15, 1918, 1936–38, 1940	3,669	2,849	5,415	186,940	166,784
Queen and Sheep Creek[3]	719,320	303,711	100,182	----	----
Sumit, 1906, 1908, 1910–11, 1914, 1924, 1938	1,205	870	1,218	30,264	28,634
Vancouver, 1909, 1911–13, 1932–33	383	964	412	----	----
Yellowstone, 1900–02	16,989	5,606	3,091	----	----
Totals	1,721,580	736,015	364,793	377,568[4]	312,633[4]

[1] Total for year includes any production from the Columbia, Fawn, Ore Hill, Sumit, Vancouver, and Yellowstone.

[2] From 1906 to 1922 production was from the Motherlode and Nugget veins; from 1928 to 1938 production was mainly from the Reno vein; thereafter it includes production from Nugget, Motherlode, Bluestone, and Reno veins.

[3] From 1900 to 1938 production was from the Queen vein; thereafter it includes production from other veins mined by Sheep Creek Gold Mines Limited (*see* Table VII).

[4] The lead and zinc totals include lead, 143,033 pounds, and zinc, 92,625 pounds, recorded as recovered from 155,625 tons of ore from the Reno mine and minor quantities from Kootenay Belle, Sheep Creek, and the Nugget-Motherlode.

The figures in Table VII representing the production from individual veins are based mainly on records of company sampling of stopes and of ore sent to mills, and generally are somewhat higher than the figures for the mines. The latter figures (Table VI) account for metal in bullion and in ore shipped.

TABLE VII.—PRODUCTION FROM INDIVIDUAL VEINS

Vein	Company[4]	Tonnage Mined to Dec. 31, 1950	Ounces of Gold Produced to Dec. 31, 1950
Western Anticline			
Sumit		1,500	875
Ore Hill[1]	Sheep Creek Gold Mines Ltd.	3,500	2,850
57	Sheep Creek Gold Mines Ltd.	15,500	5,275
64	Sheep Creek Gold Mines Ltd.	2,000	700
68	Sheep Creek Gold Mines Ltd.	16,000	5,450
75	Sheep Creek Gold Mines Ltd.	30,500	12,725
76	Sheep Creek Gold Mines Ltd.	6,500	1,700
81	Sheep Creek Gold Mines Ltd.	167,500	80,700
83	Sheep Creek Gold Mines Ltd.	56,000	19,850
85	Sheep Creek Gold Mines Ltd.	6,000	1,575
92	Sheep Creek Gold Mines Ltd.	180,500	86,275
Queen[1]	Sheep Creek Gold Mines Ltd.	234,500	93,725
Yellowstone[1]	Sheep Creek Gold Mines Ltd.	17,000	5,600
Dixie-6600	Gold Belt Mining Co. Ltd. and Kootenay Belle Gold Mines Ltd.	33,500	11,725
8000	Gold Belt Mining Co. Ltd.	59,500	17,075
8200-Columbia[2]	Gold Belt Mining Co. Ltd.	41,000	10,050
2360	Gold Belt Mining Co. Ltd.	47,000	11,900
2590	Gold Belt Mining Co. Ltd.	150	60
3040	Gold Belt Mining Co. Ltd.	18,000	6,650
3050	Gold Belt Mining Co. Ltd.	300	650
3500	Gold Belt Mining Co. Ltd.	47,000	18,625
3900	Gold Belt Mining Co. Ltd.	17,500	5,175
Bluestone	Reno Gold Mines Ltd.	3,500	1,300
Reno	Reno Gold Mines Ltd.	261,500	146,725
Totals		1,265,950	547,235
Eastern Anticline			
Bonanza	Sheep Creek Gold Mines Ltd.	*Nil*	*Nil*
Alexandra	Sheep Creek Gold Mines Ltd.	3,000	540
Vancouver	Sheep Creek Gold Mines Ltd.	390	960
Black	Kootenay Belle Gold Mines Ltd.	45,000	15,475
B	Kootenay Belle Gold Mines Ltd.	32,000	9,150
A	Kootenay Belle Gold Mines Ltd.	204,000	84,300
Motherlode[3]	Reno Gold Mines Ltd.	108,000	51,475
Nugget[3]	Reno Gold Mines Ltd.	57,500	32,250
Fawn		75	130
Totals		449,925	194,280
Grand totals		1,715,875	741,515

[1] Includes production prior to ownership by the Sheep Creek Gold Mines Limited.
[2] Includes production prior to ownership by the Gold Belt Mining Company Limited.
[3] Includes production prior to ownership by the Reno Gold Mines Limited.
[4] *See* p. 75 for present ownership.

DIVIDENDS

Dividends paid from the profits of gold mines in Sheep Creek to the end of 1946 total more than $5,400,000. This sum includes $98,674 from the operations of the Queen mine 1902–07, $2,403 royalty from the Kootenay Belle in 1906, and $163,500 from the operation of the Motherlode, 1907 and 1915–16. Dividends paid in the period 1935 to 1946 amounted to $5,215,000 and include dividends paid by companies as follows: Gold Belt Mining Company Limited, 1940–42 and 1944, $668,595; Kootenay Belle Gold Mines Limited, 1938–41, $347,856; Reno Gold Mines Limited, 1935–39, 1942 and 1943, $1,433,640; Sheep Creek Gold Mines Limited, 1936–46, $2,765,625. Dividends paid by the Gold Belt (1944) and the Reno (1942 and 1943) companies include return of capital. The Sheep Creek Company has paid dividends since 1946, but it is considered that the payments to the end of 1946 fairly represent the dividends ascribable to operations of the company's gold mine on Sheep Creek. However, it should be noted that the revenue from which subsequent dividends were paid resulted from investing in other mines of money derived from the operation of the company's gold mine.

VEINS IN QUARTZITE

Vein Quartz

Typical vein quartz is milky white and may or may not be banded parallel to the walls. Generally, but not invariably, the quartz can be distinguished from the adjoining quartzite by colour alone. Its coarse texture, its brittleness under the blows of a hammer, its own pattern of fractures, and its banding where developed, all serve to distinguish it from the wallrocks. Commonly the outlines of crystals are made apparent on broken surfaces of quartz by obscure cleavage planes that evidently are limited to individual crystals. The crystals are characteristically irregular, equidimensional to slightly elongated but with their length rarely more than twice their breadth. Elongation of the crystals, if developed, tends to be perpendicular to the vein walls. Locally crystals exceed 1 centimetre in length, but more commonly their size is measurable in millimetres or tenths of millimetres. In thin section the fabric is more clearly displayed. Crystals are commonly interlocking, in places with finely sutured boundaries like those of some particularly intricate jig-saw puzzle. The teeth of the sutures are not oriented in any one direction, as they would be had they been formed (as stylolites are believed to be) by solution of the quartz while it was being stressed under directed pressure. Most of the quartz grains in any one thin section are the same general size, but ill-defined bands generally a fraction of a millimetre across may be much finer grained. Although such bands may have been formed by cataclasis,* they do not exhibit the characteristic strain shadows and sutured boundaries. Indeed, except for some of the largest grains, very little of the quartz shows pronounced strain shadows. A preferred orientation of intermediate-sized grains in the vicinity of these large ones has probably resulted from the breaking-down of large individuals. Elsewhere preferred orientation is not conspicuous.

The contact between vein quartz and one of its walls is as a rule sharply defined by a fault surface; but the contact between quartz and quartzite of the opposite wall may be gradational across inches or even feet. In some instances solid vein quartz grades outward into a network of narrow white veinlets cutting darker siliceous rock and thence into quartzite in which the white veinlets are scarce or absent. In other places homogeneous white quartz merges almost imperceptibly with massive grey or white quartzite. Parallel mica-rich or clay-rich bands cutting through a light-grey or white siliceous rock apparently mark argillaceous beds and in many instances can be traced into unaltered argillite. Some off-white siliceous rock between the walls of the vein is seen under the miscroscope to contain more or less uniformly distributed flakes of muscovite having a strong parallel orientation. Sharply defined white veinlets of quartz cut across the micaceous bands and the off-white quartzite. The filling of these veinlets is regarded as introduced quartz, although it is not clear whether it is (1) hydrothermal quartz from some distant source, (2) dissolved from near-by quartzite and precipitated along minute fractures, or (3) quartzite recrystallized in place along the walls of such fractures. The off-white siliceous quartzite with the flakes of mica is regarded as quartzite from which some of the darker constituents have been removed in solution. The white or pale siliceous rock through which the mica or clay-rich layers can be traced is also considered to be recrystallized quartzite even though its light colour, its coarse texture, and its mineralization indicate that it is now part of the vein itself.

Vugs and comb structure are rarely seen in the veins. A few of the large elongated grains of quartz, which commonly are strained or broken, have a suggestion of crystal outline, and it is possible that comb structure once present has been partly obscured by later deformation. Some of the small irregular masses of pyrite apparently occupy

* White, W. H. (1943), pp. 518–520.

former vugs, and in the oxidized parts of the veins, where the pyrite has been leached away, vuggy iron-stained cavities are revealed; but even in these oxidized parts such crystal-lined cavities are not abundant. It would seem that only a small proportion of the vein matter, a fraction of a per cent to a few per cent, has developed by the growth of quartz crystals in open space. In some branch veinlets, on the other hand, vugs and comb structure are common, and it would seem that these veinlets, rarely more than an inch wide, were formed in large part by crystallization in the open.

The proportions of vein quartz developed by growth in open space, by growth under confinement, and by recrystallization of siliceous wallrocks are difficult to assess. As noted above, the amount of quartz grown in open space seems to be relatively small. Judging from the wide zones of quartz, particularly in branching parts of the veins, through which relic argillaceous beds can be traced, a high proportion of the vein in certain places has developed by recrystallization of quartzite. It should not be inferred that all the vein matter devoid of vugs and comb structure developed in this way. Some quartz, lacking vugs and crystal faces, occurs between walls of relatively unaltered argillite, and it is improbable that this quartz developed by removal of every constituent but the silica from the pre-existing wallrock. Probably such quartz was introduced in solution and precipitated in fractures that were so constricted that no crystal faces could develop. In the absence of such criteria as relic bedding, however, no satisfactory method of distinguishing introduced quartz from quartz formed by recrystallization in place is known.

Mineralization

Mineralization is largely confined to the vein quartz bounded on one or both sides by quartzite. Pyrite may occur in typical quartzite, but beyond the limits of the typical vein quartz its gold content is reported to be negligible. Physical rather than chemical differences between the quartz and quartzite seem to be responsible for the localization of mineralization. Relatively great stress is probably necessary to deform quartzite, and under deformation it apparently yields either by bending or by movement along discrete, relatively widely spaced joints. Vein quartz, on the other hand, is a brittle rock which breaks under stress along a myriad of closely spaced fractures favourable for the infiltration of mineralizing solutions. Where quartz and quartzite occur together, deformation is likely to be concentrated, if not confined, in the vein quartz. Where quartz and argillite occur together, deformation seems more likely to be concentrated along the contact between the two rocks, and the vein quartz may be so slightly fractured as to be unfavourable for mineralization.

