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Item 8

Geological Report on the

BETTY O'NEAL SILVER MINE

Lewis Mining District, Lander County, Nevada

by

Anthony L. Payne

March 31, 1967

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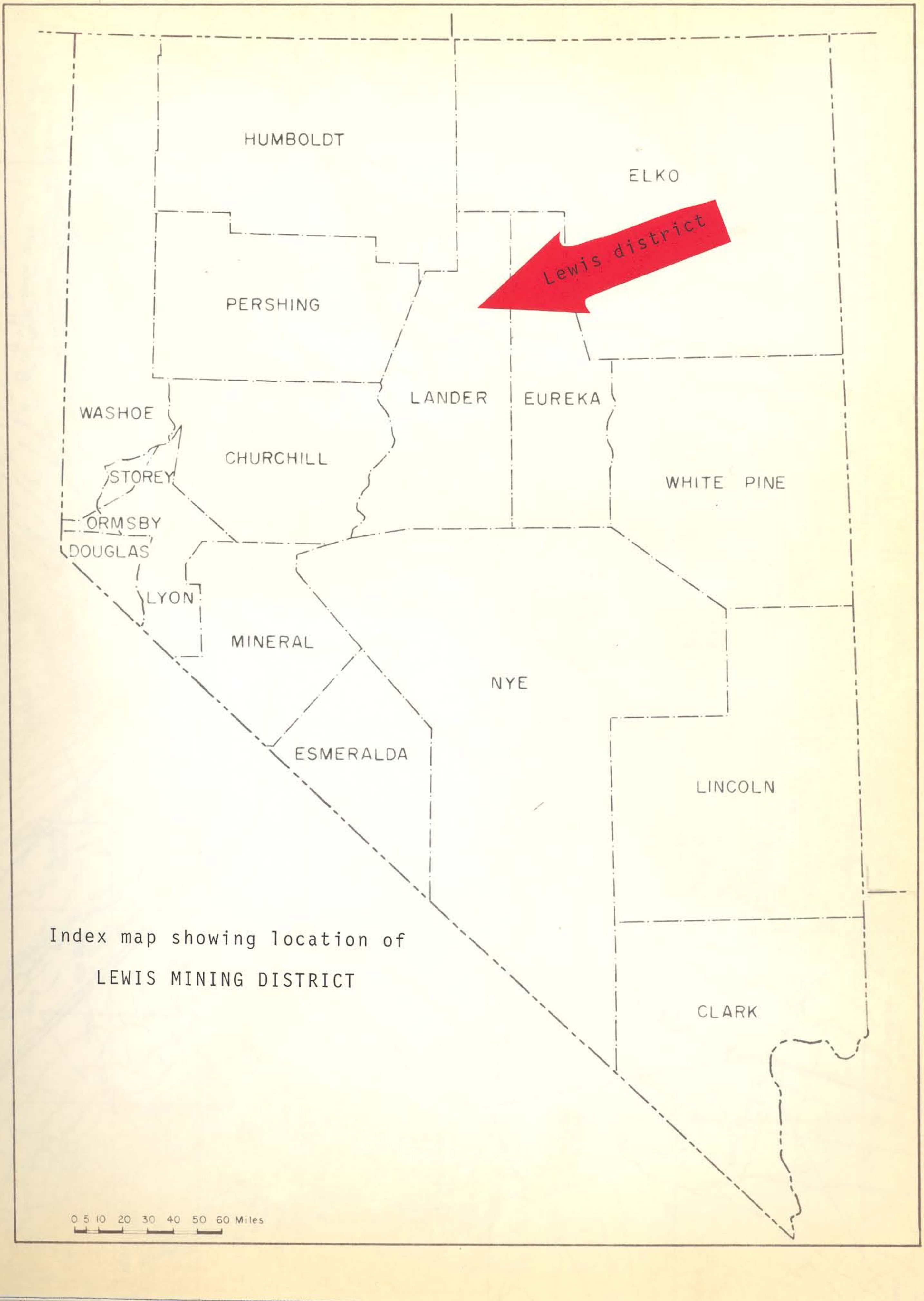
INTRODUCTION

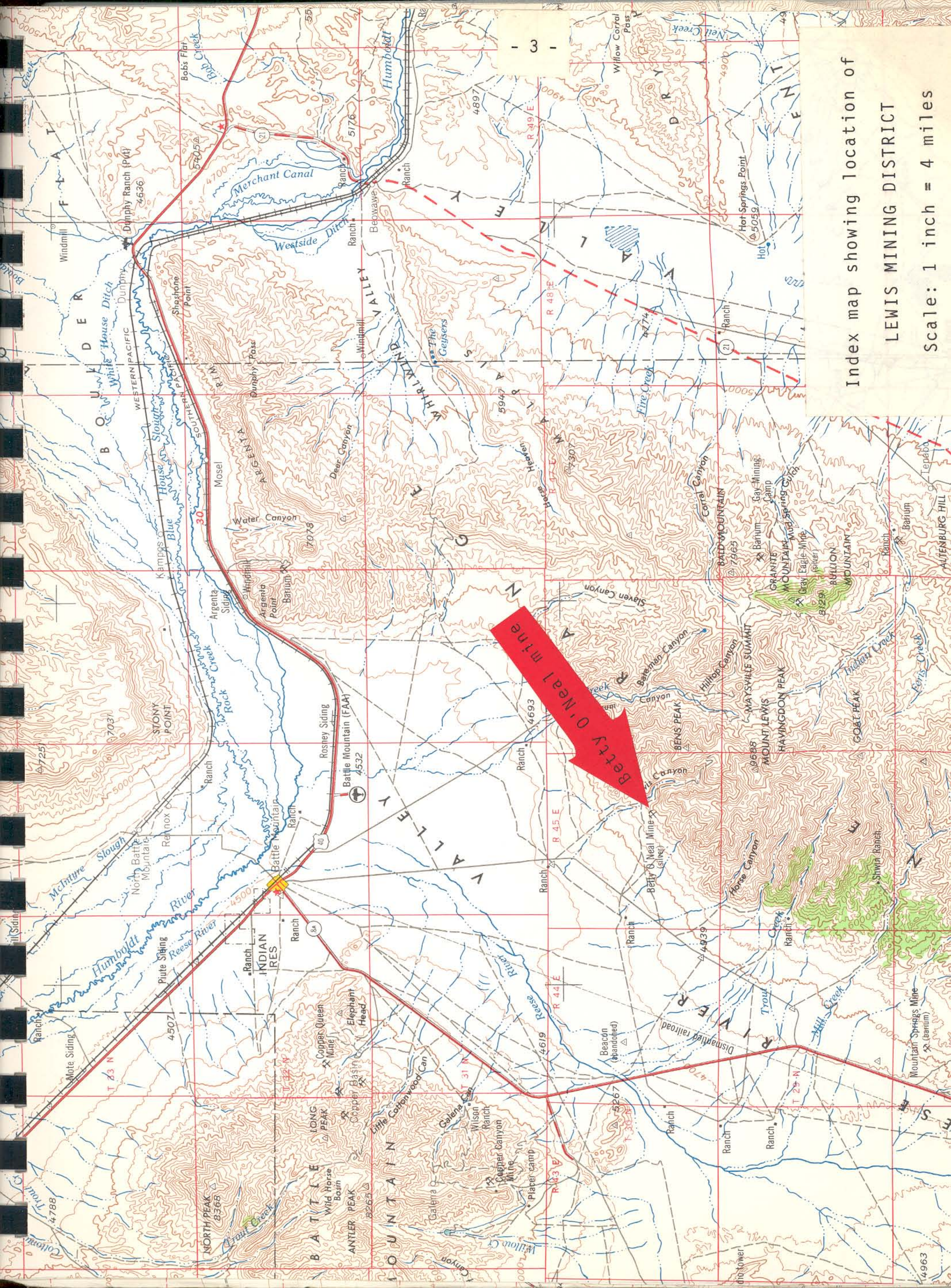
This report was prepared at the request of Mr. Clayton T. McNeil, San Francisco mining engineer and President of Betty O'Neal Silver, Inc. It is written for the purpose of summarizing progress of exploration and development work to date at the Betty O'Neal mine, to outline geologic conditions and describe the exploration potential of the property, and to make recommendations for further work.

LOCATION

The Betty O'Neal silver mine lies at the base of the northwestern slope of the Shoshone Range, in Lander County, Nevada, approximately 15 miles south of Battle Mountain on the S.P.R.R. and W.P.R.R. The mine can be reached at any season of the year over an excellent graded gravel road to the mouth of Lewis Canyon. The Lander County Airport is just southeast of the town of Battle Mountain, and although no scheduled commercial air service is yet available, excellent paved runways have been constructed, and a few landing facilities exist.



Index map showing location of
LEWIS MINING DISTRICT



Index map showing location of
LEWIS MINING DISTRICT
Scale: 1 inch = 4 miles

Index map showing location of

BETTY O'NEAL SILVER MINE

Scale: 1 inch = 1 mile

The principal properties of the company lie in sections 22, 23, 26, and 27 of T. 30 N., R. 45 E., M.D.B. & M. (see index maps).

OWNERSHIP

The property consists of 43 patented and unpatented mining claims, one millsite, and a single tract of 160 acres of patented land. Only the northernmost claims are currently being explored, as the claims at the head of Lewis Canyon have a complex history about which little is known, and are generally subject to severe winter snow conditions. The following claims are of interest at this time:

Patented claims	Unpatented claims
Valley View	Kinkaid
Ruth	Ajax
Ruby Silver	McCarr Fraction
Chloride	Estella Nevada
Betty O'Neal	Nebraska
Betty O'Neal South	Topsy
Yankey	Lewis
	Victory

The claims are shown on the topographic map of the Betty O'Neal mine area accompanying this report, and are plotted according to the old surveys.

The Battle Mountain State Bank Mortgage Corporation is the sole owner of the above-named claims. A lease with option to purchase is held by Betty O'Neal Silver, Inc., by the terms of which the company is required to pay reasonable royalties on ores produced, such royalties to apply to the purchase price should the option be exercised.

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All of the surface installations were salvaged and have been abandoned for so many years that they are worthless. Only a small concrete storage cellar was in condition to repair, and this building is now being used for storage of diamond drill core and sludge samples.

PHYSICAL FEATURES

An excellent road two-thirds of a mile long has been kept up from the county road at the head of Lewis Canyon to the old mine camp and mill at the Getchell Tunnel portal. Another road, which is a bit too narrow and steep to be safe at all seasons of the year, branches from the main mine road, one-half mile to the portal of the No. 4 and No. 5 tunnels, where most of the present work is going on. During the recent diamond drilling program, drill roads were constructed over the entire property. Most of these can be negotiated safely with a conventional pickup truck, but 4-wheel drive is advisable during wet or snowy weather, for they are narrow, steep, and not well-banked.

As can be seen on the enclosed topographic map, the spurs on the northwest slope of the Shoshone Range are extremely rugged, and the range rises abruptly from the Reese River Valley to the northwest. Heavy snow usually lies in drifts along the north sides of the spurs during the 2½ to 3 month winter season, but this does not interfere with present operations below 6,000 feet on lower, more open exposed slopes.

In the past, enough water for camp use has been developed in Whisky Canyon. Drainage water from the Getchell Tunnel was supposed to augment this source for milling purposes, but during several dry seasons in the mid-1920's when plenty of milling ore was available, it was necessary to reduce the mill to one shift on high grade because of water shortage. During these brief periods, several tens of thousands of tons of milling ore were discarded on mine dumps. In the event of new mill construction, it would be necessary to drill wells in the valley gravel in order to insure ample water.

No timber of any kind is available. The entire area is used as open range for sheep during the early summer. Cattle sometimes browse up from the valley bottom during warm spells in the winter months. Labor is extremely difficult to find in Battle Mountain at this time, for the Duval Corporation is now hiring for the Copper Canyon mill.

HISTORY AND DEVELOPMENT

Early "Betty O'Neal" Period 1880 - 1920

The Lewis (and Dean) mining district includes all those mines in the Shoshone Range northwest of the Pittsburg Mine on the divide between the Haysville Canyon and Dean Canyon (see index map). Silver deposits were discovered in Lewis Canyon in the seventies, and preparations were made to develop the Eagle, Starr & Grove, Highland Chief, and other mines. A narrow gauge spur railroad was built from Lewis Junction (on the old Nevada Central from Austin to

Battle Mountain) to Lewis, at the mouth of Lewis Canyon. This railroad was later extended to the Starr & Grove mine. A 40-stamp mill was built at Lewis during this period, and the old Betty O'Neal mine was among the early shippers. Extensive development was done in several mines and some ore was stoped, but it is doubtful whether the mines or the metallurgical operations were ever on a paying basis.

The Betty O'Neal mine was discovered in 1880 and early shallow work was on a vein that strikes north and apparently dips to the east. In 1882 the Betty O'Neal vein was being explored on the 260 level of the Betty shaft. Horizontal workings were run for 220 feet on the level, and a southeast crosscut 156 feet from the shaft reportedly intersected a high grade vein of ruby silver and wire silver. Mining was underway here and on shallower tunnel levels when a boiler at the shaft house exploded, killing several persons and resulting in lengthy litigation. Extremely bad ground had been encountered, and water conditions were unusually severe. However, Noble H. Getchell's father, L. W. Getchell had seen the mine just before the shut-down, when it was producing up to $30,000 a month, and was favorably impressed. A few years later the death of the owner apparently ended the litigation, and the elder Getchell acquired the property. In about 1910 he began attempts to operate the mine again, although it is not clear whether he actually succeeded in unwatering the shaft to the lower stopes on the Betty O'Neal vein. No important production resulted, and Mr. Getchell died in 1918 during the influenza epidemic.

Old (1921) snapshots of the Betty shaft area show a small gravity mill at the foot of the No. 4 dump (which even at that early date is quite large) just south of the Betty shaft. The mill is quite weatherbeaten in these photographs, and photographs taken just two or three years later show the structure replaced with a large shed. It is quite clear that ore was being milled from the No. 4 level, and probably from the No. 3 tunnel as well, judging from the appearances of a well traveled wagon road in several of the pictures. It is probable that mining was going on in the "Estella" vein area before 1920.

Getchell's "Estella" Period 1920 - 1929

Mr. Noble H. Getchell took control of the property in 1920 and secured the help of G. W. Sias and F. E. Nye of Boston, in forming a stock company (actually a trusteeship) for the purpose of developing the mine. Betty O'Neal Mines had a capital stock of 1,000,000 shares of $5 par value. Sias was President, Getchell was Vice President and Mine Manager, and Nye was Secretary-Treasurer. After 400,000 shares were sold at $5.00, an additional block of 200,000 shares was to be offered at $10.00, only part of which was sold. The last two blocks of 200,000 shares were to be sold at $15 and $20, but fragmentary records indicate that the total issue was about 465,000 shares.

Almost immediately upon organization, the company was in a large body of good ore above the No. 4 level on the Estella vein, and elaborate plans were made for large scale development. It seems most probable that this was a sudden development, and that the size and grade of the deposit was not expected. The Getchell tunnel was begun to connect with the Betty shaft at the 300 level, and to intersect the Estella vein some 600 feet downdip from the No. 4 level stopes. It was also planned to crosscut on to the Nebraska vein in the footwall of the Estella, and eventually under the Starr & Grove and Eagle mines in Lewis Canyon, over 2 miles in total tunnel length.

A 100 ton flotation mill was put into operation in October of 1922, and within three months the company paid its first dividend. A second 100 ton unit was immediately installed, and the two were overloaded from time to time. Company officials talked of the "250 ton mill". The sulphide ores apparently milled very well.

The best years of production were as follows[1/]:

Year	Ore milled	Heads	Concentrate content	Smelter net
1922	4,812 tons	14.10 oz Ag	63,749 oz Ag	$ 54,066
1923	38,150	19.05	665,040	438,057
1924	28,982	19.66	483,263	271,477
1925	23,290	23.49	506,500	313,502
1926	38,840	26.48	723,063	426,584
1927	26,314	30.30	781,450	490,900
1928*	10,000	35.00	343,000	170,000
1929**				
	170,388 tons	24 (avg.)	3,566,065	$2,083,586

Note: * Writer's estimate
**The mill shut down in January, 1929, without producing

Production of the district has been included with the Pittsburg and Mud Springs districts to the southeast, all of them credited

1/ These figures, as well as much of the other data here reported in narrative form, are condensed from the business papers of N. H. Getchell, which have just this month been blaced on file at the Mackay School of Mines, University of Nevada, Reno.

with a total production of $3,188,805 (Couch, B. F., and Carpenter, J. A., 1943, Nevada's Metal and Mineral Production (1859-1940), Nevada Bureau of Mines Bulletin 38, p. 74). It is obvious that the Betty O'Neal and Estella veins account for the major production from the district. The only other mine worthy of mention is the Starr & Grove, which is credited with $383,031 of production in the period 1878-1881.

The mill was completed in October, 1922, and within three months a dividend was paid. In 1925, one car of concentrates was sent to Midvale, Utah, yielding at 60¢ silver: $16,053 net, 567.7 oz. Ag per ton, 2.95% Cu, 10.13% Pb, 11.25% Zn, 21.9% sulphur, and 22% insoluble.

