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MINERALOGY OF THE RENO MINE

by

J.A. Gower

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Reno Mine

Introduction

This report, describing the mineralogy of the Reno Mine, is based upon the study of nineteen polished sections, fifteen thin sections, and several hand specimens of vein material and wall rock.

Over ten thousand gold assays were plotted on a vertical section of the Reno vein to attempt to outline orebodies, to relate vein width and gold assay, and to find structural and mineralogical controls of ore deposition.

Acknowledgements

Advice given by Dr. W.H. Mathews, Dr. R.M. Thompson, Dr. H.V. Warren, Dr. K. DeP. Watson, and Dr. W.H. White during the writing of this report is gratefully acknowledged. Thanks are also due to Evelyn F. Gower who assisted in compiling the data and typing the manuscript,

to Miss Ruth I. Irish who conducted a spectrographic analysis on a specimen of sphalerite, and to A. Endersby, Sr. and A. Endersby Jr., owners of the Reno Mine, who loaned maps and reports.

Description of Area

The Reno mine is situated near the summit of Reno Mountain at the head of Nugget (Fawn) Creek, a tributary of Sheep Creek. The main adit is located at an elevation of 6,100 feet. Salmo, the nearest town, is 14 miles distant, and Sheep Creek village, at the foot of the mountain, is six miles from the mine. The road from Sheep Creek, whose grade is one in eight, is usable only in the summer months. While the mine was in operation, winter supplies were taken up over the aerial tram connecting the mine workings to the Motherlode mill on Sheep Creek.

N-5?

The mine buildings are in a state of near ruin. The workings below No. 5 level are flooded; No. 5 level adit is partly caved causing flooding behind the caved section; No. 4 level portal is caved; Nos. 3 and 1 levels are accessible and raises down to No. 5 level are in good condition.

Owing to numerous forest fires which have swept over the area, and the damage done to small trees by snowslides, little timber has been left in the vicinity of the mine workings.

General Geology

The rocks in the vicinity of the Reno Mine are mainly sediments of Lower Cambrian age (Little, 1949). They are folded into two major anticlines and an intervening syncline. The axes of folds strike N 20° E and the axial planes dip 70° S.E. becoming flatter down the dip. The axes plunge gently to the south. A stratigraphic section is given in Table I.

Fractures striking about N 80° E cut diagonally across the folds. The Reno vein shows very little movement and appears to be the result of tension. Fractures to the south show large displacements up to a maximum of 200 feet horizontally, with a vertical component about one-third the horizontal, the south walls having moved down and to the west relative to the north walls.

These fractures have been mineralized by gold-bearing solutions. The Reno vein has been the largest producer of the twenty-nine known veins in the Sheep Creek mining camp.

History

The original holdings of 16 claims were staked in 1912 by W.B. Poole, Mike O'Donnell, and Thomas Kilpatrick. They operated the property themselves until 1921, exposing, on what is now No. 3 level, an ore shoot 500 feet long, 1 to 4 feet wide, and averaging 0.35 ounces of gold per ton. It was reported (Minister of Mines Report, 1919) that the best values occurred near the surface where the vein was narrow. On the lower levels the vein was wider but carried lower values. The vein consisted of rusty "honey-combed" quartz.

The opening of this ore shoot led to the formation, in 1921, of the Reno Gold Mines Ltd. with W.B. Poole president, T.P. Kilpatrick vice-president, and J. O'Shea secretary. Capitalization was $1,000,000.

In 1922 the following 15 claims were crown-granted: Reno, Blue Stone, Black Stone, Curlew, Donnybrook, Latham, Dandy, Red Rock, Clarence, Clarence Fraction, Gartan, Lynx, Manhattan Fraction, Trilling, and Snowdrift (Minister of Mines Report, 1922).

In 1925 the mine was optioned by American interests but no development work was undertaken.

In 1927 English capital provided funds for construction of a camp and for further development.

A 30-ton cyanide and flotation plant was built on the property in 1929 and treated almost 10,000 tons the first year. Recovery, according to McGuire (1942), was only 85%. The plant was destroyed by fire on February 25th, 1932. The Nugget-Motherlode mine and mill were purchased and a 12,800-foot tram line, with a capacity of 15 tons per hour was built.

The Reno vein was intensively explored by over fifteen miles of workings and over 200 diamond drill holes. The three parallel veins to the north were explored by a crosscut from No. 5 level, a few diamond drill holes, and short drifts near the surface. No rich ore was developed in any of the three veins.