The minerals found in the veins consist principally of the sulphides pyrite, galena, and sphalerite. Other minerals known to occur in minor amounts in the veins are calcite, sericite, scheelite, wolframite, chalcopyrite, arsenopyrite, marcasite, tetrahedrite, ruby silver, and gold. Such supergene minerals as limonite, malachite, anglesite, smithsonite, and tungstite are known to occur in minor amounts in the upper parts of several of the veins. Spectrographic analysis of some of the ore minerals indicates that the sphalerite commonly contains as much as 0.1 per cent indium and is locally associated with still greater amounts of this element.

Sulphides occur in the veins in four ways: as long streaks as much as several inches wide, paralleling the walls; in small fractures cutting obliquely across the vein; in more or less irregular masses rarely more than an inch across; or as individual crystals disseminated through the quartz. Pyrite may occur in any of these forms, but is most common in streaks and disseminations. Galena and sphalerite are commonly localized along oblique intersecting fractures that may be concentrated in one or more bands within the vein. Although pyrite and, less commonly, pyrrhotite or sphalerite may form nearly pure streaks, the combined sulphides rarely make up more than 10 to 20 per cent of the full width of the vein. Only locally do galena and sphalerite together make up more than a few per cent of the vein matter, and as a general rule they constitute from a fraction of a pound to a few pounds per ton of the ore.

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(1) Quart
(2) Pyrrh
(3) Galen
(4) Gold.
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The sequence of mineralization as established by M. C. Robinson* is as follows:—

(*a*) Introduction of quartz and scheelite.
(*b*) Shearing and fracturing of early vein filling.
(*c*) Introduction of sulphides, late quartz, and calcite.

The vein minerals were introduced in four stages:—

(1) Quartz, pyrite, and arsenopyrite.
(2) Pyrrhotite, sphalerite, and chalcopyrite.
(3) Galena, tetrahedrite, and ruby silver.
(4) Gold.

Robinson adds that "With the possible exception of pyrite and pyrrhotite, the periods of deposition of minerals of any one of the above stages do not overlap those of minerals of other stages."

The gold occurs as isolated particles, generally from a few microns to about 30 microns across. Particles of gold sufficiently coarse to be seen with the naked eye are rare. About one-third of the gold, according to Robinson, occurs within quartz, generally along boundaries between quartz grains. The rest of the gold occurs with sulphides, notably along quartz-pyrite contacts or, less commonly, along contacts between quartz and sphalerite, pyrite and sphalerite, or sphalerite and galena. A few grains have been seen completely enclosed in pyrite or in galena. A widely accepted generalization in the camp is that the parts of the vein relatively rich in galena and sphalerite are rich in gold. Although the gold is in the vicinity of these two sulphide minerals, it is not necessarily in contact with them.

Oxidation

Complete oxidation of the primary minerals has taken place to depths of a few hundred feet in several of the veins, notably the Reno, Nugget, Motherlode, and the A and B veins of the Kootenay Belle mine. The veins of the Western anticline, with the exception of the Reno, have undergone very little oxidation except at their outcrops. Many of these veins are sealed off from descending waters by a hood of argillites. Others were similarly protected until recent down-cutting by Sheep Creek and its tributaries in the latest erosion cycle breached the cover of Reno beds. The Reno vein, on the other hand, outcrops at a surface formed in an earlier erosion cycle and has thus been exposed to the influence of meteoric waters for a long period. The same is true of the Nugget vein in the Eastern anticline. The Motherlode and Kootenay Belle veins now outcrop on the relatively youthful slope of Sheep Creek valley, but conceivably they extended in the near past without interruption up to the erosion surface produced in the next to last erosion cycle, and certainly they have not recently been protected by any hood of argillites. Although sulphide-bearing ores occur in the Nugget mine at intermediate levels, some oxidation and leaching have been observed on 9 level, more than 1,300 feet from the nearest point on the present surface and about 1,500 feet from the outcrop of the vein directly above.

Although the oxidation has led to the removal of the sulphides from the vein, it may have had little or no effect on the gold values. Assay plans of the Reno mine show no significant change in the average grade of the vein that can be related to the lower limit of complete oxidation. Gold sufficiently coarse to be visible to the naked eye seems to have been more abundant in the upper oxidized part of this vein, but this may have been a characteristic of primary mineralization. Ore mined from the Nugget vein from 1907 to 1912 and from the Motherlode vein from 1906 to 1915 was almost completely oxidized, and mining activity on the latter vein ceased when about the last of the oxidized ore was stoped. It should not be assumed that decline in grades of ore at the lower limit of general oxidation was responsible for cessation of these operations. The cost of driving long low-level crosscuts to intersect the veins at greater depth discouraged further development at that time, and problems of milling sulphide ores may have contributed to the

* Robinson, M. C., unpublished M.Sc. thesis, Queen's University, 1949.

shut-down. A decrease is recorded in the grade of ore produced from the upper levels of the Kootenay Belle mine in the period from 1904 to 1909 from more than 2 ounces of gold per ton at the start of operations to less than 0.8 toward the end. This need not be interpreted as a decline in grade of ore at successively greater depths, for the initial production of this mine was entirely shipping ore and the later production was milling ore. Actual decline in grade with depth need not be attributed to the effects of supergene enrichment, for an erratic but general tendency for the gold content of ore to decrease with depth is noted many hundreds of feet below the surface, within the zone of primary mineralization.

Vein Widths

The widths of the veins in quartzite commonly range from zero to several feet. Many of the veins attain widths of 4 to 6 feet locally, but few of the veins commonly have such widths. The Queen vein, within the Western anticline, is notable for its width, commonly being more than 6 feet wide and locally much wider.* Other veins are persistently narrow; the Black vein, for example, is less than 1 foot wide for more than half its stoped extent and reaches a maximum known width of between 5 and 6 feet in only one part of the Kootenay Belle mine. Greater than average widths tend to occur (1) within the more favourable stratigraphic units, (2) where the vein fracture trends more nearly east than usual, (3) between the forks of a branching fracture, (4) where fault movement along the vein fracture is greater than average, and (5) in the lower parts of the veins.

The influence of wallrocks on the development of vein matter has already been noted.† Apparently because of appropriate composition and physical characteristics the Upper Nugget quartzite was the most favourable wallrock for the development of wide parts in the veins. Middle Nugget and Upper Navada beds are somewhat less favourable than the Upper Nugget quartzite, and Lower Navada and Upper Motherlode beds contain vein matter only locally. The Reno beds have yielded significant quantities of ore only in the Reno mine where the rocks of this formation were locally metamorphosed, apparently prior to vein genesis, to a spotted schist approaching in its competency that of the near-by quartzites.

The variations in strike of the vein fracture were very important in determining the width of vein quartz that was formed. Development of actual open space along the section of the vein fracture that strikes more nearly east than average as a result of right-hand fault movement has been generally considered to be the explanation of this relationship. Petrographic studies indicate, however, that relatively little quartz has been developed as open-space filling. A reduction in pressure across these parts of the vein fracture as a result of the fault movements may have rendered these parts more permeable to solutions, and adjoining walls may have been subjected to more recrystallization. Growth of introduced quartz during movement may also have led to development of a vein-filling without the presence of extensive open space at any time.

The distinction between influence of wallrock and influence of attitude is difficult to make, as the vein fracture tends to strike more nearly east in the more favourable wallrocks. However, the fact that the 92 vein in the Upper Nugget beds of the western limb of the Western anticline strikes about north 75 degrees east and has yielded much more ore than the same vein in the same beds of the eastern limb of this fold where the fracture strikes about north 60 degrees east shows, however, that attitude by itself may be an important control of ore deposition. That it is not the only control is, on the other hand, shown by the absence of ore in the Queen vein fracture within the Reno beds of 3 level west where the attitude of the vein is almost the same as that of its productive parts in the adjoining Navada and Nugget beds.

*The Queen vein is reported to be as much as 16 feet wide, and some of the old stopes on it are said to be as much as 25 feet wide. It is probable that the latter width includes two or more parallel veins separated by barren or sparsely mineralized quartzite.

† *See* pp. 50, 54, and notes on formations in Chapter III.

Between the forks of a branching fracture, vein quartz tends to be wider than in adjoining parts of the same vein. The quartz in such a locality seems to be largely, if not wholly, formed by the recrystallization of pre-existing quartzite, and such vein matter may or may not be as favourable for mineralization as introduced quartz in other parts of the vein. Quartz at the junction of the Kootenay Belle A and B veins is, as a rule, both slightly wider and slightly richer than in the adjoining parts of the vein. No examples are known, however, of oreshoots being restricted to the junction of two vein fractures.

A relationship between displacement on the vein fracture and width of vein quartz is apparent in many places. Thus the western orebody in the Kootenay Belle A vein shows a distinct increase in width between 6 and 10 levels that coincides with an increase in net slip from a few feet at the former level to 40 feet at the latter (*see* Figs. 7 and 11). However, although the net slip increases more than five times, the average thickness of the vein scarcely doubles. The orebodies of this same vein in the Upper Nugget beds increase distinctly in average width from 2 to 3 levels as does the displacement along the vein fracture. Below 3 level the average thickness changes little, and the displacement is nearly constant. From these and less striking examples elsewhere it would seem that other things being equal the vein widths vary directly with the amount of displacement along the vein fracture though not necessarily in a simple proportion.

A general tendency for veins to decrease in average width upward, irrespective of change in displacement, is apparent in at least the upper parts of some of the veins. Above a particular level the vein may be so narrow that mining is not profitable. Stopes above the 2 level on the 83 vein of the Sheep Creek mine were abandoned because the vein narrows at an altitude of about 3,750 feet, even though displacement along vein fracture increases upward and favourable quartzites extend for 350 feet higher. Decreasing widths of ore led to abandonment of stopes on the 81, 75, and 68 veins at approximate altitudes of 3,700 feet, 3,400 feet, and 3,200 feet respectively, although here, too, favourable quartzites extend to considerably higher levels. In the Kootenay Belle mine the veins pinch upward, and the Black vein was too narrow in the upper levels to be mined to the surface. It is probable that other veins of the Eastern anticline also pinched upward within the quartzite.

The pinching upward of the 75 vein cannot be explained by a change in displacement along the vein fracture. Movement has been greatest in the upper levels on this vein and might be expected, by itself, to lead to an upward increase in width. On the other hand, a change in the strike of this and other vein fractures might provide one explanation for the upward decrease in width. The tendency for the vein fractures to strike more nearly east at depth than at upper levels (*see* p. 40) might account for a gradual increase in width with depth, but scarcely serves to account for the relatively abrupt changes in the veins noted above.