It is believed that a total of $1.13 per share was paid in dividends on about 465,000 shares (sold for a total of $2,650,000). The best year was in 1926, when 45¢ per share was paid. Twenty cents was paid in 1927, and the last was 5¢ in February, 1928. It is probable that the stopes on the Estella vein above the No. 4 tunnel level produced all but a very small portion of the 170,000 tons of 24 oz. silver ore. This ore, if mined today, would probably yield a better margin of profit. In reviewing the weekly and monthly manager's reports, it is clear that the Boston management did not understand mining at all, and had no concept of exploration, development, or ore reserves. Up to 1926 and early 1927, exploration and development was vigorously followed, with chief emphasis on what was obviously Senator Getchell's favorite project, the intersection and development of Estella ores at depth. None of this deeper work was successful, and the Getchell tunnel was particularly disappointing. At several periods the air was so bad that the men would quit after a single shift, and progress often amounted to only a foot or so each day. At no place beneath the No. 4 level was there enough ore to furnish the large tonnages that had been planned for the mill. The weekly manager's report for 1928 indicate that anything above 20 ounces was considered ore, and the mine was completely stripped. The manager's report of September 22, 1928, for the previous week reads in part:

....."The faces of ore are gradually being worked out and we have not been successful in developing more ore from our development. It looks now as though we would run behind ten thousand dollars for the month of September. I would like to crowd more as we are in hopes of finding something new. If at the end of October there is no improvement I will have to close the mill and all mining with the exception of a small crew on development".....

Another report from the office manager to the Boston management at about this time mentions Senator Getchell's search for a new mine to move the Betty O'Neal mill, and it is certain that his interest in the Gold Circle property at Midas is related to this idea.

It is clear that a combination of three factors resulted in the closing down of the mine: (1) management did not permit Mr. Getchell to spend enough money in exploration and development, and was interested in paying dividends from the start as a means of putting the financial promotion across to the price level of $20 per share; (2) the drastic price decrease in silver forced profit below the mine's natural earning potential; and, (3) Mr. Getchell was unlucky in his attempt to follow the most obvious exploration objective--to explore at depth. The Getchell tunnel cost far more than he anticipated, and the work required more time; it was wholly unsuccessful to the time of mine closure.

Price of silver per fine ounce, 1921 - 1930 1/:

1921	$1.00	1926	$0.624
1922	1.00	1927	.567
1923	.82	1928	.585
1924	.62	1929	.533
1925	.694	1930	.385

In 1926, when reserves began to dwindle, Mr. John A. Burgess, San Francisco mining geologist, was called in to study the mine and make exploration recommendations. His recommendations, which were entirely logical and feasible, were not followed. They will be discussed in more detail below.

At the time the mill was shut down for lack of profitable ore in January of 1929, Mr. Getchell was devoting major exploration effort to the deep work on the Getchell tunnel, with only one other project of any importance mentioned--at the extreme south end of the No. 4 level. Here, the vein immediately beneath Treasury Hill was being explored while at the same time the Yankey tunnel was being driven as a cross cut on the surface. Plans were discussed to raise from the No. 4 level to the surface some 300 ft. above.

Period of leasing 1929 - 1935

After company operation of the mill was discontinued, it was operated from time to time on a custom basis. Production was too

1/ Average buying price of silver from domestic mines for 1921 to June 2, 1923; average New York price for all silver after that period.

small to be of record. The mine was leased out on the "100-foot" system, where the leaser could mine anything found within 100 ft. horizontally of a designated starting point, and not to exceed 100 ft. above the level. Profit sharing percentage varied from place to place in the mine depending upon opinion as to merit of the heading, with the company furnishing air, cars, tools, and some supplies. There is no record of any "dead" development for company account; the work was evidently done according to the notion of each leaser. The system failed, there being record of only one car of sorted ore being shipped to the custom smelter at Midvale, Utah, during the whole period of leasing.

Getchell attempt at reopening (1935)

In 1935 there was a reorganization of Betty O'Neal Silver stock with Gold Circle Mining Co., another Getchell-Sias mining venture in gold to the north of Battle Mountain at Midas. Apparently many of the same stockholders were involved, and the Security Mining Company was formed. Apparently modest additional financing was arranged through San Francisco promoters. In addition to work at the gold properties at Midas, this company late in 1935 drove the No. 2 tunnel south 250 feet under contract to follow a vein that shows interesting values all along, but apparently never really developed a good ore shoot. At the end of the No. 2 tunnel, crosscuts were driven to the left and to the right, and the one showing of mineral encountered was intensively prospected by raising. It was also planned to drive the raise from the south No. 4 to the Yankey, but the No. 4 tunnel was in bad repair, tramming was not possible, and after a few rounds (gobbing the waste in the nearby crosscut) the project was abandoned.

Evidently the expected financing failed, and a loan or other difficulty eventually put the properties in the hands of the present owners.

<u>Inactivity 1935 - 1954</u>

The property was worked intermittently by leasers through the 1940's and early 1950's, with no record of important production.

<u>Geophysical program 1954 - 1955</u>

In late 1954, Mr. E. L. Stephenson, Reno consulting geophysicist, optioned the property and obtained capital to begin drill-hole exploration of geophysical anomalies obtained by him using the ground potential method. Mr. Stephenson drilled several holes and obtained interesting, though commercially not definitive, results. The program was not carried through to completion, the implied reasons have been, (1) withdrawal of financial support (rumored to have been Standard Slag Company) and, (2) unexpectedly difficult and costly drilling. Some kind of experimental diamond drill was reportedly used. Copies of Mr. Stephenson's geophysical report, maps, and drill hole logs were purchased by Betty O'Neal Silver, Inc., and are in the company's files. The position of the drill holes is shown on the topographic map.

A general comment might be made upon the use of "Ground Potential" (sometimes called natural, or self potential) method, as well as upon a more recent development, induced polarization methods. Both "SP" and "IP" methods have been very extensively used in the last 10 years in northeastern Nevada in the search for precious metal and copper deposits in Valmy formation terrain. Many workers believe that the graphite-sulphide content of shales within the Valmy formation make interpretation of self potential and induced polarization difficult to interpret at best; perhaps even misleading. An additional difficulty in the Betty O'Neal mine area is major post-ore faulting which would tend to further complicate electrical effects associated with the weathering of sulphide ores and their containing wall rocks. It can be seen that great care should be exercised in interpretation of natural and induced potential data, for extraneous geologic influences are likely to be as strong as the effect of any sulphide ore deposits present.

Present period of activity

During 1964, Mr. McNeil was investigating old silver producing districts in Nevada with a view toward acquiring a property under reasonable terms that might be put into production when the silver situation became critical enough to result in a price increase. The Betty O'Neal properties were acquired under terms of a reasonable lease and option agreement, and late in 1964 Mr. McNeil hired Douglas Ketron as engineer-geologist in charge at the mine. Mr. Edmond F. Lawrence, Reno consulting geologist, was retained to supervise geological studies and undertake a geochemical program over the mine area. Mr. Lawrence submitted a report summarizing his findings and containing his exploration recommendations on March 30,

1965. Mr. Lawrence's recommendations were essentially to conduct about 5,000 feet of diamond drilling from the surface, to reopen the Getchell tunnel, and to channel sample the entire mine.

Inasmuch as the U. S. Government's Office of Mineral Exploration (OME) had just at that time increased their contract participation from 50% to 75% of the cost of exploration for silver, Betty O'Neal officials decided to make application for a government exploration loan. In mid-1965 an OME contract for $90,000 was approved by both government and company officials. OME officials set up the exploration program in two stages, an initial Stage I consisting of surface diamond drilling, with Stage II to be a more detailed follow-up of any encouraging results found in the initial work. The government was not willing to consider tunnel rehabilitation as exploration work, this being specifically excluded from the contract. Betty O'Neal officials decided to proceed with the reopening of the Getchell tunnel for company account. Drilling was also more costly and more time consuming than had been anticipated, and the OME did not participate in the resulting higher costs.

Late in the year, Mr. McNeil requested the writer to undertake the geochemical work, and later asked if the geologic work could be supervised as well.

Inasmuch as adequate interpretation of drilling results and geochemical data would require good maps of surface and underground workings, preparations were made to put in the necessary survey control.

As the Stage I drilling was finishing up, three unfortunate developments fell one upon another: (1) it became obvious that the OME was thinking of a second stage of drilling from the surface as the method follow-up of Stage I, which would surely have been costly and inconclusive; (2) Mr. McNeil was taken very seriously ill and was put completely out of touch with developments; and (3) it became apparent that Mr. Ketron would require almost constant direct supervision if any of the mapping and sampling were to be accomplished along with the other work.

Several decisions were made by the writer in June of 1966 which involved major changes in the original exploration-development plan:

(1) Rehabilitation of the Getchell tunnel was stopped, and the crews assigned to the No. 4 rehabilitation work near the showings which had been obtained in OME contract diamond drilling.

(2) Mr. Ketron had been asked to prepare a report on the feasibility of reopening the Water-150 level tunnel as a direct method of opening the lower portions of the mine. It was decided not to proceed with this work, or any other work below the No. 4 for the time being.

(3) It was decided to finish up the drilling of the first stage OME contract, then to prepare a completely new application to spend stage II contract funds in following up underground to actually expose the ore showings in place. Shallow surface drill holes were put down near the old Betty O'Neal vein, in the northern extension of the Estella vein, and near the Kinkaid vein in the southern mine area. This additional work resulted in expenditure of slightly more than half of the total exploration contract funds.

On May 20, 1966, an application for second stage work was submitted to Washington. It was rejected on the grounds that too much money was to be spent on rehabilitation of underground workings, compared to that actually spent drilling. In a July conference in San Francisco with Betty O'Neal corporate officials (other than Mr. McNeil) these changes were described in detail, and it was agreed that a formal recess of the OME contract should be requested, in order to rehabilitate the No. 4 tunnel with a view toward preparing a new OME Stage II application, and to finish the geologic and sampling work in the mine. Mr. Ketron was to do nothing but supervise the No. 4 rehabilitation and to attend to the underground sampling and mapping of nearby headings.

In the fall, Mr. McNeil was well enough to begin assuming project direction again, and several meetings were held in order to determine priority of work, to allocate exploration funds, and to decide upon the best means of accomplishing the short-range objectives.

The rehabilitation of the No. 4 tunnel level began to exceed the cost and time estimates worked out by the writer in cooperation with Mr. Ketron, and the underground sampling fell completely behind. It was decided to terminate Mr. Ketron's employment at the end of the year, and to program the exploration-development work in such a manner that it could be done completely under contract.

The Stage II application was submitted early in January of 1967, and government officials have already indicated that they are willing to proceed with the projects outlined, insofar as remaining contract funds will permit. They have also indicated that, insofar as practical, the contract work will be done on a "fixed unit cost" basis, which will greatly simplify accounting, and provide a measure of insurance against exceeding project cost estimates.

Present planning is aimed at following up the OME exploration work vigorously underground, adding as many of the projects described below as can be handled with additional funds that might be made available. If any of the work develops ore in sufficient quantity to begin planning milling facilities, additional exploration work should be undertaken. OME officials have indicated that if ore is found, they would be favorably disposed toward another additional contract for exploration of new targets outward from the presently explored area.

Such additional government contract money would be subject, of course to the total limit of $250,000 for any given project, and to the government's appraisal of the mine's ability to re-pay the 75% on a preferential 5% royalty on production.

MINE DEVELOPMENT

Accompanying this report is a complete set of 100-scale assay maps of the Betty O'Neal mine, together with a 100-scale composite of mine workings. The condition of the mine workings (whether caved or accessible) is portrayed on the maps and is tabularized below:

Condition of mine workings, Jan. 1, 1967

Level	Elevation	Open	Inaccessible	Total
Getchell Tunnel	5384	1140	2210	3350 1)
260	5436	--	340	340
226	5468	460	? 2)	460+ 2)
178	5518	200	? 2)	200+
Water Tunnel - 150	5542	2500	3410	5910
75	5614	220	1180	1400
Chloride No. 2 adit	5618	300	--	300
Chloride No. 1 adit	5562	200	--	200 3)
Winze	5675	510	900	1410
"C" Intermediate	5707	--	230	230
No. 5 Tunnel	5771	1510	680	3190
No. 4 Tunnel	5771	2650	460	3110
"B" Intermediate	5804	50	680	730
"SL" Intermediate	5834	80	? 2)	80+
"N" Intermediate	5834	490	--	490
"S" Intermediate	5861	310	130	440
No. 3 Tunnel	5904	320	680+ 2)	1000+ 2)
Lewis adit	5955	210	11	210
McGarr West adit	5997	430	--	430
McGarr East adit	6045	330	--	330
No. 2 Tunnel	6057	880	--	880
No. 1 Tunnel	6115	190	--	190
		13,980	10,900	24,800

1) Length of main tunnel bore is 2870 ft.

2) No old surveys available past caved heading

3) Chloride No. 1 adit not usable as it was driven on a steep down grade

All of the samples taken underground in the present exploration-development program are shown on the maps. Only one older assay map is known to exist, dated May, 1924, by Wm. L. Chapman, Mine Engineer and Assayer. Contemporary accounts question the reliability of Chapman's work, which apparently was prepared to show the mine off to best advantage to stockholders. Chapman was discharged from his position shortly after preparing the map. It has not been possible to locate a copy of his work.

Review of the old records indicates that Senator Getchell did not feel the need for a reliable assay map, as he personally took charge of the development work. The only outside engineer who might have prepared one would have been John A. Burgess, and his report makes no mention of such a map.

Very little raising or winzing was done in exploration anywhere in the mine, except on ore discovered in horizontal work. Senator Getchell preferred to drift in the hanging wall of known structures, then crosscut in both directions at intervals to intersect the ore. There are no known drill holes in the mine except for two fifty-foot holes somewhere on the 150 level drilled in October, 1925, by the Denver Rock Drill Company as a demonstration of a long hole machine.

Clean-out of old mine workings these past two years has indicated the 1926-27 mine maps to be essentially up to date. Leasing activity subsequent to the period of main production apparently did not result in much new horizontal development work.

Previous reports

In addition to the Chapman assay report and map already referred to, there are a number of other engineer's and geologist's reports on the property.

J. Carlton Bray, Reno Mining Engineer, wrote a brief account March 18th, 1922, of the geology and potential of the property. This work was done to answer an inquiry made by the Corporation Commission of the State of Massachusetts. The work was paid for by the company. A copy is available.

R. W. Foster, Boston mining engineer, wrote a report on the mine dated August 7, 1924, paid for by a Boston brokerage firm. The report was widely distributed to prospective stockholders. No copy of this report is available.

John A. Burgess, San Francisco mining geologist, wrote a comprehensive geologic report November 23, 1926, with maps and sections, together with specific exploration recommendations. This is the most factual account of conditions at the mine during the period of major activity, and the work was apparently paid for by the mine manager. A copy of this report is available.

At some time during the period 1924 to 1928, an engineer named Collier and a geologist named L. D. Sivyer may have written brief reports on the property which may be presumed to be optimistic concerning potential of the property, to judge from contemporary correspondence. Copies of these reports (if they exist) have not been located.

E. L. Stephenson, Reno consulting geophysicist wrote a "Report on Exploration at the Betty O'Neal Mine" in February, 1956. This is a 12-page summary of the geology, geophysical surveys and subsequent drilling of a small area just north of the old mine workings. Stephenson's records were purchased by Betty O'Neal Silver, Inc., and a copy of this report is in company files.

Edmond F. Lawrence, Reno consulting mining geologist wrote a report titled "Betty O'Neal Mine" March 30, 1965. This is an 18-page report, with maps and sections, describing the geology and making exploration recommendations. Mr. Lawrence was retained by Betty O'Neal Silver, Inc., to prepare the report and make application for OME exploration loan. Copies of the report are in company files.

Geological Publications

Emmons, W. H., 1910, Some mining camps in Elko, Lander, and Eureka Counties, Nevada, United States Geological Survey Bulletin 408, 130 pages.

Gilluly, James, and Gates, Olcott, 1965, "Tectonic and Igneous Geology of the northern Shoshone Range, Nevada", United States Geological Survey Professional Paper 465.

Roberts, R. J., 1962, "Some exploration targets in north central Nevada", U. S. Geological open file report.

Regional Geology

The regional geologic setting of the Shoshone Range has been described in detail in the professional paper by Gilluly and Gates (see reference above), and the following general description is largely condensed from their work.

The major geologic feature of the range is the Roberts Creek Mountain thrust which brings into contact sections of Early and Middle Paleozoic age which contrast dramatically in lithology. A siliceous sequence of rocks has been thrust from the west, including Ordovician, Silurian, and Devonian sandstone, quartzite, shale, greenstone, chert, and rare small lenses of limestone. Underlying the thrust is a wholly different sequence of Cambrian, Ordovician, Silurian, and Devonian limestones and dolomites.

The carbonate sequence underlying the thrust compares with the stratigraphy of the classic areas of study at the mining districts to the east and southeast at Eureka, Hamilton, Ely, etc. These rocks are exposed only in "windows" where doming has brought the thrust fault to the surface in such a manner that erosion has cut through, exposing the lower plate of the thrust. No such window is known to exist in the Lewis Mining district, and the thrust fault lies at great depth. It is overlain by the siliceous Valmy formation of Early, Middle, and Late Ordovician age. The formation is very thick, consisting of over two miles of sandstone, siltstone, shale, quartzite, and chert, as well as considerable thicknesses of pillow lavas, fragmental volcanics, and other greenstones.

It is generally believed that the Roberts Mountains thrust took place in Late Devonian or Early Mississippian time, and the deformation is referred to as the Antler Orogeny. No igneous activity was associated with the Antler Orogeny, and no ore deposits are genetically related to it. Several late Paleozoic sequences (including an 800 ft. limestone unit, the Antler formation) were deposited after the thrusting of the Antler Orogeny. After deposition of these sediments, a second period of thrusting again moved western sediments over eastern sequences. This thrust is known by various names from place to place in the Shoshone range, and is named "Whisky Canyon" in the Betty O'Neal mining district. This period of thrusting is thought to have taken place at the same time as the Golconda thrust to the west. Gilluly terms this the "Lewis Orogeny". Rocks of Early Triassic age may be involved in Lewis Orogeny thrusting. No Jurassic or Cretaceous sedimentary rocks have been found in the Range, making the dating of the Lewis Orogeny a matter of speculation. It is post-Early Triassic(?), and might be Late Triassic, Jurassic, Cretaceous, or even Eocene in age.