The details of production are shown graphically in Figure 1. In the National Survey of Gold Reserves, in 1936, the Reno stood 34th in Canada in production for the year (The Miner, July, 1936). The Reno mine produced a total of 145,000 ounces of gold, valued at $4,738,538, from 263,000 tons of ore. The average grade was 0.55 ounces per ton.

After the Reno vein was exhausted, the company carried on with deep development of the Nugget and Motherlode veins to the southeast, and with shallow development of the Bluestone vein to the south. The

Bluestone vein had been discovered by an electrical geophysical survey conducted by Hans Lundberg. The work proved to be unprofitable and operations were suspended in August, 1942.

The claims covering the Reno, Nugget, Fawn, Middle, Donnybrook and Lake veins were sold to A. Endersby Sr. and A. Endersby Jr. The Gold Belt Mine purchased the Blue Stone and the western end of the Fawn and Nugget property.

Structural Geology

The Reno mine workings lie entirely within the western anticline. The lowest levels are in the Nugget Quartzites, the highest in the Reno Quartzites. The main adit (No. 5 level) begins in Pend d'Oreille limestone. The argillaceous rocks are more intensely metamorphosed here than farther south. Some have been converted to a biotite-rich hornfels, some to a glistening chlorite-mica schist. Some of the quartzite beds show a development of disseminated magnetite. The quartzites are persistent and form good horizon markers. The schists are thin-bedded, lenticular and are greatly thickened in the crest of the anticline by intense folding and by flowage.

The Reno vein is a persistent fracture in the upper levels, and a number of less continuous branching fractures on lower levels. The quartz filling varies in width from 0 to 5 feet, averaging 2 feet. The fractures strike about N 77° E and dip vertically. Several lamprophyre dykes and faults of small displacement cut the veins.

Mineralogy

Macroscopic Description

The ore consists of massive and disseminated sulphides in a quartz and minor carbonate gangue. Pyrrhotite, the most abundant sulphide, is massive and commonly occurs in discontinuous bands up to 6 inches wide. Galena and sphalerite occur in small pockets and irregular bands a few inches in length. Chalcopyrite occurs in minute veinlets and tiny blebs in quartz. Free gold can be seen in rich specimens, especially in oxidized material. Scheelite occurs as small crystals in quartz, often associated with pyrrhotite. Marcasite and pyrite are found on the intermediate levels below the zone of oxidation. Pyromorphite and hydrozincite are found in open cuts and on upper levels in the zone of oxidation as coatings on rusted quartz.

Microscopic Description

The most abundant mineral seen in polished section is pyrrhotite, which occurs as masses and veinlets in quartz. It shows strong anisotropism under crossed nicols and is slightly magnetic. It is closely associated with sphalerite and chalcopyrite. Streaks of pyrrhotite commonly lie along cleavage planes of sphalerite, closely associated with blebs of chalcopyrite oriented in the same directions.

Sphalerite comprises about 15% of the metallic mineral content. It was determined by mouse-grey colour, hardness of 4, red streak, isotropism and red internal reflection. In addition to its previously mentioned occurrence it is frequently seen in large masses in quartz often with a little calcite nearby.

Chalcopyrite comprises about 5% of the metallic mineral content of the ore. It is almost invariably closely associated with the other sulphides and often with gold. It is brass-yellow in colour, negative to KCN tests, and produces a powder when scratched.

Pyrite is found in very minor amounts, associated with pyrrhotite and marcasite. It is extremely hard, has a light, bronze-yellow colour, rectangular outline, and is isotropic.

Marcasite can be seen in most sections of ore from the intermediate levels. It is hard, similar to pyrite in colour, but anisotropic. Anisotropism was partly cur observed by inferior polish.

Scheelite occurs in euhedral crystals up to 1 mm. long. It was determined in thin section by high relief, low birefringence, and positive biaxial interference figure. Tests, under the ultra-violet lamp, revealed the presence of scheelite in most specimens from the lower levels of the mine.

Gold occurs as irregular isolated grains, usually filling spaces between quartz grains, and often associated with calcite and sericite. Grain size varied between 0.05 and 0.75 mm. diameter. Gold was seen in contact with sphalerite, galena and pyrrhotite, but in no instance were any sulphides completely surrounding a gold particle. Gold was not seen in direct contact with chalcopyrite.