Branching Veins

Branching veins in which one or both branches contain ore are known at various places in the camp. More important branching veins include the Kootenay Belle A and B veins, both of which contain ore, and the Nugget and Calhoun veins, of which only the former has yielded ore. The displacement along the branching veins may be distributed about equally in each branch, or nearly all may be concentrated in one of the branches. In general the branch with the greater movement is the more continuous and the one more likely to contain ore. Where both branches have approximately the same amount of movement, the right-hand branch strikes more nearly east and is considered the more favourable for the presence of ore. In some instances the one branch may have been followed and shown to be barren, but profitable ore may exist in the other branch perhaps only a few feet away in the wall of the drift. Such occurrences of ore in branch veins were found on 5 and 6 levels of the Reno vein, and on 7 level in the eastern part of the Queen vein. One branch of both veins proved to be generally unprofitable opposite the productive part of the other branch. The same has proved true for the 83 and 85 veins of the Sheep Creek mine and for the lower part of the eastern orebody in the Motherlode mine.

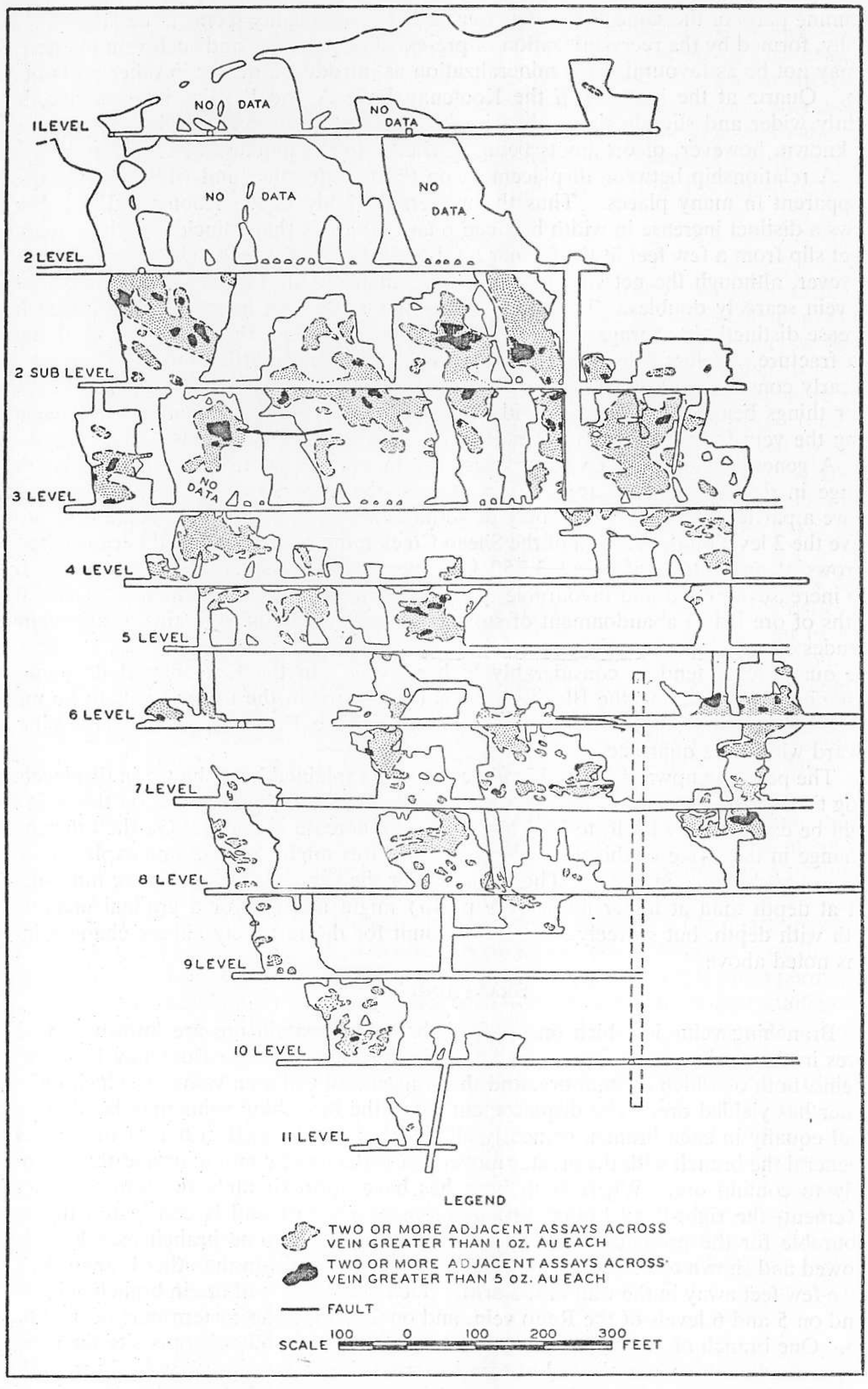

Figure 10. Longitudinal section of Kootenay Belle A vein showing distribution of gold values.

Figure 11. Longitudinal

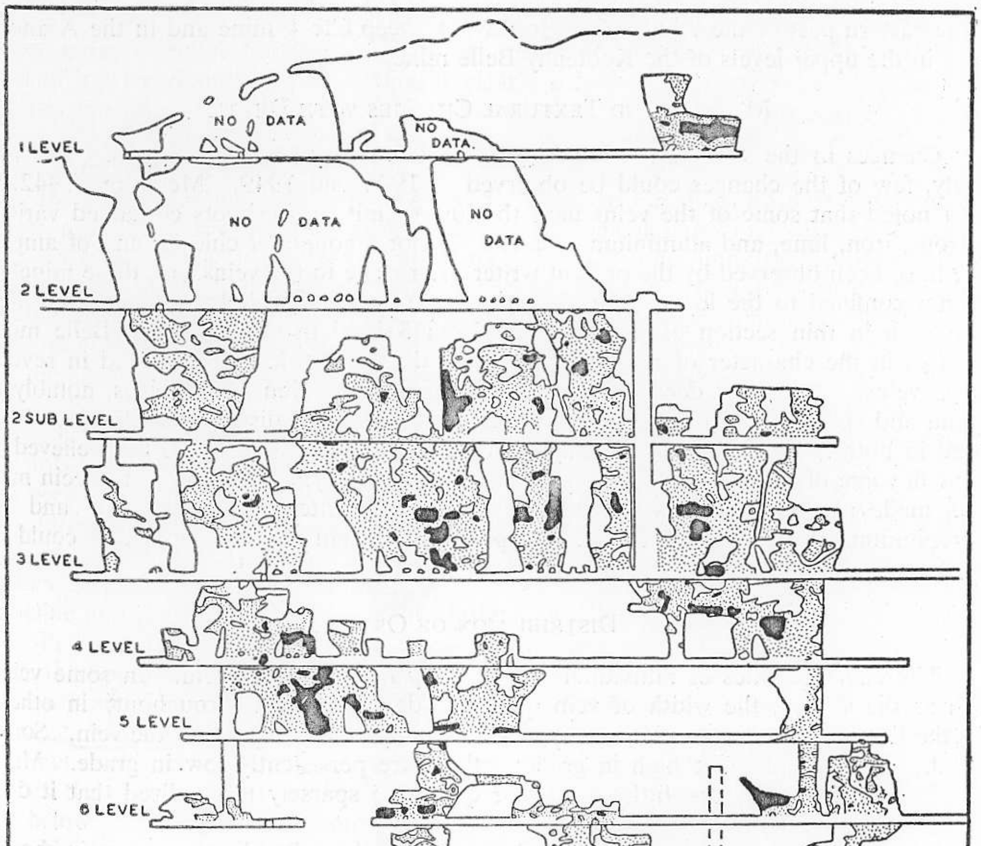

Figure 11. Longitudinal section of Kootenay Belle A vein showing variation of vein widths.

In other cases, however, oreshoots occur side by side in branching veins, as, for example, in the eastern part of the 75 and 76 veins of the Sheep Creek mine and in the A and B veins in the upper levels of the Kootenay Belle mine.

Mineral and Textural Changes with Depth

Changes in the veins with depth have been noted by various workers. Unfortunately, few of the changes could be observed in 1948 and 1949. McGuire (1942, p. 181) noted that some of the veins near the lower limit of oreshoots contained various hydrous, iron, lime, and aluminium silicates. Minor amounts of chlorite and of amphibole have been observed by the present writer in or close to the veins, but these minerals are not confined to the lower levels. Both chlorite and amphibole, for example, have been seen in thin section of vein material from 3 level in the Kootenay Belle mine. Changes in the character of mineralization with depth are widely recognized in several of the veins. A marked decrease with depth in the proportion of sulphides, notably of galena and sphalerite, and in the proportion of the vein that displays banding has been noted in both the Reno and Kootenay Belle veins, and similar changes are believed to occur in some of the veins of the Gold Belt mine. Geophysical studies of the vein minerals made at the University of Toronto using the pyrite geothermometer* and the decrepitation technique† did not indicate progressive changes with depth that could be used in identifying the levels from which any sample was derived.

Distribution of Ore

The characteristics of individual veins are by no means uniform. In some veins, such as the Queen, the width of vein quartz tends to be great throughout; in others, like the Black, only narrow widths of quartz are present in most parts of the vein. Some, like the Black, tend to be high in grade; others are persistently low in grade. Many vein fractures contain very little quartz, or quartz so sparsely mineralized that it does not constitute ore.

Distribution of Oreshoots within Veins.—Within the veins the ore occurs in shoots. Even the most productive veins, such as the Queen and Reno, had sections of considerable size that could not be mined profitably. In many of the veins, only about half the explored extent within favourable quartzite yielded ore, and in others only a very small fraction has been productive. The unprofitable parts of the veins are represented by nearly barren quartz that may be of average or more than average width, by a very thin band of quartz with or without mineralization, or in many places by a fracture devoid of vein matter.

The localization of oreshoots within a vein depends on a combination of factors that influence the width of vein-filling and the deposition of gold. No general statement can be offered to explain fully the localization of oreshoots in the veins of the Sheep Creek camp.

A special study was made of the distribution of gold within the Kootenay Belle A vein. Company data were used to prepare Figures 10 and 11, which show the distribution of gold and the vein widths within the stoped sections of the vein. Figure 10 indicates the distribution of patches containing an average of more than 5 ounces of gold per ton. These patches are irregular in outline and are as much as 30 feet in diameter. They seem to be distributed at random through lower-grade material. Locally the patches are elongated.

It is possible that day to day variations in discrimination between vein and wallrock by the sampler may introduce a pattern of assay results paralleling the backs of stopes as they were being developed. Nevertheless, the more irregular patches and those that plunge at moderate to high angles are believed to exist. Unfortunately, no wallrock structures have been observed that account for the distribution of the high-grade patches.