Two cycles of intrusive igneous activity have been identified, although both are of similar composition, monzonitic to granodioritic. Erosion cut into the earlier stocks prior to the later cycle of volcanic eruptions. Large volumes of quartz latite tuffs and related rhyolites were erupted, and a number of the vents are filled with such quantities of intrusive breccia that they have been mapped and described as diatremes.

Much later, probably in the Pliocene, widespread basaltic andesite flows and their related fluvial gravel deposits were deposited over broad areas in volcanic "fields" which have been little dissected by erosion.

After eruption of the basaltic andesite flows, movement of great normal faults began to block out the range. The fault along the northwest face of the range is recurrently active, as is evidenced by the several steep fault scarps crossing the alluvial fans forming the gravel apron along the foot of the range. Geologic relationships and gravity geophysics suggest a mile or more of offset along the frontal fault bordering the range at the Betty O'Neal mine.

The "Roberts" Mineral Belt

In a recent U.S.G.S. open-file report (Exploration Targets in North-Central Nevada, 8 p., 12 illus. 1964), Ralph J. Roberts formally describes a linear pattern of mineral deposits that has been recognized for many years by economic geologists.

A narrow "belt" trending from southeast to northwest passes from beyond Eureka, through many smaller mining districts and the Betty O'Neal area, on across the Reese River valley to the Copper Basin area and beyond. Such mineral belts are observed elsewhere in Nevada and the western Cordillera of North and South America. The most impressive mineral lineation of this kind is the famous "Colorado Porphyry Belt" which contains virtually all of the important mines of Colorado in a long narrow band trending northeast from the La Plata Mountains to a point just north of Denver, where it presumably passes out beneath the younger rocks of the Great Plains. Another spectacular alignment of mineral districts is the Papelillo belt of northern Peru which, among others, contains the important Quiruvilca copper-silver mining district.

Although such mineral belts are readily identified and few geologists will deny that they are real enough, they are very poorly understood, and there is little agreement as to their probable mode of origin. Most investigators have concluded that they represent old, deep-seated weaknesses in the earth's crust, and that tension is probably involved. Broadly speaking, the belts intimately influence the igneous intrusions related to ore. The detailed pattern of structural control of alteration and mineralization is less clear, and it is often not possible to relate individual ore structures to the overall pattern. More will be said of the relationship in discussing details of control of the Betty O'Neal ore deposits.

One of the most puzzling features of the belts is the surprising variety of mineralization observed from place to place along the trend. The silver-lead deposits of Lewis and Hill Top are in contrast to the disseminated copper deposits at Copper Basin to the northwest, or the gold deposits at Tenabo to the southeast. Such variations are so common that they might almost be said to be characteristic of the mineral belts.

The mineralization of the "Roberts" belt is mainly mesothermal in character, and this fact has great significance insofar as future development of the Betty O'Neal mine is concerned. Mesothermal mineralization is usually fairly constant in strength and character even where several separate deposits are mined in the same district. Mesothermal mining districts are usually productive through thousands of feet of vertical range. In contrast, the epithermal "bonanza" precious metal veins, particularly those in Nevada, rarely are found to continue more than a few hundred feet vertically from the point of discovery. The theoretical explanations for this difference in vertical range of mesothermal vs. epithermal ore deposits is clearly set forth in the literature, and conditions in the Shoshone Range are in conformance with the general theories.

Geology of the District

Stratigraphy

Valmy formation.-- The oldest formations exposed in the district are the sandstones, shales, quartzites, greenstones, pillow lavas, and cherts of the Ordovician Valmy formation. Very minor limestone is found in the unit (Gilluly and Gates, 1965 p. 26).

The sandstones and quartzites are the moderately well-sorted pure quartz lithology that is regionally characteristic of the formation. The cement is usually silica, but in some beds, dolomite is the cementation material. In the Betty O'Neal mining district, fine cherty sandstone or siliceous shales are very common within the Valmy formation.

Most of the chert is composed of fine quartz in a siliceous matrix, which is locally very black due to the presence of organic matter. The greenstones of the Valmy range form pillow lava through pyroclastic breccia to fine ash. The ferromagnesian minerals are altered to chlorite. A few rare limestone beds are found in the formation, which are either dense and pure, or consist of fragments of fossil shells mixed with volcanic fragments, sand, and shaly material. The Valmy formation was deposited far to the west in the eugeosynclinal portion of the Cordilleran trough. It was thrust eastward into its present position during the deformation of the Antler Orogeny. The thrust fault lies at great depth in this area, probably at least a mile, perhaps as much as 2 miles beneath the surface.

Because of structural complications of the district, it is not possible to measure a complete section of Valmy formation. Regional work suggests a depositional thickness of at least 20,000 feet.

Because of the complexity of faulting in the mine area, and the generally poor outcrops, it was not possible to subdivide the formation into different members on the geologic map. However, whenever limestone was observed on the surface, it is shown separately, for limestone appears to be especially favorable for mineralization. More will be said of this relationship below.

Antler Peak limestone.-- Both a depositional hiatus and a structural discontinuity separate the Valmy formation from the next youngest formation in the district, the Antler Peak limestone. Several faulted exposures of this unit are found along the southwest margin of the district.

It is a light-gray limestone that is usually either very fine grained or very coarsely granular. A few beds are shaly, and a minor bed of limy yellow sandstone is prominently exposed. Regional mapping indicates a thickness of about 700 feet.

The Antler Peak limestone was probably deposited some distance to the west, and was thrust into the area during the deformation of the Lewis orogeny.

Structural Geology

Regional Structures

Roberts Creek Mountains thrust.-- Late in Devonian or early in Mississippian time, the sediments deposited in the western portion of the Early Paleozoic Cordilleran trough were raised along a north-south trending geanticline (the Antler arch), and some of the sediments moved, apparently by gravity sliding, into the elongated eastern miogeosynclinal trough. This surface of movement has been named the Roberts Creek Mountains thrust because it was first found in the range of that name. In general, where the thrust outcrops in north-central Nevada, the upper plate rocks are found to be Ordovician Valmy formation, the lower plate is usually limestone of the Devonian. There is currently much interest in the structure, for there is some sort of relationship between this combination of structure and stratigraphy and the so-called "invisible" gold occurrences now being found. The gold is so finely divided that it escaped conventional prospectors in earlier days, for it did not show up in the gold pan. No known igneous activity or mineralization is directly associated with the Roberts Creek Mountains thrust. The surface lies as much as 2 miles at depth under the Betty O'Neal mining district.

Lewis ("Whisky Canyon") thrust.-- A similar thrust fault again brought western rocks into the area, this deformation probably taking place sometime during the Mesozoic. In the Betty O'Neal district, the fault has been called the "Whisky Canyon" thrust, and the Antler Peak limestone southwest of Whisky Canyon is resting upon the fault surface. The thrust crops out at the extreme south of the district, at coordinates 4,600 N 11,600 E.

Local Structures

Laramide Faulting.-- Two sets of fault patterns are prominent in the Betty O'Neal district. Both of them guide and act as channels for the porphyry intrusions and mineralization. It is probable that fracturing, faulting, porphyry intrusion, hydrothermal alteration, and mineralization are all intimately related, taking place during the Early Tertiary Laramide Orogeny. One set of faults strikes northwest (parallel to Roberts Mineral belt) and dips vertically or to the southwest. The other set of faults strikes north-northeast and dips vertically or to the northwest.

Both sets of faults are locally intruded by porphyry dikes or are mineralized. The northwest set is most often filled with porphyry; the north-northeast set is most often mineralized. It is possible that the northwest faulting is in response to shear along the trend of the Roberts Mineral belt, and that the north-northeast set is a result of tension.

Of paramount interest is the unusual Yankey structure, which cuts clearly across every older feature in the district. It is a dip-slip fault, downthrown on the southeast, and is mineralized clear across the width of the mineral belt, from Whisky Canyon to Lewis Canyon.

Most observable fracturing and jointing at the surface is sympathetic to one or the other of the two fault patterns.

Basin and Range faulting.-- One of the most recently geologic events in the district is the prominent normal faulting along the northwestern margin of the Shoshone range. This faulting, so characteristic of the Basin and Range province, began late in the Tertiary, probably in Pliocene time, and is still active at the present time. The main Basin and Range fault is the prominent break that trends northeasterly across the map from coordinates 8,000N, 8,000E to 11,000N, 13,000E. The exact vertical downthrow along the basin side (Reese River Valley) of this frontal fault is probably in excess of a mile, certainly more than enough to place any mineralization to the northwest of the mine along the mineral belt trend, far beyond reach of present day exploration-exploitation technology.

Presumably because of oversteepening of the front of the range along this fault, several slices of rock slide from the side of the mountains in response to gravity. The large mass of quartz latite and Antler Peak limestone just to the west of the district was dropped into its present position along several such faults, from a former position near the crest of the ridge on Mt. Lewis. The quartz latite was probably formerly an integrated portion of the Rocky Canyon breccia pipe (see discussion below under Diatremes).

Igneous Geology

Granitic rocks.-- To the southeast of the district along the mineral belt, a large stock of granodiorite crops out between Hilltop and Mud Springs. Several smaller satellitic plugs have been found, and it is possible that these outcroppings are underlain by a much larger mass of plutonic igneous rock at depth. Several porphyritic quartz monzonite outcrops have been observed near the main mass of granodiorite, and they are thought to be a differentiated facies of it. A quartz diorite porphyry also forms offshoots of the granodiorite stock. None of these rocks crop out in the Betty O'Neal district, although they may underlie the area at not too great a depth. The granodiorite stock is not appreciably altered, although some of the satellitic quartz monzonite and quartz diorite porphyries have been affected by hydrothermal solutions to some extent.

Diatremes.-- Several large diatremes occur to the southeast of the Betty O'Neal district. Breccias of all kinds, tuffs, and a variety of foundered Tertiary sedimentary rocks all are found in large pipes which are intimately related to a variety of igneous porphyries, several of which are also found in the Betty O'Neal district, where they are very closely related to mineralization. The largest of the diatremes is just to the southeast, of the area shown on the geologic map, and is named the Rocky Canyon breccia pipe. It is possible that the quartz latite volcanic rocks mapped at the mouth of Whisky Canyon represent a down-faulted portion of the top of the Rocky Canyon pipe, as has been described above.

Intrusive porphyry.-- Quartz latite porphyry and rhyolite porphyry are mapped together under the rubric "quartz porphyry". They show prominent chilled zones and strong flow banding near their margins. The quartz latite dikes are composed of andesine, quartz, and biotite. The rhyolite dikes contain albite phenocrysts with very little biotite. Both porphyries are usually strongly altered.

A hornblende pyroxene dacite porphyry is prominent in the Betty O'Neal mining district, and often is altered only to a chloritic facies where the green color and dark clinopyroxenes give it a distinctive appearance. Where more strongly altered, it cannot be readily distinguished from the "quartz porphyry" and for this reason is not separately shown on the geologic map. It is likely that a detailed study of the porphyry dikes under the microscope would reveal many important relationships which might help in exploration for ore.

Pebble dikes.-- Only a small amount of detailed mapping underground has thus far been done in the district by the writer. However, in the Chloride No. 2 adit, near the face, the mineralized edge of a porphyry dike consists of a fine rock flour matrix that contains rounded fragments of altered porphyry and may contain well-rounded granitic material. The rocks are so altered that relationships are far from clear, but this may be a "pebble dike" of explosive gaseous origin. If the granitic material is the granodiorite of the main pluton at Hilltop, it must have come from depth and would lend support to the idea that the stock underlies this portion of the mineral belt.

Because of the recently proven value of pebble dikes as a guide to ore (see for example the work of Lovering in the Tintic district, Utah) very close watch has been kept for such structures elsewhere in mapping. Because of the extremely soft, altered character of the dike material, they are rarely found in outcrop, and none was observed during the course of geologic mapping on the surface. However, Stephenson (1956, p. 7) noted that ".....In a few places granite float was noted at the surface....." In a recent conversation, he recalls making neither the observation nor the statement in his report, and the locality of such granite float in the district remains in question.

Future detailed mapping underground should be done with the idea of detecting the presence of all such structures, as this would be a most promising guide to new ore in the mine.

Tertiary Geology

Although few Tertiary sedimentary rocks are found in the Betty O'Neal district itself, they are abundantly exposed in the surrounding area. Much is known of Tertiary geologic history through regional investigations.

After the initial period of early Tertiary (Laramide?) faulting and igneous activity, the area was uplifted enough to de-roof the granodiorite stock. At this time the volcanic-diatreme stage of igneous activity began, culminating with the intrusion of porphyry dikes, hydrothermal alteration, and ore deposition of the mineral belt, including the silver veins of the Betty O'Neal mine. Continued uplift exposed these veins to erosion. They were originally deposited in Mesothermal conditions, at depth greater than a thousand feet.

After the veins had been exposed at the surface, a rhyolitic eruption deposited welded tuffs in several places in the Shoshone Range. These tuffs filled local low spots, as did a number of locally-derived fluvial gravel deposits, which are found to interbed with the tuffs from place to place. None of these rocks are found within the district.

Overlying the rhyolite tuff and gravel is an extensive eruption of basaltic andesite flows, from 200 to 1000 feet thick, inclined and thickening to the northeast away from the crest of the Shoshone Range. These flows are fairly young, certainly no older than Pliocene. They are found immediately north and northwest of the Betty O'Neal district.

Alluvial deposits fill all low places in the area. The Reese River Valley is masked entirely by stream gravels and bordered by extensive coalesced alluvial fans along the margins, where ephemeral streams such as Lewis Canyon, Betty Canyon, Whisky Canyon, etc. drain the ranges. Lacustrine beds may be interbedded with some of the gravels under the deeper portions of the valley, but no lakes exist at the present time.

In Whisky Canyon, narrow terraces of gravel slightly older than the present alluvium in the arroyo bottom are seen along both sides of the canyon. These gravel terraces reflect an earlier cycle of stream cutting and erosion. They are now being dissected because of rejuvenation due to fault scarp uplift at the mouth of the canyon along the Basin and Range fault.

At a number of localities, particularly where alteration has softened the rocks and converted them to clays, small landslides have slumped from the hillside, presumably during an earthquake or because of a period of unusual wet conditions.

Influence of host rock on mineralization

Previous workers at the Betty O'Neal have expressed differing opinions with regard to the miner's favorite geologic topic; favorability of host rock to mineralization. Although most of the ore in the mine has come from the Estella shoot in a relatively small area, and the wall rocks are still relatively well exposed in open mine workings, a number of different rocks are found near the old stopes and relationships are by no means clear.

Senator Getchell's numerous weekly and monthly reports make it very plain that he favored quartzite, purely because it fractured well.

Burgess (1926, p. 16) believed that ....."Quartzite and sandy limestone form the walls of the larger orebodies, and these rocks appear to be by far the most favorable for ore". Burgess thought that the Estella ore shoot was in the immediate footwall of a porphyry dike, but this geologic relationship cannot be supported on the basis of present exposures.

Although Lawrence (1965, p. 13) believed that structural intersections were of prime importance in the control of mineralization, he states...."The localization of these ore shoots may be partially controlled by stratigraphy. ".....The ore shoots are usually closely associated with black graphitic shales, calcareous black shale, and/or thin-bedded limestone." In general, Mr. Lawrence did not record rock types on his underground geologic work sheets of the mine, but his opinion is based upon many different observations in the mine.

It is obvious that stratigraphic control is of importance secondary only to structure in the control of ore shoots. It is very possible that, together with good structure, some such simple combination as the following may serve as the ideal ore control in the mine; sandstone or poorly indurated quartzite with calcareous cementation, interbedded with graphitic shales. The sandstone might be expected to be more permeable to permit passage of ore solutions. An impervious shale in one or both walls might restrict movement ot the sandstone bed. The sandstone-shale combination also might act in the traditional competent-incompetent relationship, where fractures are readily transmitted through the sandstone and do not pass into the shale. Calcareous cementation often results in good replacement and serves as a reactive modifier of the ore solution (pH). The presence of graphite generally might be expected to cause changes in oxidation-reduction equilibria (Eh) of ore solutions.

Primary Ore Deposition

Hydrothermal alteration.-- No extensive investigation was made of the changes in the wall rock caused by hydrothermal alteration along faults and veins. At various localities a decided bleaching is observed at the surface near vein outcrops or in areas where vein float is seen. Sandstones are particularly susceptible to this bleaching and iron staining. Presumably the sandstone are permeable and more reactive, as described above, and this is even further brought out during weathering and supergene processes. Other rock types, perhaps equally well altered, might not bleach so well in outcrop because of poor circulation.

Although hydrothermal alteration effects are not generally pronounced in the district, it is possible that study of thin sections under the petrographic microscope might reveal significant alteration patterns near mineralization, thus presenting a valuable guide to ore. Particular attention might be paid to impure sandstone with clayey cementation, where sericitization, for example, might readily be seen under the microscope. The alteration of the porphyry dikes might also respond to microscopic studies where hand specimen examination has been far from satisfactory.

Mineralogy of the veins.-- The ores of the district were formed in two stages of mineral deposition (Burgess, 1926, p. 9). An early barite stage carried little or no silver, and a later stage of quartz was introduced, accompanied by the ore sulphides. Several stages of quartz may have been introduced, most of it white with a sugary texture, some of it clear with acicular crystals. Calcite is often present, and when tinted pink, probably containing manganese. The ore minerals are argentiferous tetrahedrite (Freibergite), galena, and sphalerite. Recent work by Donald E. Ranta (unpublished Master of Science thesis, Mackay School of Mines, 1967) suggests that the role of galena as a silver bearing mineral at Betty O'Neal has probably been over-emphasized by previous workers. Tetrahedrite seems to account for most of the silver, with a smaller, perhaps minor amount, in the sphalerite.

Pyrite occurs in minor quantities, and the local presence of small amounts of chalcopyrite is taken as a good sign as to presence of silver in the ore. In unoxidized ore, there is approximately a fourth of a pound of lead and a fourth of a pound of zinc for each ounce of silver. Gold values in the unoxidized ore are negligible.

