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EXPLORATION OPPORTUNITIES
ON THE NORTH END
OF THE
COMSTOCK LODGE, NEVADA

By Robert E. Kendall

ROBERT E. KENDALL

Professional Qualifications

- 1948: B.S. in Mining Engineering from Mackay School of Mines, University of Nevada.
- 1948-50: Mine Engineer, Dayton Consolidated Mines, Virginia City, Nevada. Gold-Silver
- 1950-52: Mining Engineer, Mine Superintendent, Resurrection Mine, Leadville, Colorado. Lead-Zinc.
- 1952-54: Resident Engineer, Leviathan Mine, Alpine County, California. Sulfur.
- 1954-present: with U.S. Borax and Chemical Corporation.
- 54-61:
Planned and put into production open pit borax mine at Boron, California.
- 61-62:
Project Manager, drilling program and feasibility study for proposed potash mine in Saskatchewan, Canada
- 62-64:
Resident Manager, potash mine and refinery, Carlsbad, New Mexico.
- 64-68:
Project manager for construction and start-up of \$75,000,000 potash mine and refinery Saskatchewan, Canada. Made Vice-President of Canadian Potash Department in June, 1968.
- Jan. 1, 1969:
Transferred to Los Angeles. Vice President for mining and manufacturing.

ROBERT E. KENDALL
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November 15, 1968

Mr. John C. Kahn, President
Mining Corporation of America
First National Bank Building
Denver, Colorado 80202

Dear Mr. Kahn:

It is my understanding that the Mining Corporation of America holds long term leases on the mining properties formerly owned by the Consolidated Virginia Mining Company in Virginia City, Nevada.

Because of my previous association with these properties, you have asked me to supply you with reports and maps in my possession, and to suggest the possibilities which I believe exist for the exploration and development of new orebodies on the property.

Attached is a report entitled "Exploration Opportunities on the North End of the Comstock Lode, Nevada." As appendices to this report I also attach my report written in 1948 entitled "A Study of the Hangingwall Vein Systems on the North End of the Comstock Lode, Nevada," and a set of mine plans - compiled from original maps and records covering the mine workings of the Consolidated Virginia group from near surface to the 2200 foot level.

Very truly yours,


R.E. Kendall

rek/es
enc

ROBERT E. KENDALL

November 10, 1968

EXPLORATION OPPORTUNITIES

ON THE NORTH END

OF THE

COMSTOCK LODGE, NEVADA

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EXPLORATION OPPORTUNITIES ON THE NORTH END
OF THE COMSTOCK LODGE, NEVADA

SUMMARY

The Consolidated Virginia properties on the north end of the Comstock Lode have produced \$145,000,000 in gold and silver. Of this amount \$125,000,000 came from a single isolated oreshoot in the hanging wall, called the Big Bonanza. In a six year period the Bonanza oreshoot produced \$102,000,000 in bullion and paid \$74,000,000 in dividends.

A thorough study has been made of all available maps and records, the results of which are compiled in this report.

A program of exploration in and around the Big Bonanza area is recommended for the following reasons:

1. The importance and richness of the known orebody makes the area attractive for further exploration.
2. It can be demonstrated that favorable unexplored ground exists adjacent to and above the known orebody.
3. It is believed that the structural control which localized the known orebody is understood, and can be applied to the search for extensions of it or for new orebodies.

Favorable locations are pointed out and a graduated program for reconnaissance and exploration is proposed.

INTRODUCTION

My interest in the Comstock Lode stems from the fact that my father, Zeb Kendall, was associated with the Consolidated Virginia Mining Company from 1920 until his death in 1954.

As I grew up in Virginia City I became familiar with the history of the district and interested in the geology of the ore deposits. While attending the Mackay School of Mines in Reno and during the several years that I worked in the district after graduation, I had an opportunity to study a great many of the original maps and records then on file in the office of the Consolidated Virginia Mining Company and at the Mackay School of Mines library. My work as a mining engineer for the Consolidated Virginia Mining Company in the north end and later for the Dayton Consolidated Mining Company in the south end of the district enabled me to become familiar with the geology and structural control of the then exposed oreshoots of the district.