* Smith, 1947.
† Scott, 1948.

In places they coincide with narrower parts of the vein, in other places they coincide with the wider parts of the vein, and elsewhere they bear no relationship to vein width. A rather general decline in grade of the veins with depth is apparent notwithstanding the marked local variations. This decline is clearly indicated in many veins by production records as well as by assay sections. In the Kootenay Belle vein (*see* Fig. 10) patches of vein assaying more than 5 ounces of gold per ton are larger and more common in the higher part of the vein than at lower levels.

In the longitudinal sections of veins in the Sheep Creek camp it is apparent that stopes are within the limits of favourable stratigraphical units (*see* Figs. 3–8). The sections also suggest that within the favourable stratigraphic units the vertical distribution of oreshoots may have been subject to further control. Investigation of this possibility is extremely difficult because workings never expose a vein continuously throughout its vertical range and often expose very limited parts of the vertical range. Furthermore, the upper and lower margins of an oreshoot, if exposed, would probably be destroyed or obscured in the stoping operations, and finally the high cost of vertical workings limits the exploration of veins, particularly at depth. Because of the importance of the matter, the upper and lower terminations of oreshoots and the vertical ranges through which ore has been found are discussed in the following paragraphs.

Oreshoots that do not reach the ground surface may terminate upward (1) at the upper limit of quartzite, or (2) at various levels within the quartzite, by pinching to widths too narrow to mine profitably. These conditions are apparent in the Western anticline and presumably obtain in the Eastern anticline.

Pinching is characteristic of the more southerly veins of the Sheep Creek mine. Here the upper limit of ore is found at successively lower levels between the 92 vein on the north and 57 vein on the south (*see* Fig. 9). The southerly slope of this upper limit contrasts with the gentle northerly plunge of the fold axes between the same veins. From this fact may be drawn the inference that factors other than stratigraphic units have controlled the upper limit of ore in these veins, except that the upper margins of the stopes are below the Upper Nugget contact.

North of the Dixie vein, oreshoots terminated upward near the tops of the Nugget and Upper Navada in the Lower Navada and in the Reno formations. Except for the 8200 vein, the upper terminations of the oreshoots in the veins north of the Dixie are structurally controlled.

As mining progressed to deeper levels on the veins, it became apparent the various orebodies were being bottomed. In the Queen mine, between 2 and 7 levels, about 50 to 60 per cent of the length of the drifts within the limits of the Quartzite Range formation yielded ore; but east of the projected position of the Queen fault only 350 feet of 1,060 feet of vein exposed in the 8 level drift was stoped, only 65 feet of 770 feet of vein on 9 level, only 130 feet of 780 feet of vein on 10 level, and none of the veins was stoped along 440 feet of drift on 12 level. In the eastern part of the mine, therefore, the vein became subcommercial downward somewhere between 8 and 10 levels. West of the Queen fault a similar change was noted, but there the vein was subcommercial below 7 level, and drifts having lengths of 710 feet on 8 level, 140 feet on 10 level, and 520 feet on 12 level disclosed no part of the vein that could be stoped profitably. It had been demonstrated by more than 3,000 feet of drifting that oreshoots on the Queen vein had bottomed under operating conditions. It is interesting to note that the orebody east of the Queen fault bottomed between 100 and 300 feet below the one west of the fault. At the time of ore deposition, prior to this faulting, the lower limit of the western orebody was level with or slightly below the lower limit of the eastern orebody.

In the Reno mine more than 80 per cent of the length of the vein zone on levels down to No. 8 had yielded ore. Levels 9 and 11, representing more than 2,000 feet of drifting in the vein zone, showed that only 20 to 30 per cent constituted ore; and 12 level, explored for a length of 410 feet, produced no ore. On 10 level the vein zone was explored for a length of about 500 feet, in which a length of 250 feet was stoped. That was superior to the proportion of ore length to total explored length on 9 and 11 levels but was much inferior to the results obtained on the higher levels, both in the proportion of ore length to total explored length and in the actual length of ore. Thus exploration of all four of the lower levels showed much less ore than in higher levels.

Exploration on 10, 11, and 12 levels of the Motherlode mine, along the 750- to 800-foot length of vein within the Middle and Upper Nugget beds, yielded an aggregate stope length of 355 feet, 270 feet, and 50 feet in successively lower levels. At the same time, work on the lower levels of the Kootenay Belle mine on A vein demonstrated that only a relatively small proportion of this vein constituted commercial ore. A small amount of exploration on the Nugget vein disclosed no ore on 10 and 9 levels, but a stope 100 to 150 feet long was developed above 8 level. The levels at which the orebodies bottomed in these veins in the Eastern anticline lie not more than a few hundred feet above the lower limits of ore along the strike of the veins to the southwest in the Western anticline.

The distribution of oreshoots in the veins of the mines of the Sheep Creek camp is indicated in the longitudinal sections of several veins (*see* Figs. 3–8) and in the vertical sections along the two anticlines (*see* Fig. 9). If a surface is imagined running through or below the bottoms of the lowest known oreshoots in the different veins of the Western anticline, disregarding oreshoots that bottom considerable distances above it, the surface could be thought of as a plane that from the Reno vein as far south as the Queen vein slopes gently southward.

Exploration on the Yellowstone and 2360 veins below their known orebodies did not find additional orebodies at depths that are 500 feet and 300 feet respectively above the plane linking the bottoms of the orebodies in the Reno and Queen veins.

Exploration has been done as much as 250 feet below the bottoms of the lowest stopes on several veins, and the Queen vein (*see* Fig. 7) was explored at greater depths below the bottoms of oreshoots rich enough to repay the cost of exploration as well as of mining. However, it should be recognized that few veins have been explored exhaustively on the lower levels or explored at all at more than a limited depth below the lowest known oreshoots.

In the Eastern anticline the distance from north to south in which veins have been productive or have been explored is less than in the Western anticline. The bottoms of orebodies in the three main veins in the Eastern anticline were reached in 1940 to 1941, and work on the veins at lower levels was abandoned. However, it should be recognized that in the Nugget and Motherlode veins (*see* Figs. 4 and 5) non-productive intervals ranging from 300 to 450 feet occur between the bottom of one stope and the top of the one below it in the same formational unit.

The idea that the veins of the Sheep Creek camp may be productive only above a fairly regular limiting surface was conceived as an explanation for the disappointing results obtained in the lower drifts on several veins. No physical characteristics of the wallrocks or veins and no distinct changes in the character of mineralization have been recognized as marking the lower limit of ore. After the concept that veins were reaching their lower productive limit had gained acceptance, operators were reluctant to undertake further exploration on the lower levels or at greater depth. Figures 3 to 8 show the extent to which several of the veins have been explored in the various favourable formations. Veins remain strong on the lowest levels, but grades are low. However, as barren vertical intervals separate oreshoots in several veins, the development below known orebodies cannot be taken as proving that ore may not exist at still lower levels. The suspension of operations in the period 1937 to 1941 and in 1951 was caused by decline in grade of ore with depth, and by exhaustion of known ore, combined with rising costs. It must be concluded that beneath the bottoms of known oreshoots there are bodies of vein material that could constitute ore, at least under a markedly higher price for gold or markedly cheaper costs.

The greatest vertical range through which any vein has been stoped is 1,600 feet on the Kootenay Belle A vein. If the 3040 and C veins of the Gold Belt mine are parts of a single fissure, it has been stoped in the highest and lower parts of a vertical range of 1,590 feet. The Reno, Nugget, and Motherlode mines have had productive ranges of 1,490, 1,360, and 1,350 feet respectively. No other vein has yielded ore through a vertical range of more than 1,200 feet.

Distribution of Ore in the Camp.—The production from different veins varies markedly (*see* Table VII, p. 52). The greatest production has been obtained from the Reno, Queen, 92, 81, and Kootenay Belle A veins, each of which has yielded more than 80,000 ounces of gold. A concentration of production around two centres, one at the Reno vein in the northern part of the camp, the other immediately south of Sheep Creek and including the Queen, 92, 81, and A veins, is apparent, but the explanation of the concentration is less obvious.

The limitation imposed by the length of vein in favourable quartzite is important. The Gold Belt veins in general have been less productive than the veins of the Sheep Creek mine because the Gold Belt veins have distinctly shorter lengths in the favourable quartzites. However, this factor does not adequately account for the two concentrations of ore within the camp, neither does the amount of displacement on the veins. The displacement on the highly productive Queen vein is relatively large, but so also is the displacement on the much less productive Yellowstone vein, whereas on the most productive vein, the Reno, the displacement is moderate. However, it should be noted that vein fractures with less than 10 feet displacement tend to be limited in extent and for that reason are unlikely to yield large quantities of ore. The two centres of greatest production might be correlated with those parts of the camp in which the axial planes of the folds are bowed convex to the west in plan (*see* Fig. 2). Conceivably the stresses developed at the time of vein formation were localized by or even expressed in these two changes in strike, but such a relationship seems too tenuous to merit much weight. The extent to which the ground has been explored may offer a better explanation for the apparent concentration of ore in two parts of the camp, and if the ground between them had been explored more completely, the two local concentrations might be far less obvious.

Time of fault movement relative to time of introduction of vein-forming solutions is believed to have been important in controlling or making possible the formation of oreshoots. It has already been noted that fault movement on the vein fractures was not initiated simultaneously even in adjoining fractures (*see* p. 30). Similarly some veins have participated in late left-hand movements that did not affect others (*see* p. 42). The possibility that some fractures were not open at the time of introduction of quartz-forming solutions, and that immediately following this stage some veins were insufficiently fractured to admit entry of mineralizing solutions, may serve to account for tight northeasterly trending faults and veins of barren quartz, or quartz poor in gold. Unfortunately this explanation offers no help in predicting which vein fractures are likely to be richly mineralized.

VEINS IN LIMESTONE OF THE LAIB GROUP

Veins in limestone occur along the same set of northeasterly trending faults as do the veins in quartzite. The mineralization in the limestone is, moreover, similar though not identical to the mineralization in quartzite, and it can scarcely be doubted that both are derived from a common source. The gold and silver contents of oreshoots in limestone are similar* to those in the quartzites, but lead and zinc are far more concentrated in the former host. Mineralization in limestone commonly replaces the wallrock and consists of sulphides accompanied by minor amounts of quartz. Widths of high-grade mineralization are generally measurable in inches rather than in feet.

The total amount of ore mined from the two productive veins, the Sumit and Ore Hill, has been small† compared with the production for the camp, and it is highly unlikely

* Ore shipped from the Sumit ranged from about an ounce to as much as 14 ounces of gold to the ton. The very high-grade ore was very narrow. Ore of similar grade was mined from very narrow veins in quartzite on other properties.

† *See* Table VII, p. 52.

that the production to date has met the costs of operations and development. All the production from the veins in limestone has been made at levels fully 2,000 feet above the zone in which productive quartz veins occur in quartzite. The results of exploration in the limestone at lower levels have been disappointing.