The gold-silver ratio is about 2:1 (see production figures). No silver or silver minerals were seen in polished sections and it is assumed that most of the silver occurs alloyed with gold. Electrum has been reported by Schmidt (1939).

Distribution of Gold Values

The vein width and the distribution of gold values are shown in the longitudinal section of the Reno vein. An examination of this distribution suggests the following points:

1. The rich orebodies are large and have fairly regular boundaries. The richest is also the largest.

2. The orebodies are confined to the Reno and Nevada beds. There is no ore in the Pend d'Oreille limestone or the Nugget Quartzite.

3. The vein is narrow in the upper levels and increases in width with depth. No correlation can be made between vein width and gold content in the upper levels. In the large orebodies in the lower levels the richest ore occurs in the widest part of the vein. The ore bottoms at No. 11 level, but the vein persists to No. 12 level and below, both wide and well defined.

4. Pillars, which limit the stopes, are left in pinches in the vein. In many cases the grade holds up fairly well although the vein width decreases below economic stoping width.

5. Oxidation in the upper levels does not appear to have enriched or depleted the deposit. (The stopes above No. 1 level were discontinued because the ore caused sliming at the mill, which resulted in poor recovery and increased cyanide consumption.)

Relation to Structure

The structural relationship of orebodies to definite horizons and to anticlines is shown, not only by the Reno vein, but by all the veins in the camp. An inexplicable feature of this relationship, however, is the fact that, from the Reno vein southwards, the orebodies are found at progressively lower stratigraphic horizons, as shown in the longitudinal section of the camp, prepared by W.H. Mathews. It should be noted that parts of the orebodies are in the limbs of the anticline, and their projections on the section make them appear stratigraphically lower than they actually are.

Dr. Mathews made the suggestion that the original surface may have caused this distribution (personal communication). D.W. Heddle suggested that impervious cover rocks may have dammed the rising solutions. Lacking further evidence, it is impossible to more than guess at the reason for this feature of the relationship.

Temperature Control

The lower limit of the orebodies is mineralogical. The drop in values is marked by a corresponding decrease in metallic sulphides. Below the orebodies the veins are wide, persistent along strike, and the walls well defined. The Queen vein shows a type of zoning which may be typical of the camp. Other veins have not been explored to this depth. The orebodies of the Queen vein have a vertical range of 900 feet. Below them is a barren zone of white quartz about 100 feet deep. Below that is a zone mineralized by pyrrhotite and actinolite. Still lower down, the vein contains granite inclusions. A diamond drill hole from the lowest level intersected granite a few hundred feet west of the shaft. R.A. McGuire (1942), working at the Queen mine, extended this evidence over the camp, stating that granite probably underlies the area at 600 feet below the orebodies. Such extrapolation is not justified.

Samples of pyrite from various veins were sent to Dr. F.G. Smith of the University of Toronto for pyrite geothermometer tests (Smith, 1940, 1942, 1943, 1947). The temperature of formation of the veins in the southern part of the area was found to be 150° C. Smith therefore described the deposits as epithermal. The tests on Reno vein material gave much higher temperatures. The temperature of formation of pyrite in a sample from No. 3 level, 1187 feet from the portal, was 320° C. In a sample from No. 12 level (drill core), it was found to be 460° in four determinations and 600° in one determination.

Under the guidance of Dr. W.H. White, the writer examined thin sections of vein material from the Reno mine. The most notable feature of the quartz was the almost complete lack of cataclastic structure, described by White (1943) as typical of medium and high temperature gold-quartz veins. The most plausible explanation for this feature is that the process of mineralization was rapid, that is, that the quartz was not strained by later vein movements which would have permitted further injections of sulphide-forming and gold-forming solutions. Another possible explanation is that following injection of metallic minerals, the quartz was heated to a sufficient temperature to cause recrystallization and relief of internal stress.

A study of the grain size of the vein quartz showed that where the quartz was mineralized, the grains were smaller than where it was not. Rather than cutting through grains, fractures follow grain boundaries. Dr. White's suggestion is that smaller grains provide greater surface area for the precipitation of metallic minerals. The average grain size of barren quartz is 0.3 mm. while that of mineralized quartz is 0.05 mm.