Structure of the veins.-- The usual vein material consists of quartz-replaced wall rock with streaks and inclusions of partially replaced wall rock. From place to place glistening dark tetrahedrite can be found in the milky quartz, and clear crystalline quartz is usually found near the silver-bearing sulphide. The tetrahedrite may be found in a blotchy irregular matrix of finely crystalline, intergrown galena and brownish sphalerite. In the Estella shoot, tetrahedrite formed in seams and irregular masses as much as 2 or 3 ft. thick. One or both walls of the vein is usually gougy, and the veins present a fissured appearance.

The most important vein in the district is the Estella, which never comes to the surface because it terminates against the Yankey fault vein, about 100 ft. below the present surface. The Estella is best developed on the No. 4 and No. 5 tunnel levels, where it is developed northeasterly for about 600 feet, dipping to the northwest at an average of 45 degrees. Actually the structure is not a single continuous vein, but is a mineralized gougy zone that contains lenses and pods of quartz-carbonate mineralization from a few tens to a hundred or more feet along strike, and up to ten feet or so in thickness. To the northeast the vein turns to the left (to the northwest) and apparently weakens in several of the gougy splits and branches of the Topsy fault, a newly recognized northwesterly mineralized fault of some importance. To the southwest, relationships are not completely clear, but Burgess described the vein termination as being due to the vein entering the end of a dike; the dike extending farther to the northeast on each successive level downward in the mine, so that the shoot never extended past the 150 level. The Estella shoot has never been located in the deeper levels of the mine, but it appears probable that post-ore faulting did not shift the vein out of position.

Exploration work is now underway in an attempt to pick up the northeasterly continuation of the Estella vein across the Topsy fault. To the southwest, a drill hole intersection in DDH No. 3 is interpreted as being in the Estella. Burgess' explanation for "termination" of the vein is not satisfactory. The vein continues on quite persistently, as shown in the last of the development on the No. 4 level. Some confusion resulted from the fact that the Estella vein does not outcrop, and that the vertical dip of the Yankey was not understood. Because the vein does not outcrop, and the No. 4 level drifts and crosscuts are the only underground development thus far on the structure. At several places, ore grade material has been sampled from the vein (see assay map), and sampling is far from complete. An excellent chance exists for finding more ore shoots on the Estella, particularly where the better portions of the vein join the Estella vein just above the No. 4 level, in areas now rehabilitated and ready to explore at reasonable cost.

The most continuous mineralized structure in the district is the Yankey fault-vein, which trends NNE from the Yankey tunnel (6,400N 11,000E) to the main mine area (8,300N 11,800E), where it turns slightly and trends NW across Lewis Canyon. In the central portion of the district it is mineralized with quartz and carbonate gangue, and has been mined above and below the No. 4 tunnel level where the Estella vein intersects it. The vein found in the upper and lower McGarr tunnels is the Yankey vein, and considerable confusion can be avoided by dropping the McGarr name previously given to this structure.

The "discovery" vein in the district was the Betty O'Neal which strikes slightly northwest, and dips to the east in underground workings. Relationships are not clear in the old Betty O'Neal portion of the mine, for the vein appears to dip in the opposite direction on the surface, and drill hole B-1 was drilled to check this possibility. Results were not completely conclusive, and rehabilitation of the Chloride No. 2 tunnel, Water (150L) tunnel, and other shallow workings is a more straightforward method of working out the structure of the area. The Betty O'Neal ores were very rich near the surface, presumably because of moderate supergene enrichment at the top of the sulphide zone. At about the time the Betty O'Neal mine was shut down, at the turn of the century, it appears likely that they had gotten down into primary milling grade ore and were not able to make a profit smelting it directly in the Lewis Canyon works.

The Nebraska and Kinkaid (North and South) veins may represent a interesting faulted relationship of the Estella vein. The veins' strike and dip are parallel with the Estella across the Yankey fault-vein, and it is possible that pre-ore offset of the Yankey of 150 to 175 ft., downthrow on the east side, might have shifted one single ore structure just before or during metallization so that the structures are actually the same. This sort of structural relationship is observed in many mines elsewhere in the world. An almost identical structural framework exists at the Matahambre mine of Cuba, an ore deposit which shows many other striking similarities to the Betty O'Neal geology. The drill hole intersection in DDH No. 8 is in this Kinkaid portion of the vein, on the east side of the Yankey vein. It will probably terminate against the Yankey vein going downward, and in fact the suspected point of intersection can be seen in the walls of the Yankey stopes just above the No. 4 tunnel level.

Little is known about the northwesterly structures, except that they are more likely to be occupied by porphyry dikes than by good mineralization. They appear to terminate the veins of the NE trend however, and not by clean fault movement, but more by turning and pinching the veins until they run parallel to the northwest trend or have died out. The map of the surface, as well as the north end of the Estella vein on several levels underground, shows the tendency for the NE trending veins to be shifted slightly to the left (to the northwest) across the northwest structures. In other words, they are left-lateral, strike-slip faults. This is in keeping with the suspected shear mechanism of origin.

It should be strongly emphasized that all of these structural adjustments took place immediately prior to, or during metallization. Contrary to the interpretations of the U.S.G.S. in their recent small scale mapping, there is no evidence that has yet been found to support the idea that basin and range faulting passes through the center of the district. The entire northwest end of the district is sliced cleanly off at the margin of the range, where the Getchell tunnel passes from valley gravel to bedrock, but there are no post-ore faults in the mine itself southeast of this frontal fault.

In detail, the mineralization of the Betty O'Neal mining district conforms quite well structurally to the regional concept of the Roberts Mineral Belt (see above). Virtually no mineralization is seen southwest of Whisky Canyon, which itself is apparently carved on one of the northwesterly faults parallel to the main belt trend. The northeast margin of the belt can be marked less distinctly by Lewis Canyon. The belt is roughly half a mile in width between Whisky and Lewis Canyons. The position of the Estella and Betty O'Neal veins roughly in the center of this belt is thought to be somewhat coincidental, for mineralization does not die out gradually in both directions. On the contrary, strong mineralization is seen right up to the edge of the belt, and dies out abruptly across the canyons marking both edges. It should be emphasized, however, that very little "footwall" exploration has been done across the Yankey structure to the southeast in the direction of the main mineral belt. The long crosscut on the No. 5 was probably intended to accomplish this, but it headed too much to the east, rather than southeast, to pick up new ore shoots at a relatively high angle.

Secondary Modifications of Ore.-- Because of the well-known tendency of most Nevada silver ores to have limited vertical range and to be modified extensively by surficial effects of oxidation, much attention has been given to supergene alteration. Shallow ores in the mine apparently contained high grade concentrations of silver chloride, as is usually the case in silver mines of the region. There appears to be a relatively barren leached zone of 50 to 60 feet beneath the chlorides before primary sulphides are encountered. In the upper part of the sulphide zone, additive enrichment of silver takes place where fine wire silver is found attached to the surfaces of primary tetrahedrite crystals. Ore formed in this manner is somewhat richer in silver than the primary tretrahedrite-bearing ores.

It is thought that the quantity of such ore mined in the past has been relatively small, except for the shallow rich ores in the Betty O'Neal vein workings. The Estella ore shoot never cropped out, and was not subject to vigorous oxidation, so that there could have been little secondary mobilization and enrichment of silver.

Supergene copper or silver sulphides such as chalcocite, covellite, stromeyerite, acanthite, argentite, etc., have not been observed in the upper portion of the sulphide zone, where they might be expected to occur.

Following is a summary of the behavior of the various ore metals during oxidation:

Silver When liberated from base metal sulphides such as tetrahedrite and sphalerite, silver is fixed partially in sub-outcrop as the stable chloride, and some of it migrates downward in aqueous solution to the water table, where it forms native (wire) silver on silver-bearing primary tetrahedrite.

Zinc The small amount of zinc present in the ores is apparently leached completely clean of the zone of oxidation. It may be dispersed downward in aqueous solution where it might form (as yet unrecognized) coatings of secondary sulfates or carbonates of zinc.

Copper Upon decomposition of chalcopyrite, the copper migrates only for a short distance before it combines with sulphate (from the sulphide vein minerals) or carbonate (from the decomposed gangue or wall rock calcareous minerals) to form vivid green chalcanthite and malachite staining.

Lead Upon oxidation of galena, the lead apparently recombines, in situ, with carbonate to form cerussite. Ranta (1967) has observed lead carbonate replacing primary tetrahedrite in oxidized ores.

Manganese Secondary manganese oxides are widely dispersed through the oxidized zone.

Gold Although there is only a very small amount of gold in the primary ores, it apparently residually enriches, as the native metal, at grass roots.

Antimony Until very recently, methods of determination of antimony in trace amounts were so tedious that the behavior of the element has not been investigated. It should form very stable oxidized compounds, which would not easily be distinguished from limonitic materials.

GEOCHEMISTRY

When Betty O'Neal Silver, Inc., first began exploration work in the district, the writer was retained to undertake a soil sample orientation survey over the Estella stopes. A report of results was submitted in April, 1965. Because of the incomplete geologic picture at the time, certain conclusions were reached which are probably not valid. The Estella shoot has subsequently been found not to come through to the surface. What appeared to be caved areas, where the workings stoped through, are now known to be fill passes. Soil was transfered down these passes for tramming into stopes on the sub-levels above the No. 4 and No. 5 tunnels. Some of this dirt fill can be seen caving into the north end of the No. 5 level workings. Development work on the 4 and 5 furnished enough waste for stope fill below these levels.

A grid of 100 samples was laid out on 100 ft. spacings in 10 rows 100 ft. apart; an area of 900 x 900 ft. square centered over the presumed position of the Estella sub-outcrop. The soil samples were run for Antimony (Sb); Arsenic (As); Copper, cold extraction (Cu_{cx}); Manganese (Mn); Mercury (Hg); Silver (Ag); and Total Heavy Metals, cold extraction of combined copper-lead-zinc (THM_{cx}).

Because the very rapid THM_{cx} test seemed to reveal as good a geochemical pattern as any of the more tedious methods, it was decided to collect a sample grid over the entire district on 100 ft. spacings, and to run them for THM_{cx}. Any sample containing anomalous values (+15 micrograms THM_{cx}) was run for silver, using the wet method of

Bloom, which had just become available. A geochemical map showing the distribution of THM_{cx} in the soils of the Betty O'Neal mining district accompanies this report. Analytical work for silver using the Bloom method revealed a fair correlation between THM_{cx} and Ag. Those samples showing anomalous Ag were re-sampled in more detail by collecting 25 samples at each site on a 5 x 5 square grid on 10 ft. spacings, the grid centered on the initially anomalous sample. Each of the 25 new samples actually consisted of five 8" deep pits, one on the exact sample site, and one 2 ft. away in each of the four quadrants of the compass, the pattern resembling the 5-spot face of dice. About 10 grams was collected in each of the 5 pits, which was combined to make up the single sample. This extra care was taken to eliminate, insofar as possible, the suspected erratic surficial distribution of small amounts of silver in halogen compounds in the soil. Twelve anomalous areas were sampled in detail in this manner, and preliminary exploration of several of them has revealed interesting mineralized structures.

About a year ago, atomic absorption spectrophotometric methods of analysis for silver in soils had progressed well enough that as little as 0.1 microgram of silver could be quickly detected. It was decided to run all of the 100 ft. grid samples for silver by atomic absorption. The work was done in the writer's laboratory, using a Perkin-Elmer 290 instrument with Texas Instruments strip chart recorder. Several cross checks were performed using a Perkin-Elmer 303 atomic absorption spectrophotometer with digital concentration read-out accessory. A map showing the results is enclosed with this report. The atomic absorption results reveal much more detail than the data obtained by using "wet" methods of analysis. The position of the silver anomalies in most cases coincide with the Total Heavy Metal anomalies.

In recent months, effort has been concentrated on underground exploration to follow up the results of diamond drilling from the surface. Exploration of geochemical results was postponed, as the geologic work necessary to interpret the drill hole results was done. Surface mapping has in most cases detected evidence of mineralization in each of the areas where anomalous silver was found in the soil. There are so many geologic exploration possibilities, that geochemistry has for the time being been relegated to a secondary role in exploration. Exploration based partly on geochemistry will be discussed below under Recommendations.

In general it is thought that no serious mistake has resulted from mis-interpretation of the "blind-apex" of the Estella shoot. The Yankey vein actually comes up under the area sampled, immediately over the point of juncture of the Estella vein. It appears likely, though by no means certain, that enough metal passed upward along the Yankey vein, so that good anomalies were obtained anyway. In any event, subsequent routine grid sampling over other known veins in the district, which outcrop such as the Betty O'Neal and Kinkaid, shows geochemical patterns in the soils very similar to that obtained in the orientation survey.

Continued rapid advances are being made in geochemical determinative techniques. Speed, quality, and cost of the work continue to improve, and many important elements can now be determined which were difficult or impossible only a year or so ago. In the immediate future, it is recommended that use of geochemistry be restricted to analysis of soil and float only in areas of poor outcrop where a bulldozer cannot be taken for exposure and sampling of bedrock structures in place. Geochemical analysis should be made only for gold and silver. Gold and silver, if done simultaneously, can now be determined for $2.50 per sample in commercial laboratories (such as Rocky Mountain Geochemical Laboratories in Salt Lake City) to limits of detection of 0.1 and 0.25 micrograms, respectively. It is now possible to easily detect very small (tens of nanograms) amounts of mercury in soils and rocks, either by the U.S.G.S. "wet" ferrocyanide method or with the use of specialized atomic absorption spectrophotometers, such as the Lemaire bench model mercury detector. Some testing may be done around the Estella shoot to see if rock or air in the fractures might reveal a halo distribution of mercury around the ore deposit. Because of the volatility of mercury, such exploration is currently being given serious consideration in the U.S.S.R. and Canada. It is quite possible that fulminate of mercury detonation of explosives will have resulted in the complete masking of any small natural patterns that may originally have been present.

RESULTS OF PREVIOUS EXPLORATION

Getchell

As was mentioned above in the historical review, Senator Getchell was exploring exploration objectives in two locations only at the time the mine closed in 1929; (1) deep work in an attempt to locate the Estella ore shoot, and (2) exploration of the south end of the No. 4 level, following the Estella vein by drifting, and by crosscutting at the surface in the Yankey tunnel. Of course, the Yankey vein is not the Estella, and some confusion existed at the time because of misinterpretation of vein relationships.

In 1935, when modest financing permitted a brief resumption of work, a raise was put up on the south end of the No. 4 tunnel, gobbing waste in a crosscut, for the tunnel was not in good enough condition to tram waste to the dump on the surface. Some work was done driving south on the No. 2 level on the Kinkaid vein, but this too was abandoned with little attempt to develop any of the showings encountered.

Burgess

J. A. Burgess made a number of exploration recommendations in his 1936 report. Virtually no attention was paid to his suggestions, to judge from the amount of work done. It is interesting to note that he recommended several projects also proposed by the writer, before the Burgess report was obtained from the Getchell heirs. These recommendations are briefly summarized as follows:

Re-open north end of No. 5 level and drive new drift.-- This work is virtually the same as that now planned in the "E-1 area" and has the same objectives.

Drive northwesterly on the Winze level.-- This work is very similar to that proposed for the "Anomaly Vein" (see below). This project was rejected by the O.M.E. on the basis of lack of space for an important ore shoot. Study of the maps seems to indicate ample room for a major deposit. The project is quite feasible, for the work would be done off the No. 5 tunnel level only a short distance from the portal.

Drive northwest on the 75 level.-- This work is the same general area, and would explore the same possibilities as the current "E-1" project, but at somewhat greater depth. This work would have penetrated about the area where drill hole E-1 was drilled.

General.-- Some of the work recommended by Burgess at and below the 150 level, in search of the downward extension of the Estella vein, was done and was not successful. Also, a small amount of crosscutting and drifting in the Betty O'Neal area was recommended to cut the Betty O'Neal vein at greater depth. The work was not done, and cannot now be considered unless the Water tunnel (150) level or the Betty shaft is rehabilitated, or some other means is found to dispose of the waste from new work. Because little is known of the geology of the Betty O'Neal portion of the mine, it is not possible to comment on the relative merit of this exploration proposal.

Stephenson

Mr. Stephenson believes that the six drill holes put down in the northern portion of the district were incomplete, and has several times expressed the opinion that much more work should have been done. The only result of importance obtained was a two foot intersection assaying

5.2% Cu at 151-153 ft. in DDH No. 5 (9,720N, 13,360E). This mineralized intercept is unquestionably in the Yankey fault-vein, although no obvious showing of mineralization is seen along this segment of the structure. Copper mineralization might be expected to have been leached cleanly from the croppings, and apparently the chert here was not bleached prominently by the resulting acid supergene solutions, as would have been the case in more reactive rocks.

Lawrence

The following summary of results of recent diamond drilling from the surface is condensed from the application for O.M.E. Contract Stage III exploration assistance)Payne, 1967, p. 1-3).

During 1965 and 1966, diamond drilling from the surface was done at the Betty O'Neal mine as the first stage of an O.M.E. exploration contract. The locations of the holes were originally made by Mr. Lawrence, a few of them being considerably modified by O.M.E. officials in Washington. Of the nine holes originally approved in the contract for Stage I, eight were drilled for a total of 2,755 ft., as tabulated on the following page. Four additional shallow surface holes were approved in Stage II, for a total of 1,135 ft., as shown on the tabulation.

The results of this drilling indicate mineralization of interest in four of the holes; D-3, D-8, D-9, and E-1. The mineralization in D-3 is thought to be an intersection of the Estella vein. The intersection is 200 ft. (vertical distance) below the No. 4 tunnel level, near the extreme south end of the workings on this level. The intercept

O.M.E. Stage I and II diamond drilling
Betty O'Neal Silver, Inc.