CHAPTER V.—HISTORY OF DEVELOPMENT AND DEVELOPMENT POSSIBILITIES

HISTORY OF EXPLORATION AND DEVELOPMENT

In this discussion of the discoveries made and of exploration and development in the Sheep Creek camp, space has been given to the geological theories that have been held and have influenced exploration. It is felt that a knowledge of these theories will be useful in any consideration of past exploration and of the potentialities of the camp.

The earliest discoveries of the camp were the Yellowstone and Queen veins, staked July 18th and September 10th, 1896, respectively. Almost certainly ore outcropped in these two veins, for stopes were later extended to the surface in both veins. Thomas Bennett, a well-known prospector in the area, has been credited with the original discovery.*

The four original claims of the Queen group were staked along the strike of the bedding of the quartzite that is the host rock of the two veins. Presumably the claims were staked with the hope of finding other productive veins in the same wallrock. Parallel veins have since been found on these claims south of the Yellowstone and Queen but have not been productive at the surface. The quartzites are now known to outcrop, in that vicinity, only at the crest of an anticline and do not continue on surface far south of the Queen vein (*see* Fig. 1).

Later, attention was directed to a search for other shoots along the line of the two known veins, and for the next few years nearly all the claims located were either east or west of the two original groups. This search, however, was unsuccessful, and no orebodies have since been found on either vein on surface except at the original discoveries. It is doubtful, too, whether an extension of the Yellowstone vein west of Waldie Creek has been discovered to this day. The earliest known discovery of the Yellowstone vein in Kootenay Belle ground to the east was not until 1933.

The next three recorded discoveries were outside the quartzite belt. The first of these included the Galena Lady mineral claim, now lapsed, and the adjoining Joint and Double Joint claims. These claims were staked in or before 1897 and were all on the western slope of Nugget Mountain.

The Joint showings consist of an easterly trending quartz vein in limestone† containing galena, sphalerite, pyrite, oxidized streaks, and fair to spotty values in gold and silver. As far as is known, no ore has been produced from these claims. The Bluestone‡ claim was staked in 1899. The site of the original discovery is not known, but only Reno and Laib beds are exposed on this claim, and to date no ore has been produced. The Ore Hill, Sumit, and Snowstorm claims were staked in 1901 on the north slope of Mount Waldie, covering easterly to northeasterly trending veins that cut limestone and argillaceous rocks of the Laib group and Reno formation. Mining has since reached the surface, and ore can be assumed to have cropped out there.

The date of discovery of the Kootenay Belle veins is uncertain, though they are known to have been worked in the latter part of 1904. The veins are exposed on the southern part of the Yosemite claim, staked in 1898, presumably to cover the possible eastward extension of the Yellowstone vein.

Numerous discoveries were made in 1905. In rapid succession, claims were located on the Navada (6600 vein), Columbia (8200 vein), Motherlode, Nugget, Peggy (east of the Kootenay Belle ground), and Clyde veins, all in quartzite. It may be noted that the Motherlode group of claims was located along the line of the vein rather than along the line of the bedding, and the emphasis seems to have been on the exploration of a single vein rather than on the discovery of parallel veins in a belt of favourable wallrocks.

* British Columbia Mining and Engineering Record, December, 1911, and M. C. Donaldson, personal communication.

† O'Grady, 1932, p. 190.

‡ The Bluestone vein yielded 16,000 tons of ore in 1939 from the Rhomberg Fraction mineral claim; none of the stopes reached the surface.

In subsequent years some less promising veins were staked, the Fawn and the Golden Belle in 1906, the Eureka in 1907, and the Bonanza and Vancouver in 1908. Additional claims were staked from 1909 to 1910 chiefly, probably to consolidate and increase holdings. It was not until 1912 that the Reno vein was discovered. It was the last important surface discovery and turned out to be the most productive vein in the camp.

The underground development of the Yellowstone mine proved disappointing, for the third level, 350 feet below the outcrop of the one known oreshoot, yielded no ore. The underground development at the Queen mine for a time may have seemed equally discouraging. In 1902 the syndicate, which had undertaken work on the property and had mined 4,500 tons of ore worth $11 per ton, relinquished their bond. One of the owners, William Waldie, then undertook to operate the property, hoping to pay for the cost of development from the proceeds of mining. A tramway was built between the Queen portal and the Yellowstone mill, and with only a few hundred feet of drifting he disclosed and opened up the western oreshoot of the mine. For the next decade Waldie and his successors continued work on the western and central oreshoots of the Queen vein, reaching depths in 1915 of 400 feet below the lowest adit level and 610 feet below the outcrop of the oreshoot. Developing these oreshoots required no more than 150 feet of non-productive drifting on any level. The eastern oreshoot was first found on 5 level,* 225 feet east of the central oreshoot, and was developed to a depth of 290 feet below the lowest adit level before operations were suspended in 1916. Rising costs during wartime, labour troubles, and a cave-in in the shaft in July, 1916, were, at least in part responsible for the shut-down. A decline in grade of ore in the lower levels has also been cited as a reason, although it has since been established that a large quantity of ore averaging 0.6 ounce of gold per ton (worth $12 per ton in 1916) still remained in the lower part of the eastern oreshoot and that only 16 feet of drift was necessary to reach it from the eastern end of the lowest working. Once the mine was shut down it was allowed to flood, and it was not until 1934 that any serious effort was made to rehabilitate the old workings. The early operations of the Queen, although suspended in 1902 and 1916, demonstrated that valuable oreshoots existed in at least one vein in the camp, and that only relatively small amounts of exploratory drifting were necessary to prove these orebodies.

The Kootenay Belle veins had their first period of exploration and produetion between 1904 and 1911. In that period 5,100 tons of ore was won from shallow workings and yielded gold and silver to the value of $100,000. The mine was closed in 1911.

The original work on the Nugget vein was stimulated by the discovery of rich ore at the surface in the period from 1905 to 1907, and within a few years the vein was explored by four adits to a depth of 350 feet below the highest point on the oreshoot and 450 feet below the apex of the vein. During this period several additional subparallel veins were found on the property, and some drifting was done along two of them. Good values and widths were reported on one of these veins, the Calhoun, which at its western end converges on and joins the Nugget vein, but no part of it has been stoped. No blind oreshoots are known to occur in this part of the mine, although the Nugget vein was explored for several hundred feet on either side of the upper orebody. After yielding about $220,000 from 14,000 tons of ore, the mine was shut down in 1911 pending the driving of a lower crosscut and installation of new milling facilities, but it was not until the end of World War I that these developments came about.

The development of the Motherlode mine followed the success of the Nugget venture. Prior to 1910 a small amount of work, chiefly surface excavations, had disclosed the upper parts of two orebodies on the Motherlode vein. Work from 1910 to 1912 opened up these two orebodies to depths of about 500 feet below the surface, and drifts on 3 and 5 levels linking them disclosed a smaller, blind oreshoot. Oxidation extended to the full depth of this development, and it is reported that very little unaltered sulphide ore could be found even at the lower levels, although heavy sulphides did occur locally on 3 level.

* *Min. of Mines, B.C.*, Ann. Rept., 1910.

In 1911 it was announced that ore blocked out was sufficient to supply a mill of average capacity for three years. Accordingly a mill, of 100 tons daily capacity, was installed. It was operated slightly less than the predicted three years before visible ore was exhausted. The possibility of ore continuing to greater depths was considered, but a low-level crosscut to test the vein was not driven until 1939.

By the middle of World War I the camp had yielded about $2,500,000, mainly from three veins, and the more obvious geological controls of orebodies had been recognized. At least as early as 1915 work on the Motherlode vein had made it apparent that the vein is represented in schistose rocks by a tight fracture devoid of values, whereas on entering quartzite it widens out into productive oreshoots.* Underground work had been devoted principally to the development and stoping of exposed oreshoots, but, in the course of drifting on both the Queen and Motherlode veins, blind oreshoots had been discovered. Exploratory drifting had been carried on for distances of several hundred feet beyond the limits of known orebodies on both the Nugget and Motherlode veins, but without success. By 1915 all lateral exploration had ceased, and the managements of the different mines were reluctant to undertake further developments at depth in the face of high wartime costs.

At the end of World War I the Nugget vein was reached below the original adit levels by means of a long crosscut driven from No. 5 level of the Motherlode mine. The crosscut and the raise from it to No. 4 level of the Nugget mine linked the Nugget vein with the Motherlode mine, tram-line, and mill. The vein was stoped for 250 feet above the crosscut level, but no ore was located in the vein between the top of this stope and No. 4 level. Whether or not the exploration of this non-productive part of the vein was adequate, the inference was made that barren zones could occur within the veins separating a productive zone above from one below. One vein, moreover, was now known to have yielded ore through a vertical range of 900 feet. Had the price of gold and the cost of production been more favourable in the early twenties, these conclusions would no doubt have fostered the exploration in depth of many of the other veins, but such exploration was not to come until the following decade.

For several years after the closing of the Nugget mill in November, 1922, activity in the camp was limited to a small amount of exploratory work and to the shipment of a few carloads of ore from several of the veins. Development on the Reno property attracted the greatest interest and, by 1928, trenches, open-cuts, and about 1,000 feet of underground workings had exposed at least two orebodies. The vein itself had been traced for a length of 1,400 feet and through a vertical range of 700 feet; six other parallel veins had also been exposed. In 1929 a 30-ton cyanide mill was built to treat the output of the mine and was operated until February, 1932, when it was destroyed by fire. In that period gold worth more than $400,000 was recovered.

Following the fire, Reno Gold Mines Limited acquired the Nugget-Motherlode properties, including the old Motherlode mill. The old mill was reconditioned and was linked to the Reno mine by a 12,500-foot aerial tramway. In the meantime, work was continued in the Reno mine. The remodelled mill, with a capacity of 100 tons a day, began operation in December, 1932, and was operated on Reno ore until that mine was exhausted in March, 1939. In October, 1939, the mill was reopened to treat ore from the lower levels of the Motherlode mine and from the Bluestone vein. In 1941 the mill was operated mainly on ore from the Nugget mine between the 4900 level and the older workings at higher elevation. The mill was finally shut down late in 1941.

In the period from 1932 to 1934 the success and promise of the Reno mine, together with the rise in the price of gold, stimulated interest in the camp, and several of the old mines were reöpened. Work began at the Kootenay Belle mine in the fall of 1932 under the direction of the Kootenay Belle Syndicate, and the following year a company was organized to promote large-scale development. A 50-ton mill was built at the property

* Galloway, 1915, pp. 156–160.

in the autumn of 1934 and was replaced by a new 100-ton cyanide mill in the autumn of 1936. The latter was operated until the mine closed at the end of 1942.