Paragenesis

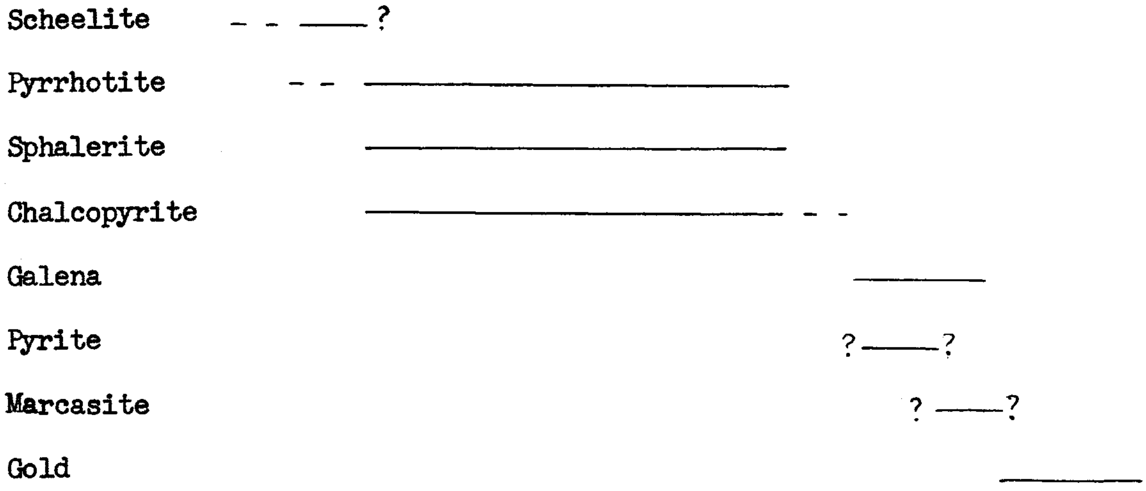
Evidence of the exact paragenesis of the Reno ore is not clear cut. Pyrrhotite was probably deposited first, but the abundant evidence of exsolution of pyrrhotite, sphalerite, and chalcopyrite indicates that at least part of the pyrrhotite was deposited at the same time as the sphalerite and chalcopyrite. Galena is later than these minerals, but it may not be very much later. From the aclastic structure of the quartz it may be assumed to be later in the same mineralizing injection and not a result of later injection of mineralizing fluid. Marcasite probable formed in an acid solution by replacement of pyrrhotite. Pyrite may have formed in the same way but in a less acidic solution. W.A. Tarr (1927) states that the factors controlling the deposition of marcasite are: (1) character of solution and (2) temperature of solution. The optimum conditions for deposition of marcasite are 1.18% free H_2SO_4 at 100° C. A change of temperature in either direction reduces formation. Pyrite would be deposited at a higher temperature, possibly melnikovits at a lower temperature. Pyrite would also be deposited in a less acidic solution.

M.J. Buerger (1934) states that marcasite is lower in sulphur than pyrite. An acid solution removes sulphur from pyrite, forming H_2S by combination with H^+ ions, and causes the deposition of marcasite.

Gold was probably the last mineral to be deposited. Its association with calcite and sericite suggests that these minerals were effective in causing the precipitation of gold.

The position of scheelite in the sequence is not known. Stevenson (1943) reports that scheelite may occur in low temperature veins with low or medium temperature minerals, hence no special significance can be attached to its occurrence at the Reno mine. Its occurrence at considerable depth suggest that it may have formed early in the sequence.

Table II Paragenetic Sequence



Wall Rock Alteration

Thin sections of quartzitic wall rock were not examined. Robinson (1949) reports that it is not altered, but has aclastic structure, which he attributes to healing by recrystallization. A thin section of the schistose wall rock of the Reno vein was examined by the writer. It showed abundant biotite, sericite, some calcite, especially along the vein contact, and a considerable amount of a variety of chlorite believed to be penninite. Very small garnet crystals were observed, also small acicular inclusions in the chlorite, believed to be rutile (Dr. K. DeP. Watson, personal communication).

Spectrographic Investigations

A specimen of sphalerite from No. 3 level was analyzed spectrographically by Miss R.I. Irish. Her results were compared with those of Warren and Thompson (1945) on a specimen from a lower level.