Drill hole	North	East	Elevation	Depth	Results
Stage I					
D-2	6,500	11,598	6402	375	30 - 50 mineralized 130-150 mineralized 210-230 mineralized
D-3	7,335	11,171	6130	614	530-535 8.27 oz. Ag 535-540 21.86 oz. Ag
D-4	6,732	11,728	6357	150	none
D-5	5,501	11,640	6299	350	none
D-6	8,378	10,941	5881	307	none
D-7	7,685	12,570	6347	205	none
D-8	7,911	11,796	6072	303	90-95 2.18 oz. Ag 130-135 57.35 oz. Ag 155-165 12.51 oz. Ag
D-9	8,693	12,462	6115	451	0-20 mineralized 180-200 mineralized 380-400 mineralized 400-405 19.90 oz. Ag
		Total, Stage I (2,755)			
Stage II					
B-1	8.956	10,796	5693	325	none
E-1	8,959	11,702	5882	310	270-275 0.68 oz. Ag 275-280 0.90 oz. Ag
K-1	6,055	11,540	6242	200	none
K-2	6,043	11,344	6197	300	none
		Total, Stage II (1,135)			
		Total to date, 3,890 ft.			

in D-8 is thought to be on an unexplored segment of the Kinkaid vein, and is at and just above the elevation of the No. 3 tunnel level. The interesting intercept in drill hole D-9 is thought to be an unexplored segment of the Nebraska vein, approximately 80 ft. (vertical distance) below the No. 5 level. The mineralized fissure in E-1 was intersected at approximately the expected position of a possible faulted extension of the Estella vein.

Three of these intercepts are now being explored underground. The D-8 area is being explored by crosscut on the No. 3 level, working off the S-227 raise above the No. 4 tunnel level. The D-3 area is being explored underground by diamond drilling from a new crosscut and a drill station in an old raise above the level. The E-1 area is being explored by re-entry into old mine workings at the north end of the No. 5 level, so that two flat drill holes can be diamond drilled on this level. The drill hole intersection in Drill Hole D-9 will not be investigated at this time. It is too marginal and too near a fairly well explored section of the vein to be attractive at this time.

EXPLORATION POSSIBILITIES

A number of factors combine to make the Betty O'Neal district inviting for exploration at this time. The mine was shut down during a rapid falling of silver prices, when little exploration work was done save for very expensive and inconclusive attempts to find the Estella shoot on the lower levels of the mine. No really detailed geologic mapping has been done underground, nor has good systematic sampling been undertaken. No diamond drilling or long hole drilling has been done. The moderate amount of recent surface drilling has turned up several promising mineralized intercepts. As has been outlined above, the ores of the district are controlled by subtle, exceedingly complicated geologic conditions, and there is a good chance that a number of ore shoots of the size mined in the past might be developed.

In considering future development, it is probable that some shallow ores may be found that are rich enough to ship directly to the smelter, such as represented by the drill hole intersection in D-8, currently being explored on the No. 3 level. However, most of the primary ores can be expected to be of milling grade. It is not possible to predict exactly what an economic break-even, of "cut-off" grade might be, but at the present price of silver and current costs of labor and supplies, 20 ounce ore might be considered a minimum cut-off in a moderate sized, well run operation.

In order to construct an efficient mill that could be amortized in conformance with good tax practice, a minimum of 100 tons per day throughput capacity should be considered, and a minimum of 5 to 7 years of operation. In other words, 150,000 to 250,000 tons of ore, an amount almost exactly equal to the production of the district thus far, if one makes allowances for the fact that 10 to 20% more silver could have been taken out if former operators had not forced the grade up over 30 ounces in an attempt to carry development costs and pay dividends in 1926, 1927, and 1928. Construction of the mill should not be considered until from a third to a half this tonnage, say

60,000 to 100,000 tons of ore, is blocked out, preferably more. Ten ore shoots 5 ft. thick, 100 feetlong, and 150 ft. along the dip would provide this initial tonnage, this being about the average size of the shoots mined in the Estella shoot and the Betty O'Neal vein.

EXPLORATION POSSIBILITIES

The most promising exploration possibilities are summarized below. They are listed in order of priority, taking into account geologic merit as a first consideration, but also feasibility, cost, timing, etc. It will be noted, for example, that all of the projects can be done from the surface or on or above the No. 4 and No. 5 tunnel levels. Unless some of this shallow work is successful, it is not recommended that deep exploration work be done in the mine, as the cost of the work is out of proportion to the risk involved at this time.

Present exploration work

The Stage III O.M.E. Exploration Contract recently approved will accomplish three major exploration objectives:

D-8 area

The high grade intercept in drill hole D-8 is being explored by a new crosscut on the No.3 tunnel level (caved at the portal), working from the S-227 raise from the No. 4 tunnel level. About 95 ft. of crosscut is to be driven, followed by 35 feet of drifting and/or raising to test the extent and character of mineralization (see Figures 1 and 2). This intercept is probably of a northern segment of the Kinkaid vein.

D-3 area

The ore intercept in drill hole D-3 is being explored by short diamond drill holes underground to be drilled from two stations; one prepared at the end of a new crosscut on the level, the other in the 60 ft. raise already driven off the level (see Figures 3 and 4). This work is being done to check the up-rake extension of any ore shoot present, and to explore the intersection of the Estella vein with the Yankey vein, some 110 feet above the No. 4 level.

E-1 area

The mineralized zone in drill hole E-1 is being explored by short diamond drill holes to be drilled from a station to be prepared in the old drift at the north end of the No. 5 tunnel level. In order to by-pass extremely pad caved ground in the Estella stopes, where dirt had been used for fill, 80 ft. of new crosscut is to be driven across from the footwall, then 150 ft. of old workings will be rehabilitated, some of which are probably caved. This work is aimed at testing for a possible northward extension of the Estella, across the Topsy fault, where the vein has apparently been shifted to the northwest (see Figures 5 and 6).

The completion of these three projects will expend all currently authorized O.M.E. exploration funds, together with Betty O'Neal corporate allocation for 25% participation. If any of the work is successful, additional exploration funds should be provided to accomplish the following additional projects.

Future Exploration Work

No additional deep drilling from the surface should be considered at this time. These diamond drill holes are unsatisfactory from almost every point of view. The roads are expensive to install, and surface physical and weather conditions not conducive to good progress. Very poor sample recovery has been obtained, especially in the upper, oxidized portion of the holes. During drilling they were often in such poor condition that recovery was below 20% in altered and mineralized zones. The chert was exceptionally tough on bits, and drilling costs are very much out of line for deep drilling from the surface. A secondary consideration is that if drill holes of several hundred foot depth are to be drilled out away from the mine, there would be almost no way to follow up except to drill many more holes from the surface, before deciding to develop the showing underground. This is a very expensive method of development. The structure and mineralogy of the Betty O'Neal ores makes deep diamond drilling a risky proposition at best. The ore shoots are short and discontinuous, and a drill hole might be put through a major shoot without detecting it, unless some means of insuring better core recovery can be assured.

The drilling of short holes underground is much more satisfactory, for the holes are smaller, are started in good solid ground so that vibration and tool-whip are minimized. Also, the drillers on this type of equipment are of necessity more experienced than the typical surface operator of the truck-mounted drills. In any case, very close supervision of the driller is always necessary in this kind of country rock.

Following are the most attractive prospects at the mine at this time.

Estella Vein

In addition to the O.M.E. work currently in progress in the D-3 area on the Estella Vein, there are a number of exploration possibilities in the No. 4 workings. Spotty sampling to date has revealed three showings of ore which have not been developed. Systematic close-spaced samples would doubtless reveal many more such showings. Each of them should be followed by raising, or by diamond drilling or percussion long hole drilling off the level. Such work should be aimed at following leads upward until they develop into a mineable shoot, or where a major ore intersection might be encountered where the Estella joins the Yankey vein a hundred feet or so above the level. Inasmuch as the No. 4 tunnel is now rehabilitated, and the irregular mine workings provide a variety of different angles from which to drill, this work could be done with little further initial outlay, and with minimal overhead expense.

<u>Kinkaid vein</u>

In addition to the O.M.E. work now in progress in the D-8 area, there are several exploration possibilities on the Kinkaid vein. Much of the work on the No. 2 level was done in 1935, late in the development of the mine. The Kinkaid North adit and winze was likewise mostly done during the depression years. Some small amount of stoping was done on the vein in the "S" Intermediate and No. 3 tunnel levels, but little of these old workings have been sampled. As can be seen on

Cross Section A-A', no work has been done deeper in the mine, particularly where the Kinkaid is expected to intersect the Yankey fault just below the No. 4 level in the south and central portions of the mine. This intersection is projected at about 50 ft. below the No. 4 level in the D-3 area. The most efficient method of exploring the vein would be by several short crosscuts from the present No. 4 level workings, drifting in both directions on the vein. Alternatively, the vein might be explored by diamond drilling or percussion long hole drilling from present No. 4 and No. 5 tunnel level workings (see Cross Sections A-A', B-B', and C-C'). Here again, all initial costs have been borne by other work, and the actual contract footage costs are all that would be involved.

Anomaly vein

The anomaly vein, recently followed a few rounds in a drift in the adit of the same name just uphill from the No. 5 portal, has not been adequately explored. Relationships are shown on the Geologic Map and on Cross Section C-C'. The vein shows a fairly impressive amount of float on the surface, and as exposed in the adit, is a good strong structure along a porphyry dike. It is possible that the anomaly adit segment of the vein is leached. The No. 5 tunnel level is 90 ft. vertically below, and a short drift should be driven from it along the contact of the dike. If the vein is encountered, it should be followed, and a raise putup on the best showing.

Betty O'Neal vein

A good showing of ore is exposed at the extreme south end of the Chloride No. 2 adit (see accompanying assay map). This may be an unexplored northward extension of the Betty O'Neal vein, for projections of the showing up-dip, down-dip, and to the north along strike all miss the other workings cleanly. It is proposed that the Chloride No. 2 adit be rehabilitated, installing rail, air, and water lines. Drifting on the structure should be attempted, and if the ore is found to be continuous, a raise put through to the surface or off at a slight angle to connect with the Powder adit level. This work might easily be followed up 90 ft. or more below by re-opening the Water tunnel, the portal of which is 550 feet away.

Unexplored veins on surface

At a number of places, geochemical sampling and surface mapping have revealed veins which have not previously been described, which have only been superficially prospected by shallow pits. Each of them is named below, and it is recommended that they all be explored in the same manner. A large bulldozer with three-prong hydraulic ripper should be used to excavate a single clean trench deeply enough to determine the strike and dip of the structure. Care should be taken not to smear spoil all over the hillside and obscure the bedrock situation. While the bulldozer is on the site, a portal for a short exploratory adit should be prepared downhill from the trench exposure, in such a manner as to gain the greatest possible amount of depth for the length of adit to be driven. After all of the portal sites are prepared in this manner, a crew can work from one adit to the other with small compressor, 12-B mucking machine, etc., to drive far enough to determine the width and character of the mineralization. If the vein is still oxidized and leached at the adit level, a short winze should be put down on the most likely portion of the vein until un-oxidized sulphides are reached, probably less than 10 or 20 feet in all cases.

Following are the most promising of the veins observed on the surface; in most cases the dip is not known; the strike of the structures has been inferred from float.

Triangle vein.-- At 10,300N 12,150E a geochemical anomaly, an area of mineralized float, and a narrow topographic depression all occur near triangulation station H. This area is completely unexplored, and it is recommended that an adit be driven to explore the structure at depth. Thirty-five to forty feet of back can easily be gained in less than 100 ft. of adit, if the bulldozer cut at the portal is carefully done. The topographic depression might be due to the oxidation of the sulphide ore minerals, and the easily eroded soft walls along an ore shoot. Such topographic depressions are often used as a guide to such ore shoots in Nevada.

Treasury vein.-- At 7,200N 10,290E a very strong vein is seen at the downhill edge of a very large silver anomaly previously thought to be related solely to the Yankey vein, which crops out boldly farther up the hill. The vein shows much crystalline quartz, and considerable iron staining is presumably due to former sulphide minerals. After determining the dip by deep bulldozer trenching, an adit should be driven to explore the showing at depth. It should be possible to obtain 35 to 40 ft. of back without driving more than 100 ft.

Pipe vein.-- At 8,280N 10,580E another combination of narrow topographic depression, vein float, and (small) geochemical anomaly has been found.

It should be explored by adit, and it will be simple to obtain 50 ft. of back in a short distance.

Lucky Day vein.-- At 5,540N 12,100E there is a deep topographic depression, a strong geochemical anomaly, and indication of mineralization and alteration at the surface. A short adit should be driven under the showings to test for an ore structure.

Mike Burke vein.-- At 5,100N 11,820E a narrow but bold vein outcrops on the side of the hill. Several prospect pits have been suck on it, but it lies outside of the geochemical grid, and little can be said of the strength of mineralization. While the bulldozer is working in the Lucky Day area, it should be possible to cut deeply enough into the croppings on the Mike Burke to determine if further work is waranted.

Whisky Canyon thrust

With the current exploration emphasis on thrust faults in north-central Nevada, attention is naturally focused on the Whisky Canyon thrust where it is mineralized or adjoins mineralized ground in the Betty O'Neal district. It is generally believed that thrusts act as a barrier and conduit for ore solutions, thus presenting a particularly good host for mineralization. The base of the upper plate is commonly broken; in this case the Antler Peak limestone. Such a combination of underlying fractured Valmy formation capped by broken limestone of the thrust plate might result in important ore deposition. The thrust probably lies at reasonable depth all along Whisky Canyon. However, two localities appear particularly inviting. One is the silicified and pyritized outcropping on the east side of the mouth of Whisky Canyon, a strong geochemical anomaly was obtained. The second place is where the Yankey fault-vein crosses Whisky Canyon near the intersection of coordinate lines 6,000N 11,000E. Here, the Antler Peak limestone outcrops to the east of the structure, on the downthrown side. A vertical drill hole should be drilled at about 8,500N 9,000E and another at 5,900N 10,950E. In neither case is the depth of the hole known for certain, but it may be presumed that if within several hundred feet the hole does not pass through the thrust fault, showing evidence of mineralization, and into the underlying Valmy formation that any ore present would be too deep to economically explore and develop.

Many other exploration possibilities exist in the district, and doubtless future experience will suggest many more. It is hoped that the above outlined proposals will redevelop the mine, and that exploration to replace ore as it is mined can be put on a routine basis, the expense of the work carried by mineral production.

RECOMMENDATIONS

The following exploration recommendations are made with a view toward developing the mine in the most efficient manner.

Mine sampling

Every showing of mineral should be channel sampled on close spacings in a systematic manner.

These sampling results are absolutely essential if a thorough understanding of the relationships of the geology to mineralization is to be understood.

Several unexplored veins encountered underground have been found where a mineable width and grade of silver ore awaits further development. It is probable that systematic sampling of the workings would reveal many more such showings. If enough of these showings were explored and developed, good tonnage of ore might be blocked out at far lower cost that drilling from the surface and driving out to deep drill hole intersections.

If the price of silver should increase only moderately, it is possible that much of the unmined material in the small bodies developed below the No. 4 and No. 5 levels might become good grade ore. The spotty samoling done to date permits no evaluation of this possibility.

Underground Geologic Mapping

All open mine workings should be mapped in detail on a scale of no smaller than 50 ft. to the inch. In districts such as the Betty O'Neal where complex structure and stratigraphy are the ore control, good geologic mapping is often the most economical and efficient method of guiding exploration work. None of the mapping done underground by previous workers records the nature of the wall rock in detail, and no systematic plotting has been made of such important details as presence of carbonate, carbon content, etc. As an example of the possible results that might be obtained, several limestone beds were found interbedded with the other Valmy lithologies on the surface. If such units could be identified from place to place underground, they might be projected into known mineralized areas where unexplored exploration possibilities exist. Such relationships would result from routine geologic mapping underground.

It would be most efficient to have the geologist doing the mapping also make the channel sample sites as the work went along. In this manner, a relatively inexperienced helper-sampler could be hired, thus observing state safety laws about being alone underground, insuring good supervision of the sampling, and considerably reducing the over-all cost of the work.

Exploration

It is recommended that the O.M.E. Stage III work be carried out. If any of it is successful, the other projects listed above should be done in the order listed. It would help greatly in laying out this additional exploration work if the channel sampling and geologic mapping were completed, so that results could be used in planning.