Gold Belt Mining Company Limited, formed in 1932 and incorporated the following year, explored ground west of the Motherlode mine on the north side of Sheep Creek. Work began on the property in June, 1932, and until the spring of 1935 was concentrated on the driving and developing of the two upper levels. North American Mines, Inc., then acquired a large interest in the company, and the lower levels were developed. The ultimate success in this venture led to the installation in the autumn of 1938 of a 150-ton mill, which was operated until midsummer of 1943.

A small amount of work was done on several of the properties south of Sheep Creek during 1932 and 1933. In 1934 these properties, including the Queen, Yellowstone, Alexandra, Vancouver, and Midnight, were amalgamated under the newly formed Sheep Creek Gold Mines Limited. Work on the Queen vein by this company led to the installation of a 150-ton cyanide mill, which was operated, with several interruptions, from May, 1935, until midsummer of 1950.

The operations in the various mines in the period from 1930 to 1943 yielded 547,890 ounces of gold, out of the total of 736,015 ounces credited to the camp in the period from 1900 to 1951.

Several geological discoveries made during the thirties had a marked influence on developments. Two of these stemmed from the examination of the unwatered Queen mine in 1934 by H. H. Yuill and his assistants. They recognized that the western orebody in the Queen vein was cut off in the lower levels by an important normal fault, and they predicted, correctly, that its continuation could be found at higher levels to the west of the workings then existing. They realized, too, that the quartzites in the vicinity of the Yellowstone and Queen mines lay at the crest of an anticline and had been exposed beneath the cover of Reno and younger beds by deep dissection in the vicinity of Sheep and Waldie Creeks.* Thus, in spite of the absence of these quartzites on the higher parts of the valley walls both north and south of Sheep Creek, it was then possible to predict their presence at depth in both areas. The first conclusion, regarding the presence of ore west of the Queen fault, was confirmed in the winter of 1934–35. The ore recovered from the Queen vein in the period from 1935 to 1937, inclusive, was chiefly from the lower end of the eastern orebody below the workings abandoned in 1916 and from the faulted part of the western orebody. It amounted to 113,000 tons, from which the gold recovered average 0.298 ounce per ton and was worth almost $1,200,000 (gross). The profit derived from this work was adequate to warrant the search for parallel veins in the quartzite farther south on the anticlinal structure. Two vein fractures had been exposed by surface work in the argillaceous quartzites overlying the Nugget quartzite, 800 and 1,700 feet south of the Queen vein, and it was proposed to intersect these in the quartzites at depth. Accordingly, in 1936, a crosscut was driven south from 5 level on the Queen vein. The first vein was cut at a distance of 800 feet and was drifted on for 600 feet with inconclusive results. Later the vein was reached by a crosscut on 7 level and was followed in a drift for 600 feet before a large high-grade oreshoot was encountered. A total of about 2,800 feet of level workings in quartzite was thus necessary to discover the main orebody of this one vein. The vein has since yielded 128,000 tons of ore assaying 0.55 ounce of gold per ton, worth almost $2,500,000.

The significance of the anticlinal structure in the Queen and Yellowstone mines had not been missed by others. It was essentially this new interpretation that led North American Mines, Inc., to invest in the Gold Belt Mining Company, in whose property the quartzites might also be expected to occur at depth. Prior to 1935 the work on this property had been confined to development on veins on the upper slopes of Nugget Mountain in the Reno formation, which there forms a hood over the quartzites.

At the instigation of North American Mines, several holes were drilled down from the 600 level (altitude 5,046 feet) in the late spring of 1935 to confirm the presence of

* This concept had previously been suggested by A. Lakes, but had either been discredited or overlooked.

the quartzites, and in the latter part of that year a long low-level crosscut (1850 level) was started from the lower slopes 1,000 feet north of and 400 feet above Sheep Creek to explore these favourable beds. By July of the following year this crosscut had been driven 3,150 feet from the portal and several veins had been intersected. Drifts totalling 945 feet on the 2360 vein, 425 feet on the 2590 vein, and 400 feet on the 3040 vein revealed no orebodies; with few exceptions the assays indicated subcommercial grade. After almost 5,000 feet of workings on the 1850 level had yielded no ore, the management was reluctant to expend more money on exploration, but one other vein zone exposed in the crosscut was tested. This vein zone had been intersected 1,500 feet from the adit portal in argillaceous schists, and it would be necessary to drift westward for several hundred feet before favourable wallrocks would be encountered. The sole encouragement for this work was the fact that a small amount of ore had been recovered from surface workings (the Columbia adits) in what appeared to be this vein zone. The distance from the crosscut to the quartzites proved even greater than had been anticipated, amounting to slightly more than 850 feet, but a few feet beyond the eastern edge of the quartzites, on what is now known as the 8000 vein, the drift entered a low-grade oreshoot, and a few hundred feet farther west higher-grade ore averaging almost 4 feet in width was encountered. The results of development on this vein and on a parallel vein 200 feet to the north were so encouraging that another crosscut, the 2100, was driven to explore these veins 250 feet lower. This crosscut intersected another vein, the 6600, which had been prospected in the early part of the century, and which had yielded a few tons of ore from the Navada adit. This vein* was later to yield 11,700 ounces of gold, worth more than $400,000, from the Gold Belt and Kootenay Belle holdings. The 8000 vein at the 2100 level contained three orebodies, but the work on the 8200 vein disclosed only subcommercial grades.

The productive depth of veins had been repeatedly increased by continued underground work throughout the history of the camp until 1937. Mines had been closed previously, but in each instance the fall in profits that led to the closure stemmed more from rising costs of labour, equipment, and supplies than from a decline in the grade of the ore. In view of the erratic distribution of values within the veins of the camp, it is doubtful if before 1937 any over-all decline in assay values with depth had been proved. With the added profit margins given in the early thirties by the rise in the price of gold and the fall in operating costs, the possibilities of production at greater depths were viewed with optimism. The levels at which the Queen vein was producing, 2,500 to 2,800 feet above sea-level, were regarded as ones to which other veins might be worked. With the Reno vein then producing at altitudes of 6,000 and 7,000 feet, such a concept made the future for the Reno mine look promising indeed. In 1937, however, when the lower part of the Queen vein was being developed, a diminution in the amount of ore present was clearly demonstrated. Vein widths persisted but grades declined with depth, and at successively lower levels a smaller and smaller proportion of the vein could be mined commercially.

The decreasing proportion of ore with depth,† first fully established in the Queen vein, was to be observed also in the Reno in the following year (1938). The exploration of the lower part of the Reno vein, though not as exhaustive as in the Queen, nevertheless showed a similar bottoming of commercial ore within the vein. These facts made it necessary to discard the idea that all veins could be worked down to the altitude of the lower stopes on the Queen vein. It was realized also that oreshoots on veins between the Queen and Reno might bottom at intermediate altitudes, and this concept served not only to explain the absence of ore in veins at the lower levels of the Gold Belt mine, but also to give promise of better grades at higher levels. This idea had been expressed at least as early as July, 1939, and from that time on development in the Gold Belt mine was conducted with the view of exploring the veins between an upper limit of quartzite and a lower

* On the Kootenay Belle ground the vein was explored and stoped from the Dixie adit.

† *See* pp. 61–62.

limit of commercial grades. The 2360 and 3040 veins, which had been barren of ore on the 1850 level, proved to be productive at higher levels, as had been predicted, and two other veins, the 3500 and 3900, were found to contain orebodies which bottomed at levels somewhat higher than in the veins to the south.

Experience in mines along the Western anticline between 1937 and 1939 indicated that a lower limit of oreshoots had been reached in the Queen vein, in several veins in the Gold Belt mine, and in the Reno mine. In the same period, operators came to believe that the commercially productive sections of veins lay above a gently southerly sloping surface (*see* pp. 61–62). This depth concept influenced subsequent exploration and to a degree restricted exploration to ground that, on the basis of this belief, was thought to be potentially favourable. In 1940 and 1941 the bottoms of commercial oreshoots were reached in the mines of the Eastern anticline. At that time the possibility of discovering orebodies large enough to pay for the cost of exploration on the Motherlode, Nugget, and Kootenay Belle A veins seemed so remote that work at lower levels on them was abandoned.

Attention was paid to the possibility of finding new orebodies in branch veins. Exploration on branches of the veins on 5 and 6 levels of the Reno mine had been successful in finding ore, but an extensive programme of diamond drilling for branch veins in 1936 and 1937 did not locate any significant new orebodies. Crosscutting in the Sheep Creek mines disclosed orebodies in branching or subparallel veins of a single fault zone (*see* pp. 57, 60).

Geophysical surveys were made in 1938 of the area between the Reno and Nugget mines by Hans Lundberg for Reno Gold Mines Limited. Details on the cost, procedures, and results are not available. It is reported, however, that one of the major anomalies led to drilling and the discovery of the Bluestone vein, which was completely buried by overburden. Relatively small amounts of mineralization exist in the vein on the uppermost level, and stoping was abandoned above the second level at a point 150 feet below the surface. It seems, therefore, that geophysical studies could be used to advantage in areas covered by overburden to locate relatively shallow orebodies. So far as is known, however, no geophysical work has been done in other parts of the camp.

GEOLOGICAL CONCEPTS THAT HAVE INFLUENCED THE SEARCH FOR ORE

In summary it should be noted that some of the developments in the early days of the camp and virtually all later development was guided by several conclusions on the geological factors localizing orebodies. The conclusions which follow were based on mining experience and were generally accepted within the camp. They are:—

1. The ore is confined to a series of roughly parallel northeasterly to easterly trending fault zones. Even though mineralized quartz has been found in at least one northwesterly trending fault, no ore has yet been found in any of them.

2. Orebodies are localized within the northeasterly to easterly trending zones where one or both walls consist of quartzite. The Upper Nugget quartzite is, as a rule, the most favourable wallrock, other things being equal, but in some localities, as for example in the northern part of the Western anticline, the Upper Navada quartzite may be more favourably situated. Drifts driven on the productive veins have been concentrated within the quartzite units and, in recent years, have generally been stopped on reaching the top of the Quartzite Range formation or, in some instances, the top of the Upper Nugget member. It should be noted, however, that under some circumstances ore or potential ore may be found where the northeasterly trending fractures intersect limestone as in the Sumit and Ore Hill veins.

3. Orebodies tend to be wider where the strike of the vein fracture is more nearly east than usual. By careful mapping of the vein zone at points exposed on surface and at intersections with drill-holes and crosscuts at depth, it is possible to indicate areas where the vein has a trend that is favourable for the occurrence of ore.

4. In the quartzites, orebodies have been found through a vertical range of not more than about 1,600 feet in any one vein. Higher parts of the vein tend to be too narrow for profitable mining development, and the lower parts tend to be too low grade. Development to greater vertical ranges has in recent years been avoided where it was thought that the vein lay outside the limits of the productive vertical range. It has been recognized that some veins, for reasons which may or may not be apparent, yield ore from only a fraction of the maximum known vertical productive range.