Table III

Minor elements in sphalerite

Element	No. 1* %	No. 2** %
Arsenic	-	-
Antimony	-	-
Bismuth	-	-
Cadmium	.4	.1
Copper	.01 - .1	.1
Gallium	-	-
Germanium	-	-
Gold	Present	-
Indium	-	?
Iron	+ .5	+ 10%
Lead	+ .5	.1
Manganese	.1 - .5	.1
Silver	Tr	-
Tellurium	-	-
Tin	-	-
Titanium	Tr	-
Vanadium	-	-
Cobalt	-	-

Warren and Thompson (1945) state that the presence of gold, silver, and lead are the result of mechanical inclusions of other minerals containing these elements. The specimen studied by them apparently contained such inclusions; the specimen studied by Miss Irish contained

* by R.M. Thompson
** by Miss R.I. Irish

lead but neither gold or silver.

The presence of other elements in both specimens seems constant. The relative amounts can not be compared accurately because of a difference in the lines on the plates, the one done by Miss Irish being considerably darker. However, there are no significant discrepancies.

It is impossible to reach any important conclusions from only two analyses. Perhaps the safest is that this is a normal type of mineral deposit with the usual minor elements present.

Referring to the conclusions of Warren and Thompson(1945) it may be stated that the Reno deposit bears out the conclusions reached regarding the relation of manganese content and of presence of sphalerite to the vertical range of ore. Sphalerite is found throughout the mine, and its manganese content is large relative to that of mines of greater depth extent.

Conclusions and Economic Possibilities

With the evidence so far brought to light, it is not unreasonable to conclude that the Reno deposit is a shallow, fairly high temperature type. It might be classed as shallow mesothermal, bordering on xenothermal. The other Sheep Creek deposits are low temperature mesothermal, bordering on epithermal, but probably formed at greater depth than epithermal deposits.

The close spatial association of the granitic stock, the veins, the rhyolite porphyry sills, and the lamprophyre dykes indicates a genetic relationship with the order of formation as given. The same magma probably provided all the intrusives.

The depth of ore deposition was controlled partly by structure but mainly by temperature, which, in turn, was controlled by the distance to the magma, the height to the original surface, and possibly other factors which affected the temperature gradient.

The Reno vein is exhausted. More work on all parallel veins is warranted, especially those to the south of the Reno vein. The northward extension of the eastern anticline should also be explored.

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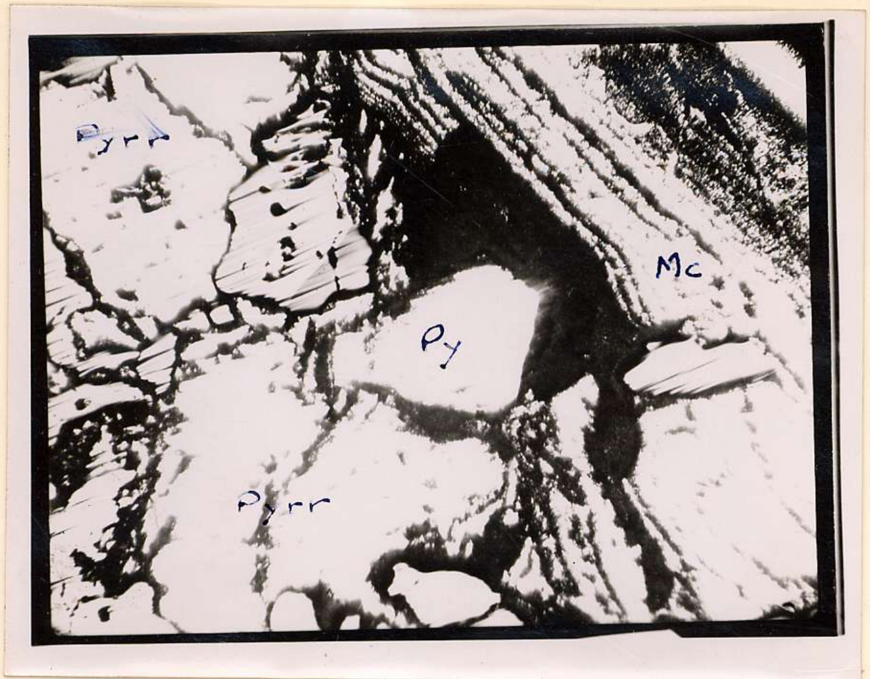
Plate I
Photomicrographs of Polished Sections



x 150

Marcasite (Mc) and pyrite (Py) replacing pyrrhotite (Pyrr)
Plane polarized light

x150

Marcasite (Mc) and pyrite (Py) replacing pyrrhotite (Pyrr)
Crossed nicols

Plate II
Photomicrographs of Polished Sections

x150

Gold (Au) in fracture between quartz (Qtz) grains.
Galena (Gal) nearby.