Respectfully submitted,

Anthony L. Payne

Anthony L. Payne
Mining Geologist, P.E. 1515

March 31, 1967

Reno, Nevada

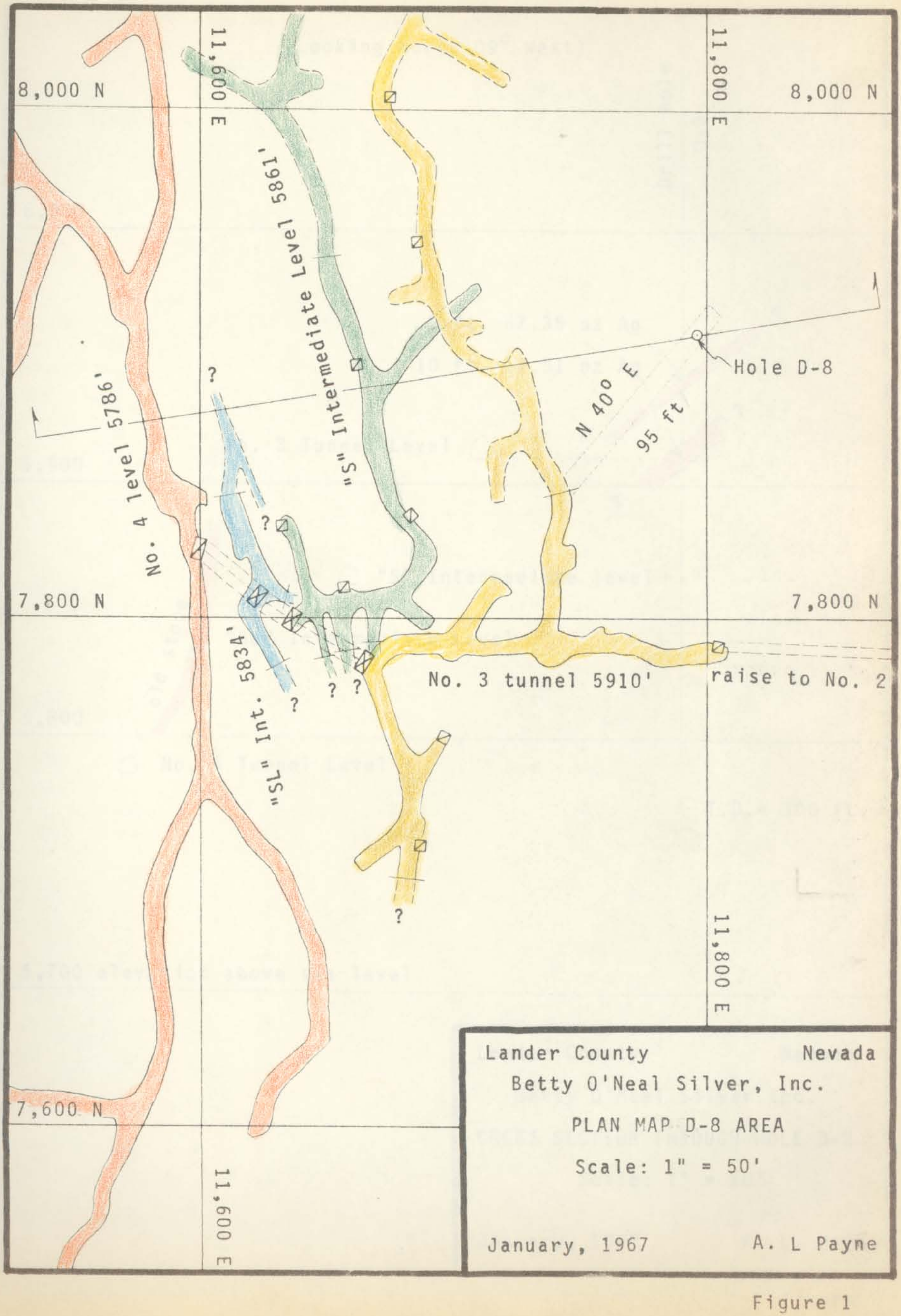

8,000 N
11,600 E
11,800 E
8,000 N
"S" Intermediate Level 5861'
No. 4 level 5786'
N 40° E
95 ft
Hole D-8
"SL" Int. 5834'
7,800 N
7,800 N
No. 3 tunnel 5910'
raise to No. 2
11,800 E
7,600 N
11,600 E
Lander County
Nevada
Betty O'Neal Silver, Inc.
PLAN MAP D-8 AREA
Scale: 1" = 50'
January, 1967
A. L Payne

Figure 1

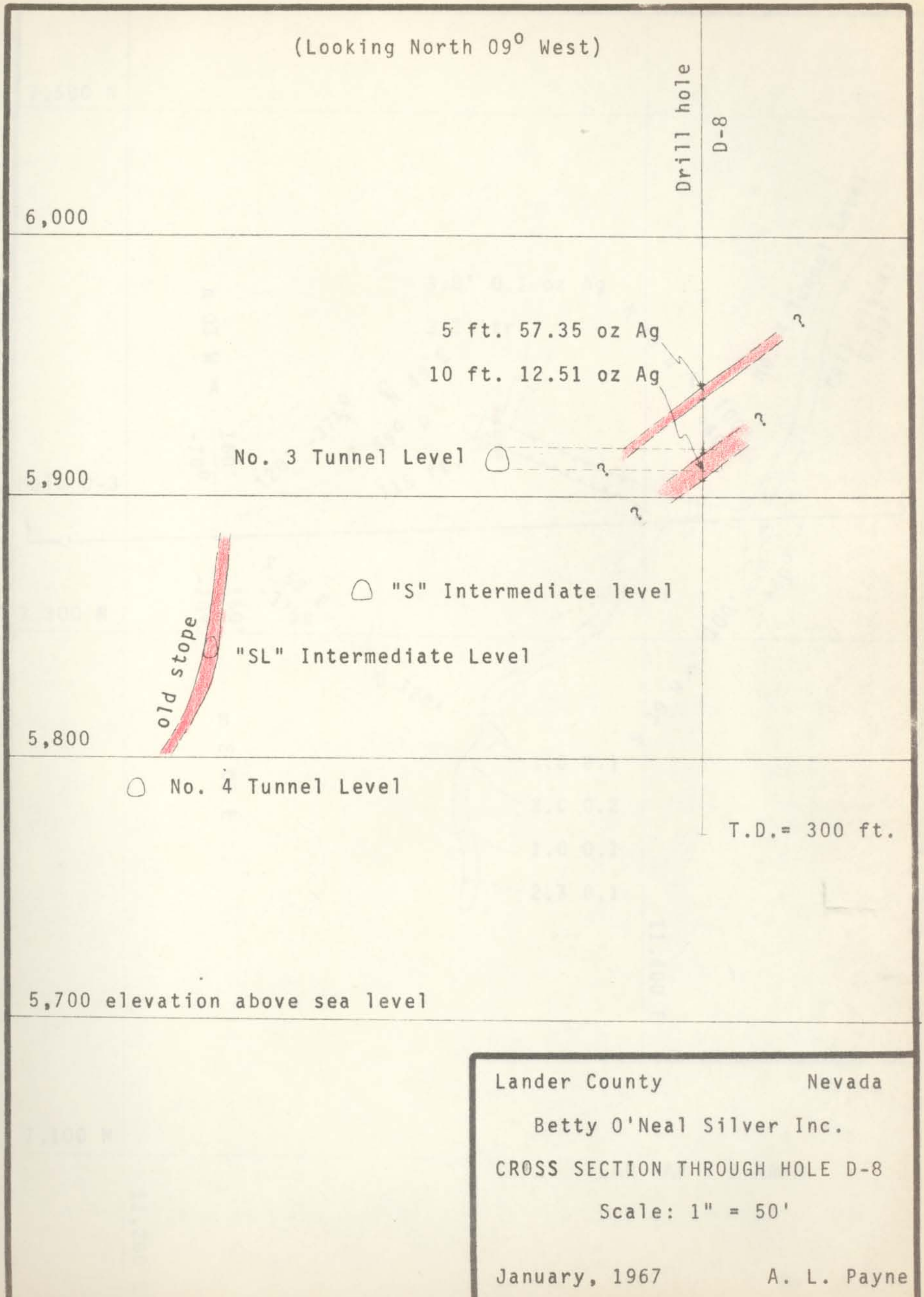
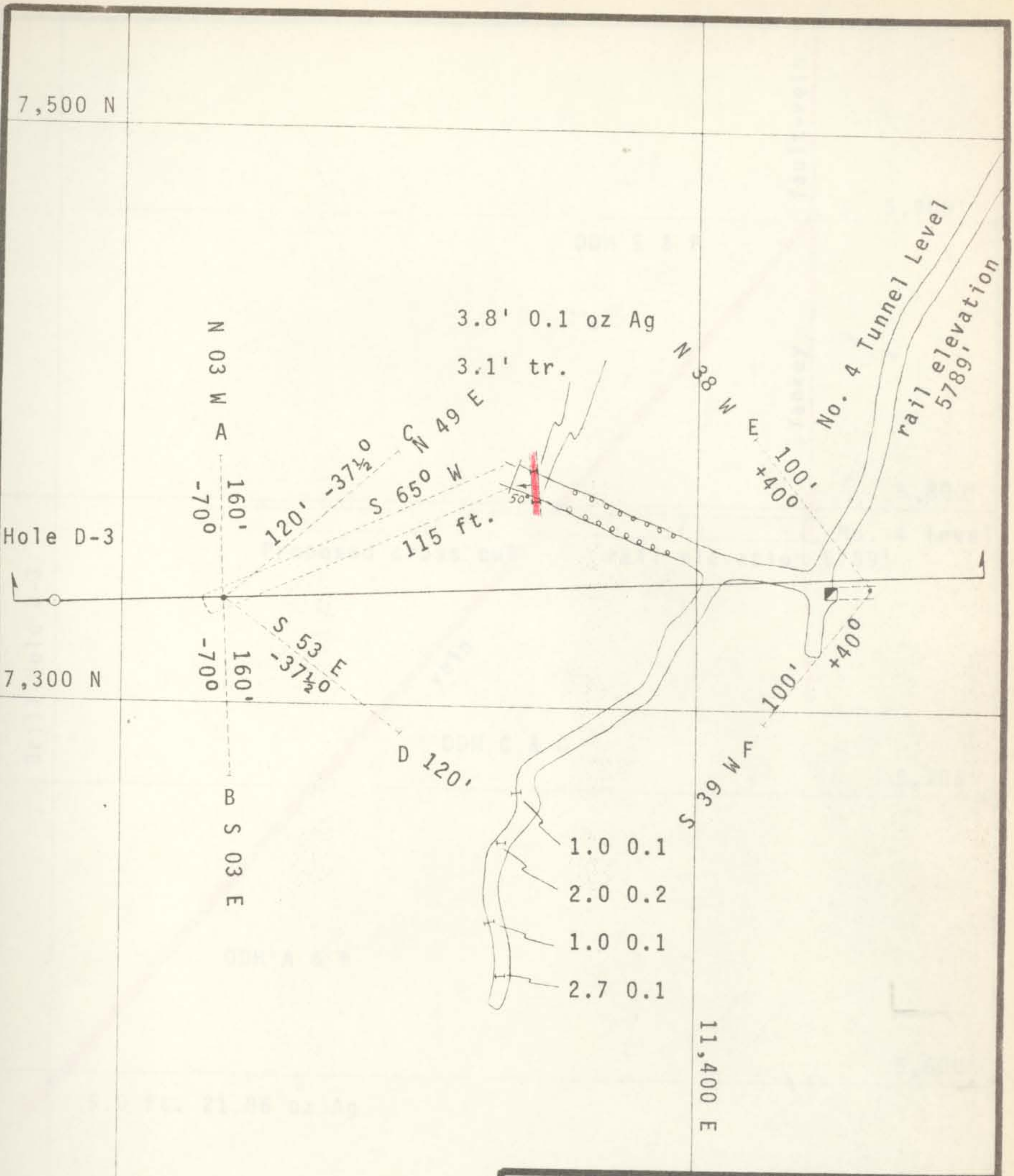

(Looking North 09° West)
Drill hole
D-8
6,000
5 ft. 57.35 oz Ag
10 ft. 12.51 oz Ag
No. 3 Tunnel Level
5,900
"S" Intermediate level
old stope
"SL" Intermediate Level
5,800
No. 4 Tunnel Level
T.D.= 300 ft.
5,700 elevation above sea level
Lander County
Nevada
Betty O'Neal Silver Inc.
CROSS SECTION THROUGH HOLE D-8
Scale: 1" = 50'
January, 1967
A. L. Payne

Figure 2



Lander County Nevada

Betty O'Neal Silver, Inc.

PLAN MAP D-3 AREA

Scale: 1" = 50'

January, 1967 A. L.Payne

Figure 3

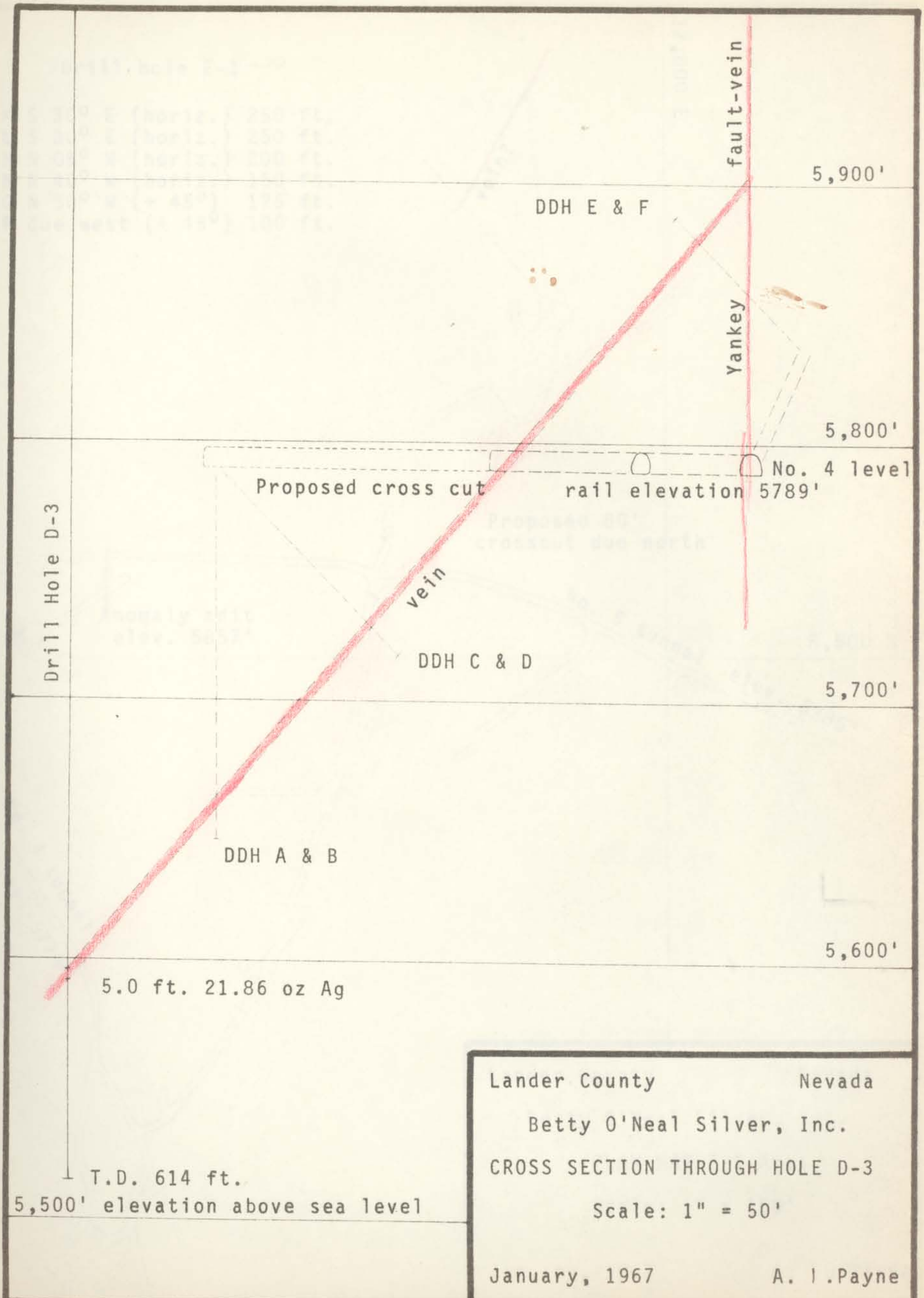
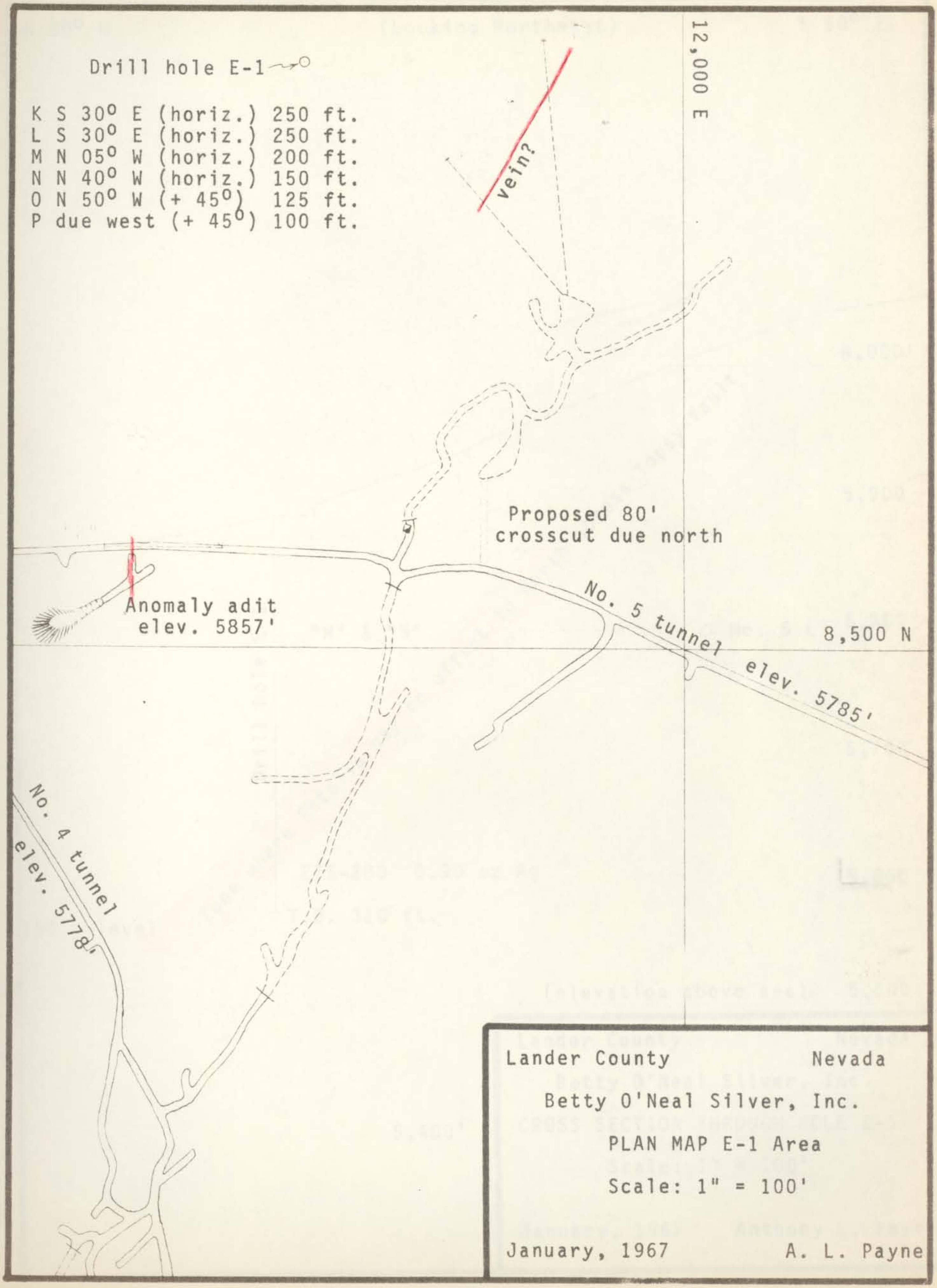

fault-vein
5,900'
DDH E & F
Yankey
5,800'
No. 4 level
Proposed cross cut
rail elevation 5789'
Drill Hole D-3
vein
DDH C & D
5,700'
DDH A & B
5,600'
5.0 ft. 21.86 oz Ag
T.D. 614 ft.
5,500' elevation above sea level
Lander County
Nevada
Betty O'Neal Silver, Inc.
CROSS SECTION THROUGH HOLE D-3
Scale: 1" = 50'
January, 1967
A. I. Payne