5. The productive parts of the veins are found at successively lower levels as the southern part of the camp is approached. Thus the Reno vein, in the northern part of the camp, has been productive between altitudes of 6,900 and 5,400 feet; the Kootenay Belle A vein, in the central part of the camp, has been productive between altitudes of 4,300 and 2,700 feet; and the 75 vein, in the southern part of the camp, has not been productive above the 3,300-foot level. Exploration for orebodies has, therefore, been concentrated within the range in altitude that for the particular part of the camp has been found to be favourable. It should be noted that the Sumit and Ore Hill veins have yielded ore from limestones at altitudes of 5,100 to 5,600 feet. It seems, therefore, that the favourable limits of depth for ore in quartzites are considerably lower than those for ore in some other type of rock, and that failure to find ore in a particular vein cutting quartzite above a certain level should not necessarily discourage exploration in limestone at higher levels. The failure, to date, to obtain large quantities of ore from limestone in the northeasterly trending fault, should, on the other hand, discourage very large expenditures in development in this rock at any level.

6. Orebodies may occur in one or both forks of a branching vein. If a branch is encountered in drifting, an accepted rule is to follow the "strongest" branch, that is the branch with the most gouge, the widest zone of shearing, the most drag, or the greatest displacement. If the two branches are of nearly equal strength, the right-hand branch trends more nearly east and is regarded as the more favourable, but ore may occur on both branches.

EXPLORATION POSSIBILITIES

Veins in Quartzite

On a broad scale, exploration of the Sheep Creek camp is incomplete, and even within the most extensively developed parts of the camp possibilities remain of finding ore. As a rule, drifts have been driven at vertical intervals of not less than 100 feet, and bodies of ore of smaller dimensions could be missed. However, it is questionable whether the expense of more drifts at smaller intervals would be justified by the additional ore they might disclose. Diamond drilling or crosscutting for ore in branching or subparallel fractures in an explored vein zone have likewise been spaced at too wide intervals to establish the absence of all such ore. Blind drifting, drilling, or crosscutting is not to be recommended in an effort to rectify these omissions, but careful study and utilization of geological information can, almost certainly, disclose more ore and lessen the cost of mining development.

Despite a history of exploration extending over more than fifty years, no simple criteria have been recognized by which a vein fracture that contains little or no ore can be distinguished from one that may be highly productive. The only known way to determine whether or not a vein contains profitable concentrations of ore is by thorough and costly exploration in underground workings.

The writer of this bulletin is impressed by the indication of a favourable depth range or depth zone (*see* items 4 and 5, above; *see also* pp. 61–62 and 69–70). The upper and lower limits of the zone are not marked by recognized structural or other geological features, but the known orebodies in the Western anticline and, to a less definite degree, the orebodies in the western limb of the Eastern anticline may be said to lie within a zone or within a limited vertical range. Unfortunately no characteristics of vein or wallrock are known that assist in predicting the relationship of a vein exposure to the upper and lower limits of this vertical range. Veins become too narrow for profits as they approach the upper limit. At the lower limit the veins are as wide as, or wider than, average and are not barren, but under the conditions of the past fifteen years too little of the vein matter is rich enough to return any profit after allowing for the cost of exploration and mining. If the demand were high and other conditions were favourable, it might be possible to mine siliceous flux below the favourable zone from parts of veins already developed. It may also be inferred that under conditions more favourable than those now existing further exploration and development below the lower limit of the "favourable zone" might be profitable, costly though such work would be.

The following observations and suggestions relate to development and exploration possibilities within the camp mainly in the more intensely developed parts.

Any future development in the Sheep Creek camp might be either (1) a search, conducted with a minimum of capital expenditure, for shipping ore on the extension of known orebodies or in branch veins within explored vein zones, or (2) expensive exploration for new bodies of milling ore and for new veins within and beyond the area now opened by mining. To be successful economically, the second would require the discovery of enough ore to warrant equipping the property for production.

No very large tonnage of shipping ore should be anticipated within easy reach of the present workings. Small-scale development, such as could be carried on by lessees, should be conducted as early as possible to take advantage of existing facilities, pipelines, tracks, timbers, and the workings before they deteriorate beyond hope of easy repair. Development, for the same reason, should be restricted to the vicinity of existing and accessible workings.

Pillars and sills adjoining known orebodies are obvious and readily available sources of ore, and have provided a considerable proportion of the material so far recovered and shipped by lessees.

Other sources of ore may be found around the margins of existing stopes. Examination of mine records and particularly of assay plans of stopes may be of great assistance in locating such extensions of orebodies. Careful study of the vein in the backs and ends of stopes may also reveal ore which had previously been left unmined. Low-grade vein material, averaging perhaps 0.3 ounce of gold per ton, could be treated profitably during the period of greatest activity in the 1930's when mining and milling facilities were available, providing the ore width was adequate. Approximately three times that average grade was required in 1949 to meet the cost of mining and shipments of ore to the smelter. Stopes which had been abandoned in the thirties as low grade offer no hope of becoming sources of shipping ore. However, those which had been abandoned because of the narrowness of vein material may be a potential source for shipping ore if sufficiently high in grade. It had been a common practice in the thirties to mine stopes to a minimum width of about 3 feet, even where the vein was much narrower, and to accept the resulting dilution of the ore. A vein which assayed 2 ounces per ton in gold could not, however, be mined economically in this way if its width were much less than about 6 inches, and many stopes advanced in high-grade vein material were abandoned if the vein became too narrow for economical mining across 3-foot widths. Some such high-grade portions of the vein can be mined profitably in very narrow stopes yielding, with a minimum of dilution, material of sufficient grade to bear shipment costs. Inasmuch as the veins tend to be both narrow and high in grade in the upper part of the productive zone, search for recoverable ore of this type should be concentrated in the higher levels of the mines.

The discovery of ore in the walls of veins already developed can be facilitated by careful search for branch fractures, particularly those branches in which a considerable proportion of the fault movement of the vein zone has been concentrated. A section of a previously developed vein fracture that has an abnormally small fault movement compared with the movement in adjacent sections of the same vein to the east and west, or above and below, is one that should be scrutinized for important branch or parallel fractures that might have localized not only part of the fault movement, but also much of the ore. Where such evidence indicates that previous development has locally been off the principal fracture of a productive vein zone, a few short drill-holes or short crosscuts are justified in a search for more ore. Sections of the vein zones where the absence of parallel oreshoots has already been established by drilling should, of course, be avoided for such exploratory work.

Inasmuch as the present pattern of orebodies cannot be fully explained by the known ore controls, the location of additional orebodies within a partly developed vein cannot be predicted. Elements of luck still exist to lure the miner into exploring farther along the extensions of the vein, and such efforts are occasionally rewarded. However, experience in the mines has proved that such blind drifting into sections of the veins in which favourable conditions for ore are not specifically indicated is, in the long run, unprofitable.

Any new extensive development programme in a search of new veins is almost certain to be very expensive. The easily discovered orebodies, those which extended to the surface, have probably all been located and mined. Other orebodies may be concealed only by overburden, but very detailed surface prospecting or geophysical surveys coupled with diamond drilling or underground work will probably be necessary to demonstrate their presence. Still other orebodies, like those in the southern part of the Sheep Creek mine and in the northern part of the Gold Belt mine, may have their apices many hundreds of feet below the surface, and these would be located only by underground work.

The ground offering most certain prospects for the discovery of ore in the Sheep Creek camp is in the parts of the Western anticline and of the western limb of the Eastern anticline in which productive veins have been found. Whether veins as rich as the Queen and Reno remain to be found in the vicinity of the present mines is not known, but smaller veins, comparable with the 75, 8000, and the 3500, can almost certainly be anticipated. Northeasterly trending faults are known to occur at the surface or at shallow depths at several places between the Gold Belt workings and the Reno mine, and from the Sheep Creek mine south to the saddle 750 feet south of Mount Waldie. It is a reasonable geological assumption that these vein fractures and others in their vicinity are potential sources of ore where they cut across favourable quartzites. Failure to find ore where such a vein is exposed on the surface or at some level underground does not necessarily prove that ore may not occur in the vein at another elevation.

Within the part of the camp that has been productive, the favourable quartzites remaining to be explored may be several hundred to a few thousand feet below the surface and could be fully tested only by crosscuts driven in appropriate positions. It would be necessary to test veins at different elevations and to test the favourable quartzites on both limbs of the Western anticline to avoid the possibility of missing such veins as the 8000, which is non-productive on one limb, or the 92, which is only sparingly productive on one limb. Crosscuts driven on opposite sides of the Queen fault would also reduce the problems of locating offset sections of the veins. Crosscuts driven along some clearly recognizable stratum may also be advantageous, inasmuch as the displacement of vein fractures which cut it can be determined with a minimum of drifting. Additional work could then be concentrated on those fractures which have moderate to large displacements and therefore probably have considerable lateral extent.

In considering the ground at depth between the Alexandra and Bonanza veins, it should be remembered that all the workings on the Bonanza veins are well above the elevations of the known oreshoots in the comparable part of the Western anticline. The amount of movement along the Bonanza vein fractures is large, and they can, therefore, be expected to extend to considerable depth, well into, if not beyond, the productive zone. Other vein fractures, hitherto undiscovered because of widespread overburden on the lower slopes of Waldie Creek valley, can be anticipated between the Bonanza and Alexandra veins. The Alexandra vein has, however, produced disappointing amounts of ore to date even though exploration has been concentrated within the projected limits of the productive zone, and there is no assurance that veins to the south would be more productive. Although exploration south of the Alexandra vein may not seem as promising as work done in the Western anticline, it would probably be no less favourable a gamble than the 1850 crosscut of the Gold Belt mine was in 1935. It could only be hoped that such a crosscut might be at least as successful as was, ultimately, the work done at the Gold Belt mine.

The Upper Nugget quartzite north of the Fawn mine does not merit underground development unless very detailed surface or geophysical surveys indicate the presence of ore-bearing veins. Exposures in this area are poor locally, but traces of auriferous float might be expected in the talus and soil below any potentially productive veins. Such traces have not been reported.

It may be of interest to note that the Kootenay Belle, Motherlode, and Nugget veins in the Eastern anticline and the veins of the Sheep Creek mine in the Western anticline have been productive in the Middle Nugget member, and that elsewhere little or no exploratory work has been done in this member, which generally lies well below the bottoms of the mines and in much of the area is below the 1,600-foot vertical range discussed on pages 61 to 63.

Another area that merits some study is the eastern limb of the Eastern anticline. To date only a few vein fractures have been located in this limb, and only one, the Eureka, has been explored underground. That the stresses responsible for the vein fractures farther west acted this far to the east is established. The small amount of material mined from the Eureka vein is not enough to show that the processes of mineralization were here sufficiently intense to form orebodies, but, on the other hand, it is not known that the Eureka vein has been tested at the most favourable level. Until this part of the area is shown to contain orebodies, the expense of crosscutting should be avoided, but some surface work, and perhaps even geophysical surveys, might well be conducted at different levels to expose and explore northeasterly trending fault zones within the Nugget and Navada members.