x150

Gold (Au) in quartz (Qtz) associated with sphalerite (Sph)
and soft micaceous gangue, possibly Secicite (Sc)

Figure 1

GRAPHS OF PRODUCTION AND COSTS

RENO MINE

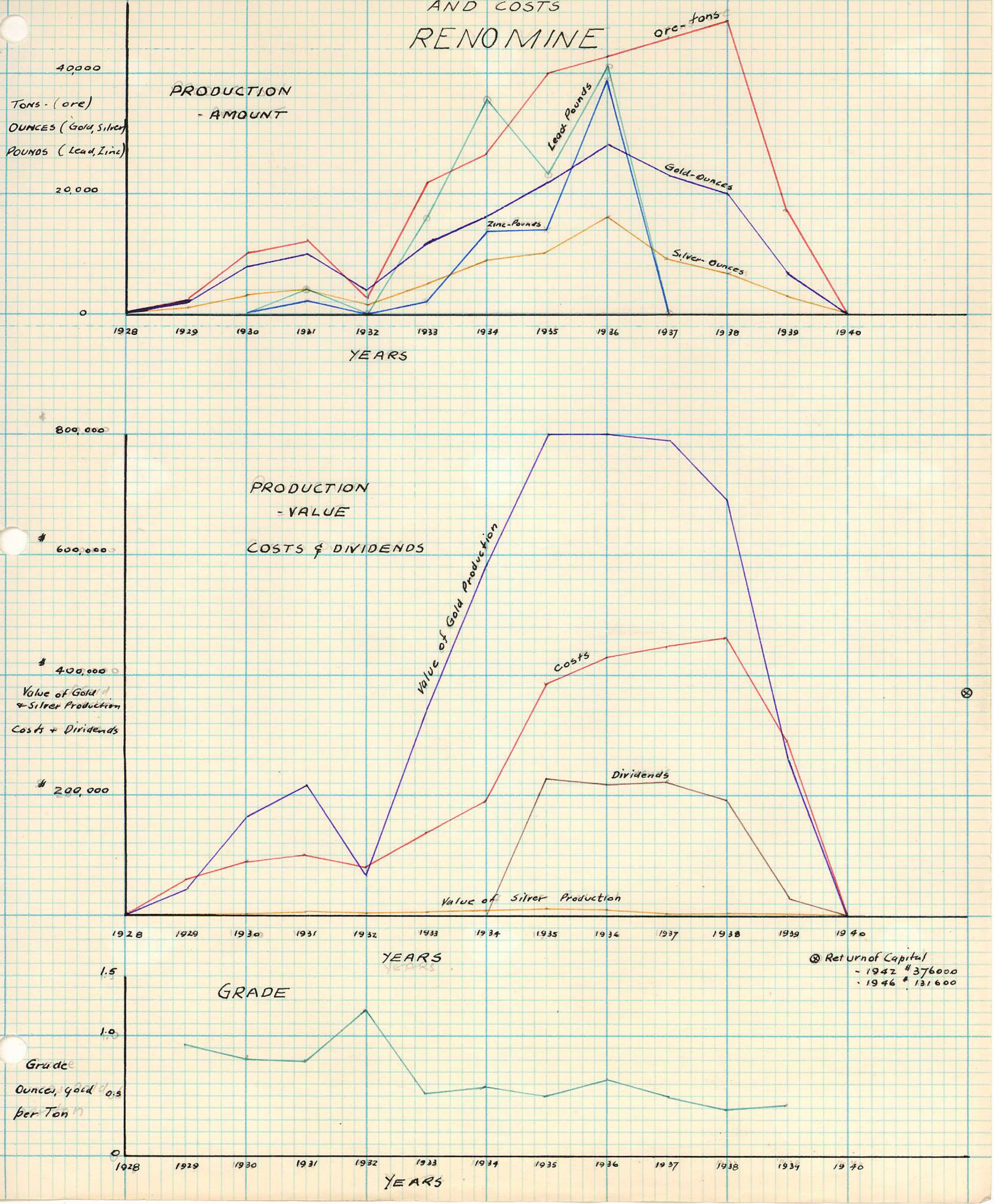


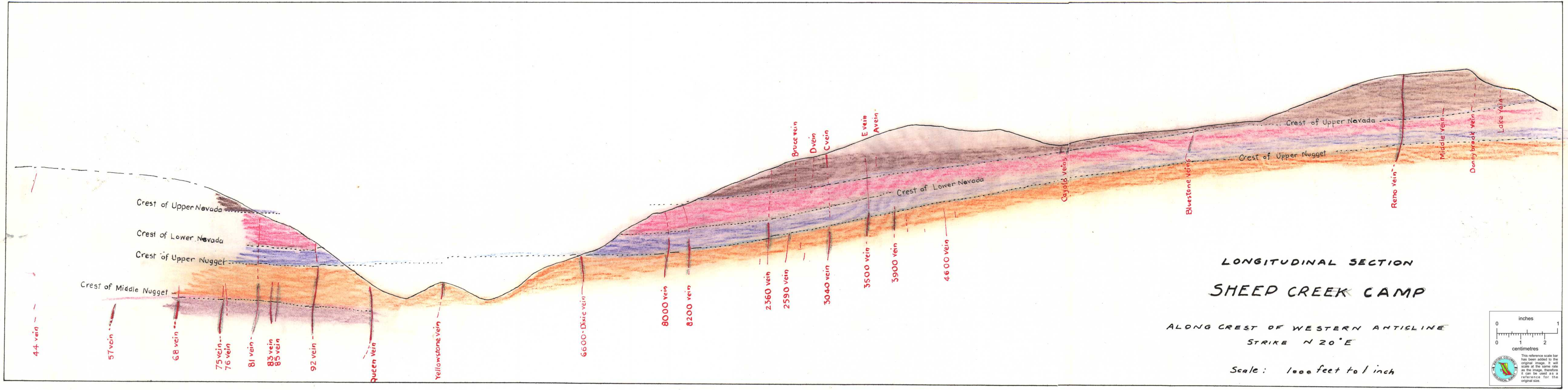
Table I

Stratigraphic Section Reno Mine

	Rock Units	Thickness (Feet)
Pend d'Oreille	Limestone and limy argillite	500
Reno	"Blue" quartzite	250
	Schist and Hornfels	200 - 400
Nevada	Quartzite	50 - 300
	Thin-bedded Argillaceous quartzite	100
Nugget	Massive white quartzite	
	Med. bedded by quartzite	600
	Thin-bedded Argillaceous quartzite	200
Motherlode	Quartzite)	
	Argillaceous quartzite)	600
	Schist	

Table IV
Production by Stopes

Stope No.	Tons	Ounces	Grade
302A	950	446	.470
314A	1265	308	.243
316, 316A	2893	739	.255
318	1150	395	.344
318A	7322	2553	.348
514A	777	157	.202
514B	886	153	.173
517	1126	268	.238
517A	1802	662	.366
519	3640	1719	.472
519A	9666	6330	.655
521A	4859	2964	.610
521B	7350	3805	.520
525	2818	604	.205
542	323	74	.231
546	1788	529	.296
604	3441	1483	.431
607	4712	1594	.339