Figure 4



Drill hole E-1
K S 30° E (horiz.) 250 ft.
L S 30° E (horiz.) 250 ft.
M N 05° W (horiz.) 200 ft.
N N 40° W (horiz.) 150 ft.
O N 50° W (+ 45°) 125 ft.
P due west (+ 45°) 100 ft.
vein?
12,000 E
Proposed 80' crosscut due north
Anomaly adit elev. 5857'
No. 5 tunnel elev. 5785'
8,500 N
No. 4 tunnel elev. 5778'
Lander County
Nevada
Betty O'Neal Silver, Inc.
PLAN MAP E-1 Area
Scale: 1" = 100'
January, 1967
A. L. Payne

Figure 5

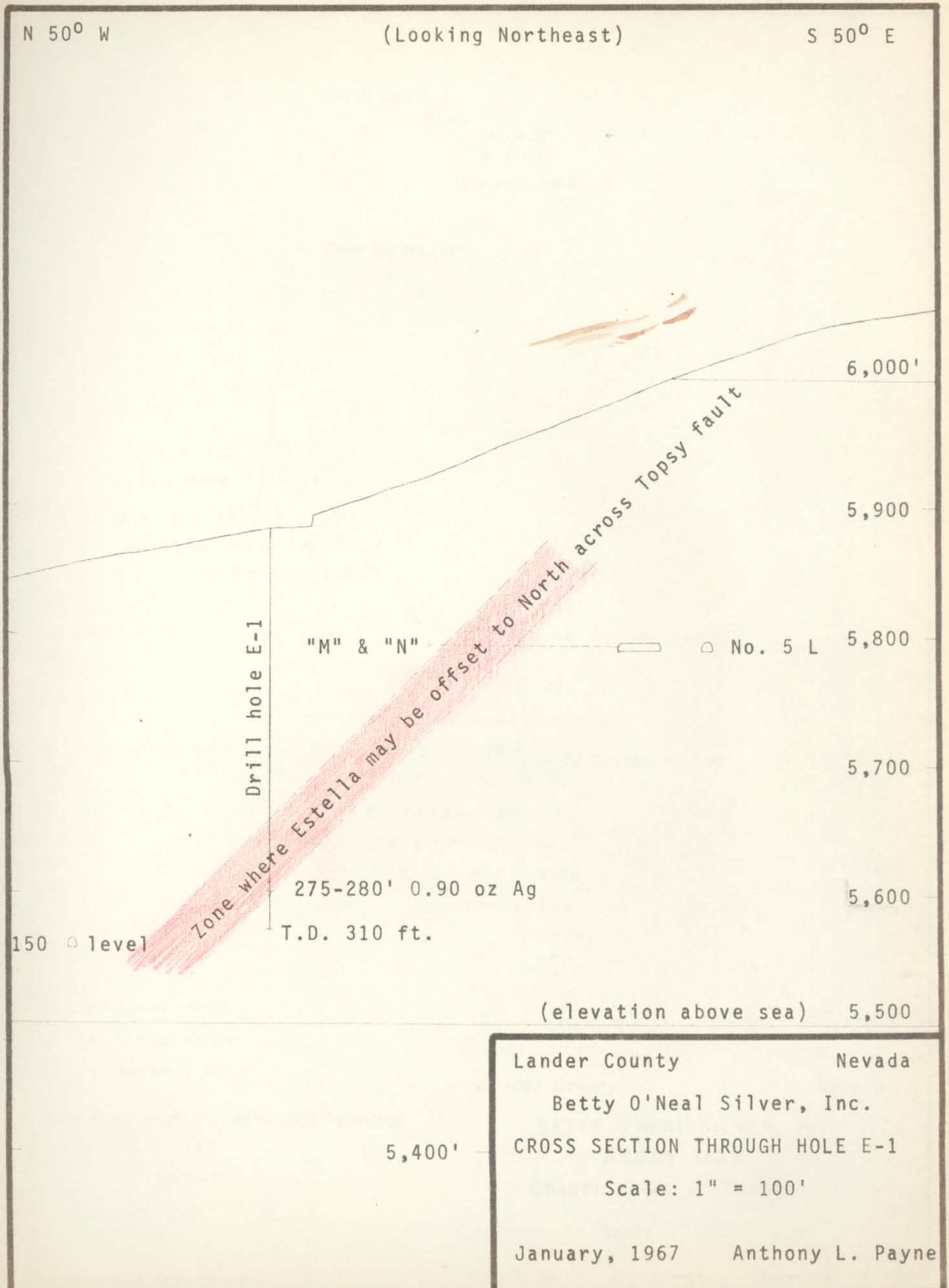
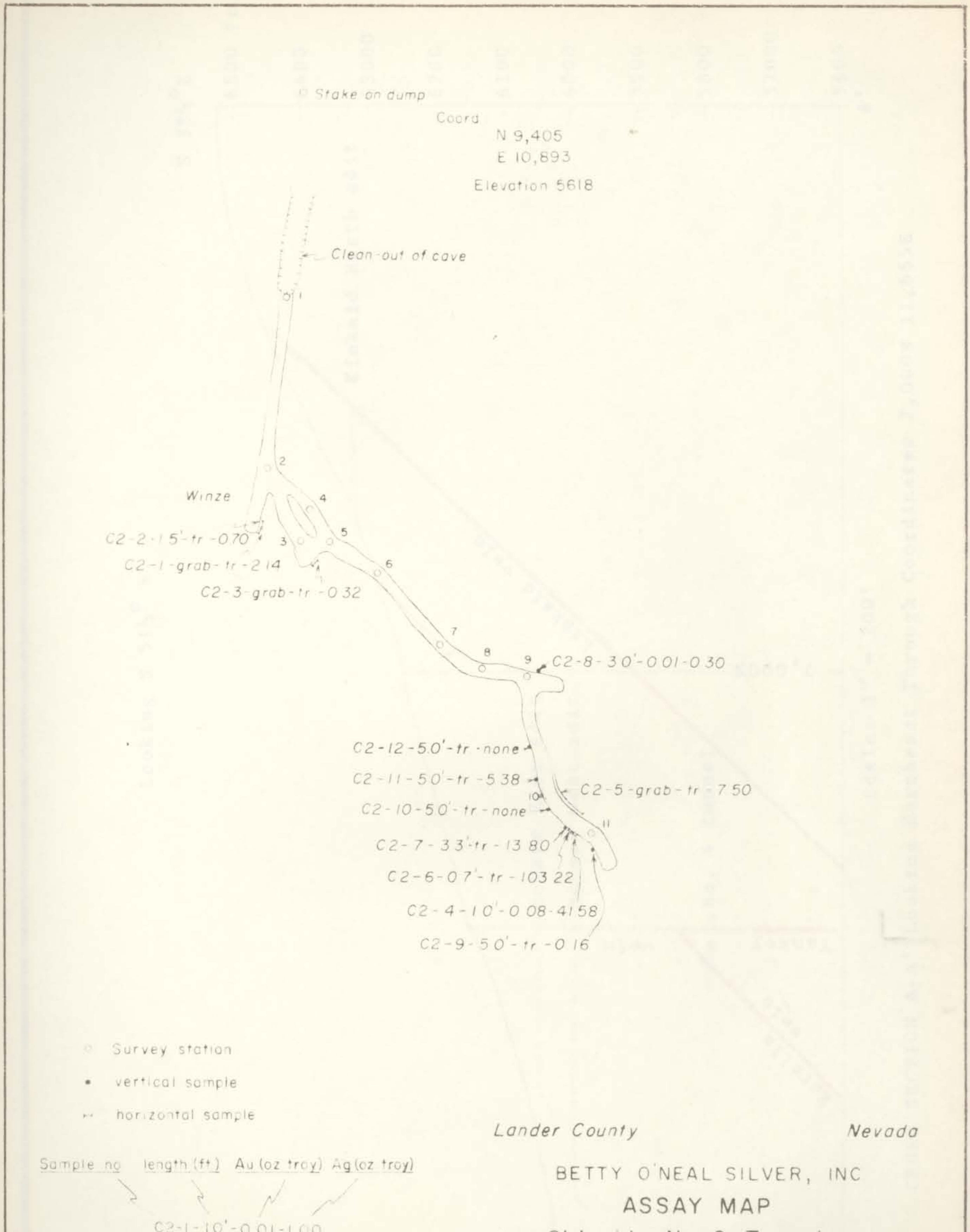

N 50° W
(Looking Northeast)
S 50° E
6,000'
5,900
5,800
5,700
5,600
5,500
5,400'
Drill hole E-1
"M" & "N"
No. 5 L
Zone where Estella may be offset to North across Topsy fault
275-280' 0.90 oz Ag
T.D. 310 ft.
150 level
(elevation above sea)
Lander County
Nevada
Betty O'Neal Silver, Inc.
CROSS SECTION THROUGH HOLE E-1
Scale: 1" = 100'
January, 1967
Anthony L. Payne

Figure 6



Lander County *Nevada*

BETTY O'NEAL SILVER, INC

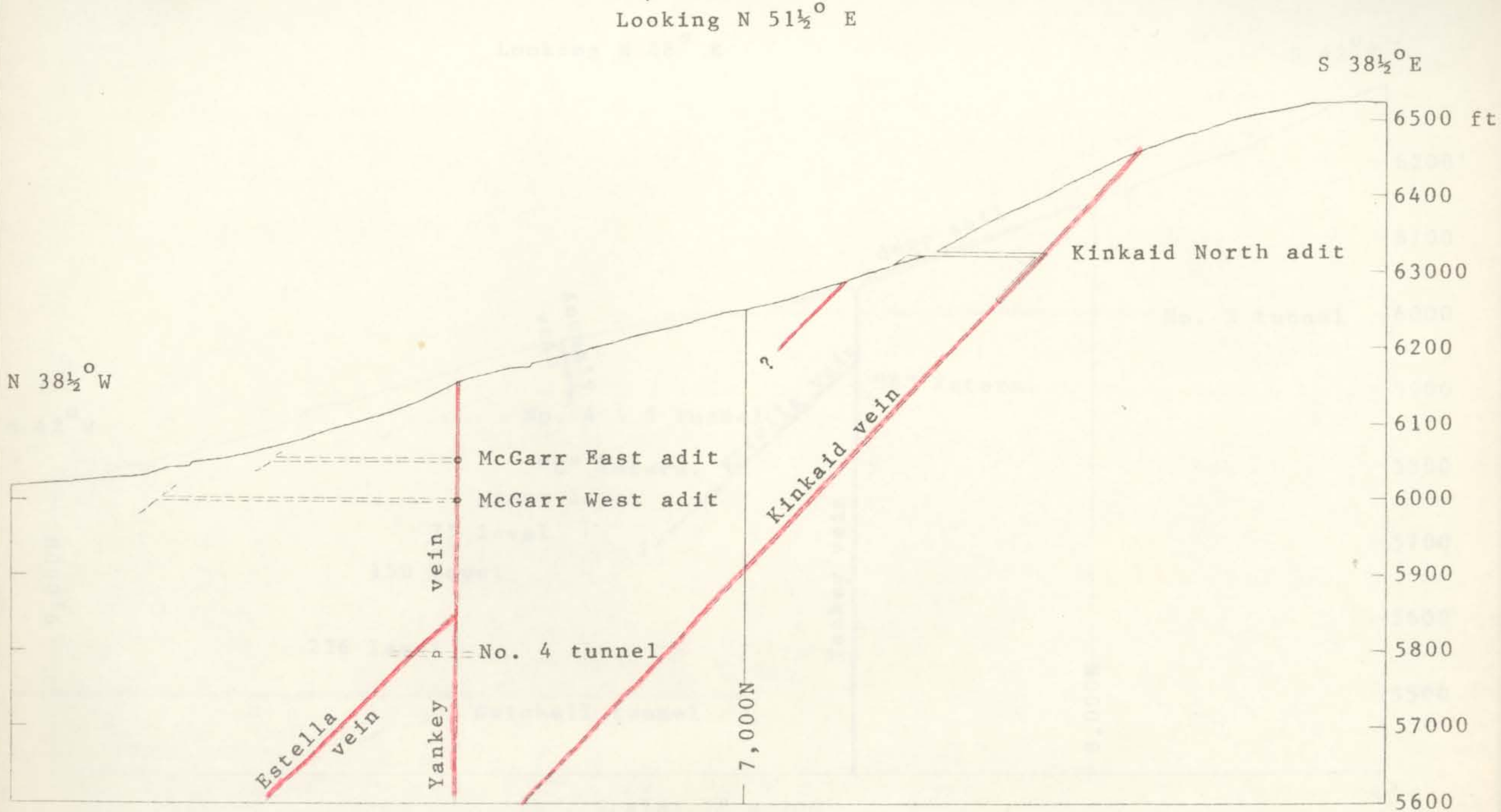
ASSAY MAP

Chloride No. 2 Tunnel

Scale 1" = 50'