Extrapolation of the upper and lower limits of the productive zone eastward from the developed mines cannot be done with sufficient confidence to indicate the most favourable levels for exploration in the eastern limb of the Eastern anticline. Should it be proper to project the limits horizontally eastward, the lower northeastern part of Yellowstone Mountain and possibly the higher exposures of the Nugget beds north of Sheep Creek would lie within the extension of the productive zone. If the Weasel Creek fault is post-ore, the favourable zone would lie more than 1,000 feet higher on the east than on the west side of the fault, and conceivably this zone may have been completely removed by erosion north of Sheep Creek, and may lie at relatively high levels on the slope of Yellowstone Mountain south of Sheep Creek. The Eureka adit would, in this case, lie beneath the zone or low within it. If, on the other hand, the Weasel Creek fault is pre-ore, the zone would lie at relatively low levels east of Weasel Creek fault and the Eureka adit might be at or above the top of the zone. The tightness of the vein fracture in this adit and the presence of occasional small lenses of vein quartz favour the latter suggestion. Waldie Creek almost certainly lies above the zone on the eastern limb of this fold, and surface work at all elevations except perhaps creek level is likely to be fruitless.

Veins in Limestone

Some investigations of vein fractures in limestone at levels of from 2,000 to 3,000 feet above the productive zone in quartzite may be warranted, although the limited production from limestone so far fails to encourage large expenditures for exploration. So far ore has not been found in the limestone at the depths at which the veins have been productive in the quartzites. Whether any of the vein fractures extend into the limestone belt east of the Weasel Creek fault is completely unknown.

formerly owned by Reno Gold Mines Limited: Dandy, Curlew, Manhattan Fraction, Larkhall, Cassiar Fraction, Blackstone, Snowdrift, Bluestone, Cayote, Rhomberg Fraction, part of the Nugget, and part of the Golden Fawn. The claims acquired by Gold Belt Mining Company Limited include the Rhomberg Fraction, on which Reno Gold Mines Limited mined ore from the Bluestone vein. In 1951 Gold Belt Mining Company Limited, then a wholly owned subsidiary of North American Mines, Inc., was dissolved, North American Mines retaining ownership of the property. The 1952 tax records indicate that North American Mines then owned thirty-seven claims or fractions and also owned part of the Golden Fawn and part of the Nugget claim.

ORE RESERVES

The known ore reserves of the Sheep Creek camp were in 1949 almost entirely confined to the Sheep Creek mine. It was reported by this company on May 31st, 1949, that 50,578 tons of ore averaging 0.341 ounce of gold per ton was blocked out, enough for about two years' operation at current rates.* Virtually all the known ore in the Gold Belt mine had been extracted by 1943, when the mill was finally shut down, but a small amount of development work done in 1946 demonstrated the presence of an oreshoot at the west end of the 3500 vein between the 1400 and 1100 levels. This ore remains to be mined. The ore remaining in the Nugget vein between 6 and 5 levels has not been estimated, but this part of the vein constitutes the main reserve of the Endersby holdings. A section of the Fawn vein in the lower level and a part of the Calhoun vein are reported (A. Endersby, Jr., personal communication) to be of commercial grade, but lack of transportation facilities has prevented its being mined. The ore remaining in the Kootenay Belle mine is confined to pillars and small pockets at the margins of former stopes. No other ore is known in the camp at this time.

MINING FACILITIES†

Sheep Creek Mine

The Sheep Creek mine was the one mine in 1949 that was still fully equipped and in operating condition. However, by 1951 all known orebodies were mined, equipment was withdrawn, and the workings were flooding. The mill and surface plant were left intact.

Kootenay Belle Mine

The Kootenay Belle mine is flooded below 6 level, but nearly all the other workings are accessible. Natural ventilation is good, and tracks and air-lines are still available on 6 and 3 levels. The mill was dismantled and shipped to Retallack in 1943, where the company has treated lead-zinc ores. The compressor is still in operation. Mill building, compressor-house, several residences, and a few other buildings are in good order.

Gold Belt Mine

All level workings of the mine are accessible, although timber sills in the 1782w drift are in poor condition and may soon render higher parts of the 82 vein unapproachable. Natural ventilation has been good since the shaft on the 3500 vein linking the 1200 and 600 levels was completed. Rails and air-lines are intact, as is the hoist at the head of the 3500 vein shaft on 600 level. Most of the movable mine equipment has, however, been sold, and the remainder is on sale. The power-line was damaged by a snowslide in the spring of 1949, and other snowslides in this same year partly or completely demolished the mill, mill office, cook-house, and several other buildings. Most of the mill machinery had been removed prior to the catastrophe.

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* Exploration at lower levels of the Sheep Creek mine in 1949 and 1950 disclosed little new ore, and continued rise in costs led to a slight reduction in ore reserves previously estimated. As a result, after 43,998 tons of ore had been extracted, the mine was shut down in the early part of 1951, and the workings have been allowed to flood.

† This section refers to conditions in 1949 unless otherwise stated.

Fawn and Cayote Mines

The Fawn and Cayote mines are fully accessible, but no tracks or air-lines are laid.

Bluestone Mine

The 3 level is flooded, and 2 level is caved at two points near the portal. The 1 level is fully accessible.

Reno Mine

The mine is completely flooded below 5 level, and 5 level itself is partly flooded by a cave-in 675 feet from the portal. Natural ventilation between 4 and 1 levels is good, despite the fact that the portal of 4 level is almost completely closed by caving. Air-lines and tracks were still available in several parts of the mine. The tram-line to the Motherlode mill has been dismantled between the Reno and Bluestone mines. As towers had collapsed at several places between the Bluestone mine and the mill, the tram-line is no longer in operating condition. Most of the buildings at the Reno mine, with the exception of the core shed, are in poor condition; many are completely broken down by the weight of winter snow.

Motherlode and Nugget Mines

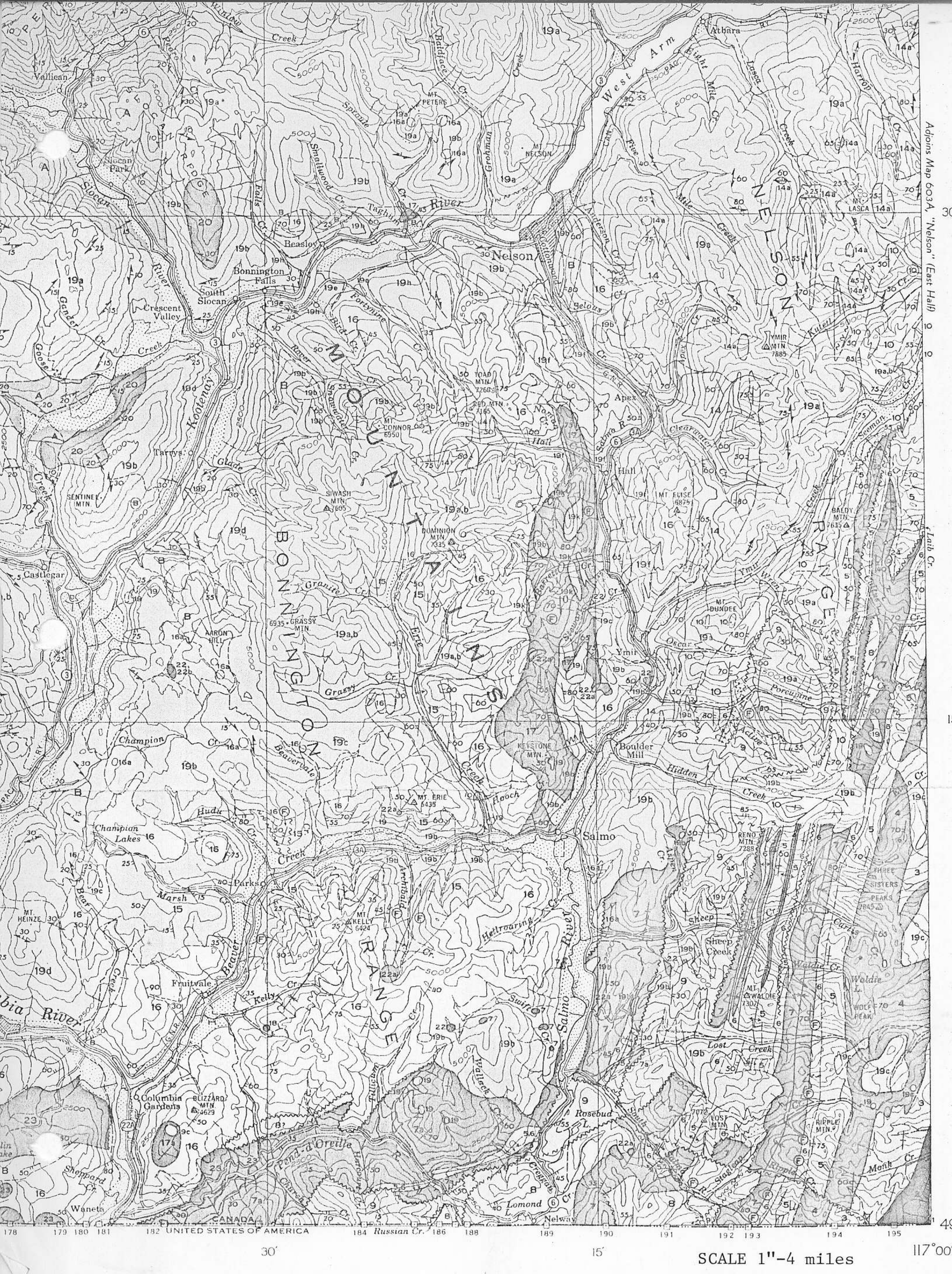
The workings on the Motherlode vein are flooded below 10 level. Natural ventilation is good in the Motherlode mine and in the upper part of the Nugget mine. Lower levels in the Nugget mine are being ventilated by an artificial system which takes advantage of the air current on 10 level between the Motherlode mine and the surface. Most of the mine timbers in the Motherlode mine at and above 6 level and in the Nugget mine at and above 5 level were put in prior to 1922, and many of them would need to be replaced before any new mining activity could be initiated. The tram-line to the Motherlode millsite was still in operating condition, but the mill itself was dismantled in 1943. The compressor, operated by water power, was still in good condition.

Ore Hill Mine

Most workings are accessible, although 8 level was partly caved and partly flooded. No air-lines or track remain. The bunk-house and a few cabins are still standing but in poor condition.

Bonanza Mine

All but the uppermost level are fully accessible, but no equipment remains.



SCALE 1"-4 miles