620	2228	564	.253
630	5587	2868	.513
641	5911	3347	.565
643, 544	3730	1237	.332
706	4124	1351	.325
707	10039	3103	.309
710	1218	258	.212
711	2773	888	.320
714	1198	719	.600
716	538	156	.289
717, 719	13064	10400	.796
721	3880	3783	.975
805	597	134	.225
807, 809	7758	4075	.525
815	643	120	.187
816	2844	773	.272
817	6421	2238	.364
819	4847	2260	.466
830	3867	1612	.417
834	3810	1847	.485
907	7233	5876	.812
909	3197	1423	.445
934	1574	776	.495
1007	4446	1849	.416
1009	7919	4583	.613
1103	1872	715	.382
1103 Winze	593	71	.119
1104	1007	277	.275
1105	2883	1454	.505
1109	976	255	.262
Total	173545	83795	.483 (Average)



LONGITUDINAL SECTION

SHEEP CREEK CAMP

ALONG CREST OF WESTERN ANTICLINE
STRIKE N 20°E

Scale : 1000 feet to 1 inch

This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.

After: W.H. Mathews

LEGEND

- Lithological Boundary
- Fault
- Dyke
- Vein widths under 2' ▨ over 2' 🟥
- Contours on assay values oz/ton (gold)
- Specimen numbers ● 1

LONGITUDINAL SECTION
RENO VEIN

STRIKE N 77°E DIP 90°

From Company Plans

Scale 1" to 100'

J. A. Gower