A.L. Payne and D.R. Ketron *December 19, 1965*

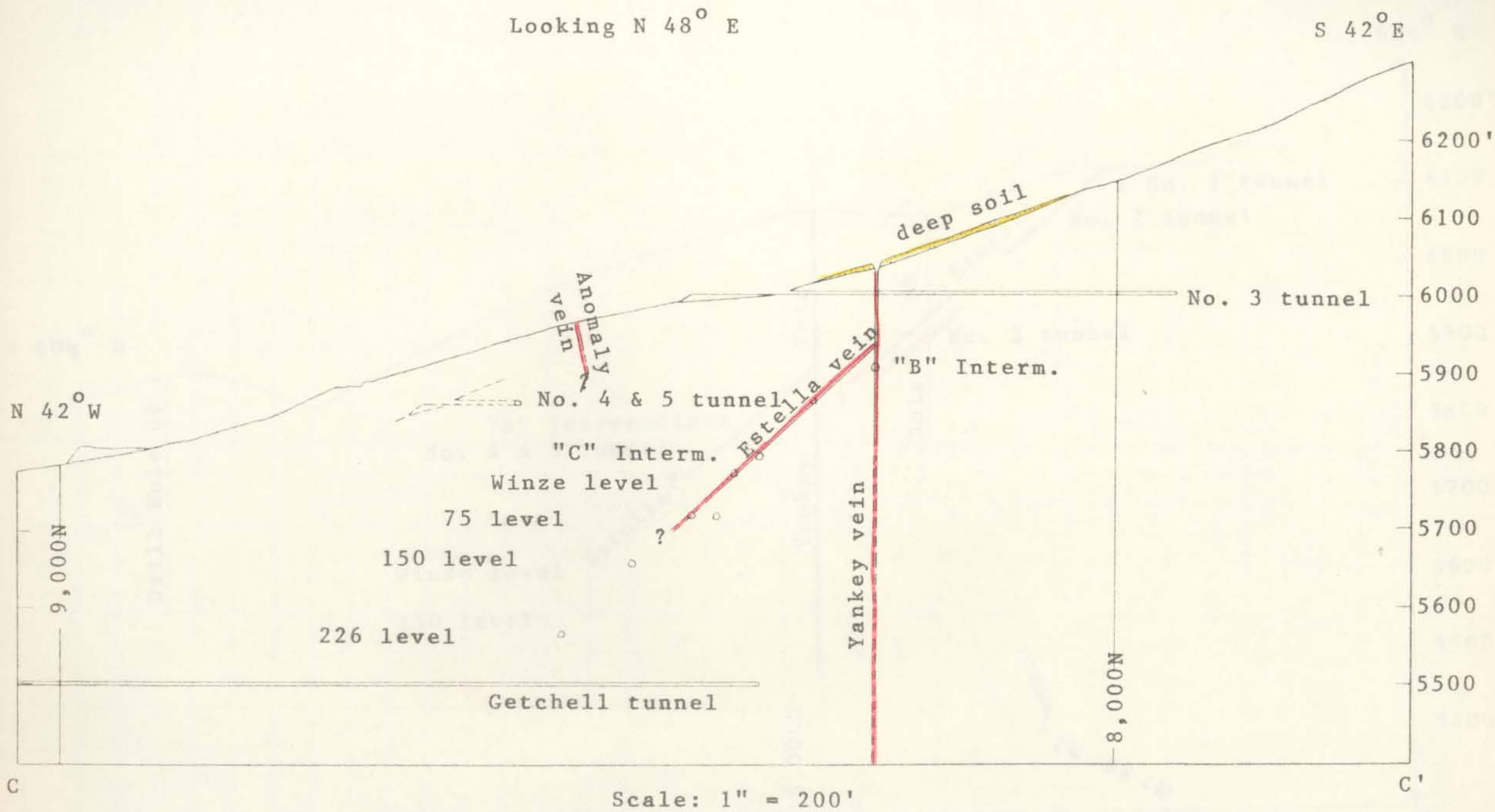
Figure 7



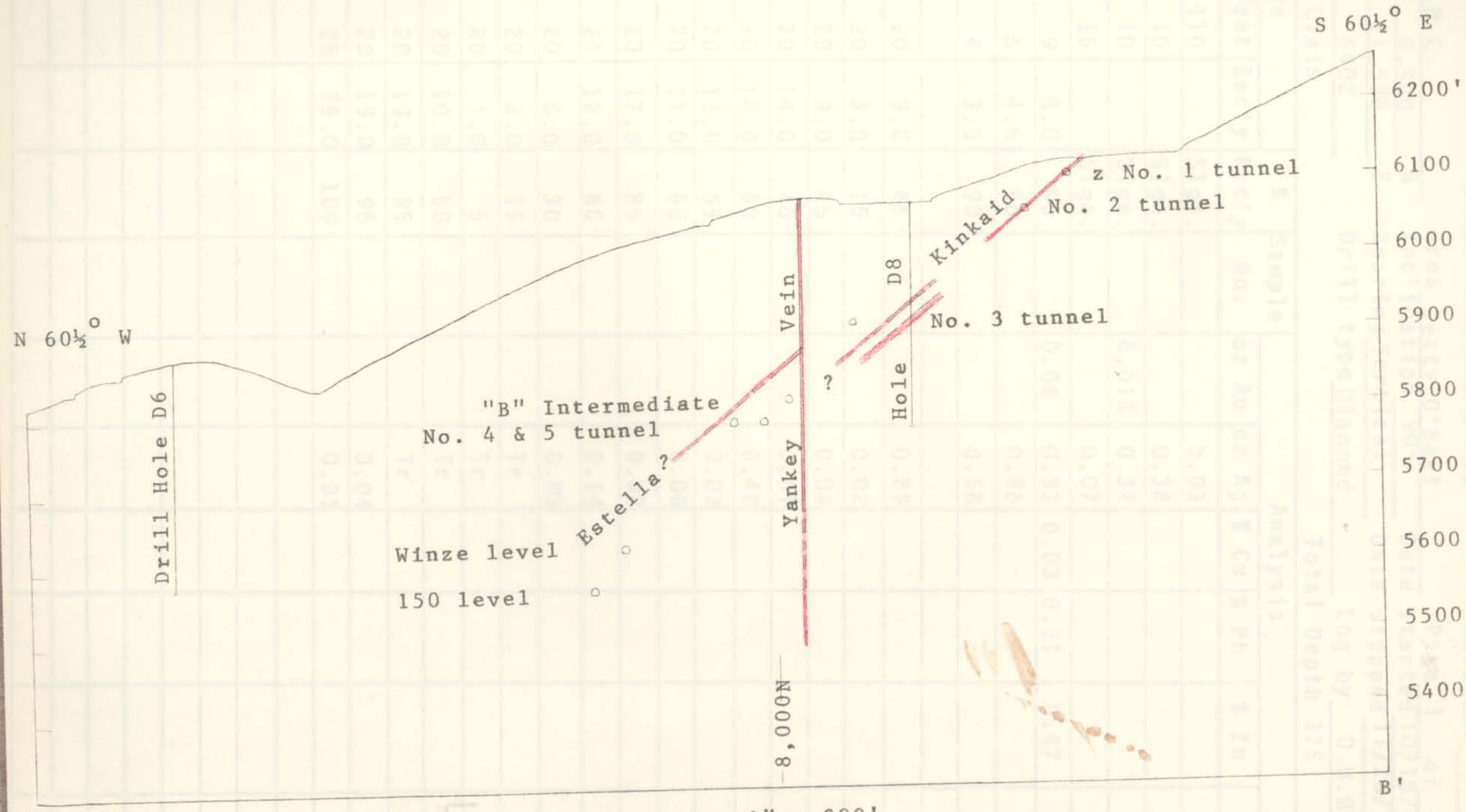
Scale: 1" = 200'

CROSS SECTION A-A' Looking Northeast Through Coordinates 7,000N 11,665E

Figure 8



CROSS SECTION C-C' Looking Northeast Through Coordinates 9,000N 11,095E



Scale: 1" = 200'

Cross Section B-B' Looking Northeast through Coordinates 8,000N 11,640E

Figure 10

DRILL HOLE ASSAY LOG

Hole No. D-2

Project O.M.E.
Area Betty O'Neal
Page 1 of 1

Coordinates 6,500 N
Inclination 90°
Date started 10/18/65

11,598 E
Bearing Vertical
Date stopped 11/28/65

Elevation 6402
Drill type Diamond
Log by D.W.G.

Yankey Claim
Total Depth 375

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu	% Pb	% Zn	
0	110	110		Slge.			0.03				
160	170	10		Slge.			0.38				
210	220	10		Slge.		0.015	0.32				
185	200	15		Slge.			0.07				
211	220	9	8.0	90		0.06	0.93	0.03	0.51	0.47	
211	216	5	4.5	90			0.86				
216	220	4	3.5	90			0.58				
50	70	20	9.0	45			0.29				
70	90	20	3.0	15			0.02				
90	110	20	9.0	45			0.04				
110	130	20	14.0	70			0.01				
130	150	20	12.0	60			0.40				
150	170	20	13.0	65			0.02				
170	190	20	11.0	55			0.06				
190	210	20	17.0	85			0.02				
210	230	20	12.0	60			0.14				
230	250	20	6.0	30			0.03				
250	270	20	3.0	15			Tr				
270	290	20	1.0	5			Tr				
290	310	20	10.0	50			Tr				
310	330	20	19.0	95			Tr				
330	350	20	19.0	95			0.04				
350	375	25	25.0	100			0.01				

DRILL HOLE ASSAY LOG

Hole No. D-3

Project O.M.E.　　Area Betty O'Neal　　Page 1 of 2

Coordinates 7,335 N　　Inclination 90°　　Date started 11/29/65

11,171 E　　Bearing Vertical　　Date stopped 1/26/66

Elevation 6130　　Drill type Diamond　　Log by D.W.G.

Betty O'Neal South Claim　　Total Depth 614

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
0	20	20		Slge.							
20	40	20		Slge.							
40	60	20		Slge.							
60	80	20		Slge.							
80	100	20		Slge.							
100	120	20	13.0	65			Tr				
120	140	20	20.0	100			Tr				
140	160	20	20.0	100			0.02				
160	180	20	17.0	85			0.08				
180	200	20	7.0	35			Tr				
200	220	20	8.0	40			Tr				
220	240	20	12.0	60			Tr				
240	260	20	10.0	50			0.02				
260	280	20	19.0	95			Tr				
280	300	20	17.0	85			Tr				
300	320	20	15.0	75			Tr				
320	340	20	15.0	75			Tr				
340	360	20	19.0	95			Tr				
360	380	20	18.0	90			Tr				
380	400	20	12.0	60			0.02				
400	420	20	11.5	57			Tr				
420	440	20	5.0	25			Tr				
440	460	20	14.0	70			Tr				
460	480	20	8.0	40			0.03				
480	500	20	14.0	70			Tr				
500	520	20	17.0	85			Tr				
520	540	20	20.0	100			8.06				
540	560	20	12.0	60			1.26				
560	580	20	8.0	40			Tr				
580	600	20	7.0	35			1.14				
600	614	14	2.0	14			1.05				

DRILL HOLE ASSAY LOG

Hole No. D-3

Project ______ Area ______ Page 2 of 2

Coordinates ______ N Inclination ______ Date started ______

______ E Bearing ______ Date stopped ______

Elevation ______ Drill type ______ Log by ______

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
520	525	5	5.0	100			0.02				
525	530	5	5.0	100			0.03				
530	535	5	5.0	100			8.27				
535	540	5	5.0	100			21.86				

DRILL HOLE ASSAY LOG

Hole No. D-4

Project O.M.E.
Area Betty O'Neal
Page 1 of 1

Coordinates 6,732 N
11,728 E
Inclination 90°
Date started 3/29/66

Bearing Vertical
Date stopped 4/4/66

Elevation 6357
Drill type Diamond
Log by D.W.G.

Kinkaid Claim
Total Depth 150

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
30	50	20	1.5	8			0.04				
50	70	20	1.0	5			0.05				
70	90	20	1.0	5			0.08				
90	110	20	1.0	5			Tr				
110	130	20	1.5	8			0.03				
130	150	20	2.0	10			0.05				

Note: All samples were composite of core and sludge.

DRILL HOLE ASSAY LOG

Hole No. D-5

Project O.M.E.
Coordinates 5,501 N
11,640 E
Elevation 6299
Mike Burke Claim

Area Betty O'Neal
Inclination 90°
Bearing Vertical
Drill type Diamond

Page 1 of 1
Date started 3/4/66
Date stopped 3/26/66
Log by D.W.G.
Total Depth 350

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
20	40	20	20.0	100			Tr				
40	60	20	20.0	100			Tr				
60	80	20	20.0	100			Tr				
80	100	20	20.0	100			Tr				
100	120	20	20.0	100			Tr				
120	140	20	20.0	100			Tr				
140	160	20	20.0	100			Tr				
160	180	20	20.0	100			Tr				
180	200	20	20.0	100			Tr				
200	220	20	20.0	100			Tr				
220	240	20	20.0	100			Tr				
240	260	20	20.0	100			Tr				
260	280	20	20.0	100			Tr				
280	300	20	20.0	100			Tr				
300	320	20	20.0	100			Tr				
320	340	20	20.0	100			Tr				
340	350	10	10.0	100			Tr				

DRILL HOLE ASSAY LOG

Hole No. D-6

Project O.M.E.   Area Betty O'Neal   Page 1 of 1

Coordinates 8,378 N   Inclination 90°   Date started 1/27/66

10,941 E   Bearing Vertical   Date stopped 2/28/66

Elevation 5881   Drill type Diamond   Log by D.W.G.

Betty O'Neal Claim   Total Depth 305

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
50	65	15	11.0	73			Tr				
85	100	15	2.0	13			0.01				
100	125	25	4.0	16			0.01				
140	155	15	1.0	7			Tr				
170	200	30	1.0	3			0.01				
200	220	20	11.0	55			Tr				
220	240	20	10.0	50			Tr				
240	245	5	4.0	90			Tr				
245	265	20	16.0	80			Tr				
265	285	20	8.0	40			Tr				
285	305	20	6.0	30			Tr				

DRILL HOLE ASSAY LOG

Hole No. D-7

Project O.M.E. | Area Betty O'Neal | Page 1 of 1

Coordinates 7,685 N | Inclination 90° | Date started 4/5/66

12,570 E | Bearing Vertical | Date stopped 4/18/66

Elevation 6347 | Drill type Diamond | Log by D.W.G.

Nebraska Claim | Total Depth 205

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
20	40	20	19.0	95			Tr				
40	60	20	17.0	85			Tr				
60	80	20	18.0	90			Tr				
80	100	20	20.0	100			Tr				
100	120	20	20.0	100			Tr				
120	140	20	20.0	100			Tr				
140	160	20	20.0	100			Tr				
160	180	20	20.0	100			Tr				
180	205	25	25.0	100			Tr				

DRILL HOLE ASSAY LOG

Hole No. D-8

Project O.M.E. Area Betty O'Neal Page 1 of 1

Coordinates 7,911 N Inclination 90° Date started 5/21/66

11,796 E Bearing Vertical Date stopped 6/2/66

Elevation 6072 Drill type Diamond Log by D.W.G.

Estella Nevada Claim Total Depth 300

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
133	133	0				0.03	263.3				
80	100	15	15.0	100			Tr				
(Omit 90-95)											
90	95	5	5.0	100			2.18				
100	120	20	20.0	100			Tr				
120	140	15	15.0	100			Tr				
(Omit 130-135)											
130	135	5	5.0	100			57.35				
140	155	15	15.0	100			0.82				
155	165	10	10.0	100			12.51				
165	185	20	20.0	100			1.20				
185	205	20	20.0	100			0.03				
205	225	20	20.0	100			Tr				
225	245	20	20.0	100			0.04				
245	265	20	20.0	100			Tr				
265	285	20	20.0	100			Tr				
285	300	15	15.0	100			Tr				

DRILL HOLE ASSAY LOG

Hole No. D-9

Project O.M.E. | Area Betty O'Neal | Page 1 of 1

Coordinates 8,693 N | Inclination 90° | Date started 4/21/66

12,462 E | Bearing Vertical | Date stopped 5/19/66

Elevation 6115 | Drill type Diamond | Log by D.W.G.

Victory Claim | Total Depth 451

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
0	20	20	Slge.				0.96				
20	40	20	Slge.				0.44				
40	60	20	Slge.				0.22				
60	80	20	+1.0	5			0.24				
80	100	20	1.0	5			0.02				
100	120	20	3.0	15			0.04				
120	140	20	6.0	30			0.02				
140	160	20	13.0	65			Tr				
160	180	20	15.0	75			0.05				
180	200	20	16.0	80			0.30				
200	220	20	12.0	60			0.02				
220	240	20	15.0	75			Tr				
240	260	20	16.0	80			Tr				
260	280	20	20.0	100			Tr				
280	300	20	13.0	65			Tr				
300	320	20	11.0	55			Tr				
320	340	20	7.0	35			Tr				
340	360	20	8.0	40			Tr				
360	380	20	11.0	55			0.02				
380	400	20	16.0	80			0.26				
400	420	20	20.0	100			4.22				
420	440	20	20.0	100			0.02				
440	451	20	20.0	100			Tr				
400	405	5	5.0	100			19.90				
405	410	5	5.0	100			Tr				
410	415	5	5.0	100			Tr				
415	420	5	5.0	100			0.03				

DRILL HOLE ASSAY LOG

Hole No. B-1

Project O.M.E. | Area Betty O'Neal | Page 1 of 1

Coordinates 8,956 N | Inclination 90° | Date started 6/4/66

10,796 E | Bearing Vertical | Date stopped 6/25/66

Elevation 5693 | Drill type Diamond | Log by D.W.G.

Betty O'Neal Claim | Total Depth 325

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
0	20	20	0.0	Slge.			0.05				
20	40	20	0.0	Slge.			0.04				
40	60	20	1.0	5			0.01				
60	80	20	3.0	15			0.01				
80	100	20	3.0	15			0.15				
100	120	20	5.0	25			0.16				
120	140	20	4.0	20			0.18				
140	160	20	8.0	40			0.26				
160	180	20	6.0	30			Tr				
180	200	20	5.0	25			Tr				
200	220	20	4.0	20			Tr				
220	240	20	7.0	35			Tr				
240	260	20	14.0	70			Tr				
260	280	20	5.0	25			Tr				
280	300	20	19.0	95			0.27				
300	320	20	10.0	50			Tr				
320	325	5	4.0	90			Tr				

DRILL HOLE ASSAY LOG

Hole No. E-1

Project O.M.E. | Area Betty O'Neal | Page 1 of 1

Coordinates 8,959 N | Inclination 90 | Date started 6/27/66

11,702 E | Bearing Vertical | Date stopped 8/1/66

Elevation 5882 | Drill type Diamond | Log by D.W.G.

Topsy Claim | Total Depth 310

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
0	20	20	Slge.				0.03				
20	40	20	Slge.				Tr				
40	60	20	15.0	75			Tr				
60	80	20	12.0	60			Tr				
80	100	20	7.0	35			Tr				
100	120	20	6.0	30			Tr				
120	140	20	16.0	80			Tr				
140	160	20	14.0	70			Tr				
160	180	20	11.0	55			Tr				
180	200	20	8.0	40			Tr				
200	220	20	7.0	35			Tr				
220	240	20	3.0	15			Tr				
240	260	20	3.0	15			0.02				
260	280	20	18.0	90			0.36				
280	295	15	11.0	73			0.04				
295	310	15	13.0	87			0.12				
270	275	5	5.0	100			0.68				
275	280	5	5.0	100			0.90				

DRILL HOLE ASSAY LOG

Hole No. K-1

Project O.M.E.
Area Betty O'Neal
Page 1 of 1

Coordinates 6,055 N
Inclination 90°
Date started 7/15/66

11,540 E
Bearing Vertical
Date stopped 7/29/66

Elevation 6242
Drill type Diamond
Log by D.W.G.

Kinkaid Claim
Total Depth 200

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
0	20	20	Slge.				0.08				
20	40	20	Slge.				0.02				
40	60	20	Slge.				0.10				
60	80	20	6.0	30			0.06				
80	100	20	1.0	5			0.06				
100	120	20	6.0	30			0.05				
120	140	20	18.0	90			0.05				
140	160	20	20.0	100			0.08				
160	180	20	20.0	100			0.02				
180	200	20	20.0	100			0.02				
108	114	6	3.0	50			Tr				

DRILL HOLE ASSAY LOG

Hole No. K-2

Project O.M.E. | Area Betty O'Neal | Page 1 of 1

Coordinates 6,043 N | Inclination 90° | Date started 8/2/66

11,344 E | Bearing Vertical | Date stopped 8/17/66

Elevation 6197 | Drill type Diamond | Log by D.W.G.

Yankey Claim | Total Depth 300

Footage				%	Sample	Analysis					
From	To	Feet	Rec'y	Rec'y	No.	oz Au	oz Ag	% Cu			
20	40	20	2.0	10			Tr				
40	60	20	3.0	15			Tr				
60	80	20	13.0	65			Tr				
80	100	20	11.0	55			0.02				
100	120	20	20.0	100			Tr				
120	140	20	18.0	90			Tr				
140	160	20	9.0	45			Tr				
160	180	20	19.0	95			0.05				
180	200	20	19.0	95			Tr				
200	220	20	20.0	100			Tr				
220	240	20	20.0	100			Tr				
240	260	20	20.0	100			Tr				
260	280	20	20.0	100			Tr				
280	300	20	20.0	100			Tr				
180	185	5	5.0	100			0.05				