During this period I began a systematic study of the literature of the district and the original records and maps relating to the Consolidated Virginia Mining Company. Quite early in this study I was struck by the fact that there appeared to be large blocks of unexplored ground immediately above and adjacent to the rich and immensely profitable Big Bonanza in Consolidated Virginia ground.

In 1948 I wrote a preliminary report of my findings and drew some conclusions about exploration possibilities for extensions of the Big Bonanza. The original of this report, entitled "A Study of the Hangingwall Vein Systems in the North End of the Comstock Lode, Nevada," is on file at the Mines Library of the University of Nevada, and a copy is attached.

The validity of the recommendations contained in that report hinges on whether or not in fact the ground above and adjacent to the Big Bonanza was left unexplored. In an old mining district with a long history this is often a difficult case to prove. In order to verify my preliminary conclusions, during the next four years I made a systematic study of all available

mine maps, annual reports, superintendents weekly and monthly reports, and data from other sources from the period of the discovery of the Big Bonanza to the present time. At the time of my study the records of the Consolidated Virginia Mining Co. were still largely intact and accessible to me, and this was supplemented by a search of the extensive records in the Mines Library at the University of Nevada, much of which has been donated to the library by my father.

One of the problems in examining the maps of an old mining district is the multiplicity of scales and coordinate systems in use over the years. This makes direct use of the original maps nearly impossible for generalized work. In order to facilitate the study, I set out to consolidate all the maps in the area of interest on a single coordinate grid and to a uniform scale. This was done in draft form during the period 1948 to 1952. Since not all past exploration activity is necessarily plotted on an existing map, I read all the available company annual and Superintendent's reports for the period 1875 to 1952 and made notes on the relevant information contained in these documents. Workings which did not appear in any map but which were described in the Superintendent's reports were plotted on the map in dashed lines in my best estimate of their direction and location. Since my files contain all the annual Superintendent's reports for Consolidated Virginia consecutively from 1874 to 1913, I believe this is the most complete compilation made to date for the property.

This work remained in draft form from 1952 until the present. I have recently completed the consolidated mine maps into usable form, and they are attached to this report. They consist of a series of 14 sheets of the Consolidated Virginia - California claims from the 500 foot level to the 2150 foot level, and a series of 9 sheets of the Ophir-Mexican claims from the 500 foot level to the 2100 foot level. They show all the important mine workings in this vertical interval known to exist. Particular care was taken not to miss any mine openings which might occur in an area of potential interest for exploration.

There are mine workings extending about a thousand feet below the bottom level shown on the attached maps. These are of less interest because they are all below the really productive areas of the mine and are considerably below any zones which I believe are worthwhile exploring in the initial phases of my program.

HISTORICAL SKETCH

General

The Comstock Lode, situated in Storey County, Nevada, is located about 28 miles south of Reno at an elevation of 6200 feet. It lies along the east flank of Mount Davidson in a normal fault zone striking south and dipping to the east. Its' productive length extends for a distance of about four miles, from the northern edge of the town of Virginia City to Silver City on the south.

The Comstock Lode is one of the major precious metal mining districts in the West. Discovered in 1859, it produced \$381,000,000 in gold and silver up to 1940 (Couch and Carpenter-see Bibliography). About 55% of the bullion production was in silver and 45% in gold. Reworking of mill tailings have probably added another \$15,000,000 to this figure. About \$300,000,000 of this production occurred in the 17 year period between 1863 and 1879.

The ore typically occurs in discreet oreshoots separated laterally and vertically by large areas of low grade or waste vein matter. Only a small percentage of the mineralized area contained profitable ore, but many of the oreshoots were so profitable that they are locally called bonanzas. The district has three major productive zones along its strike.

To the south are the Gold Hill group of bonanzas, situated in the Belcher Crown Point, Yellow Jacket, and Imperial mines. The second bonanza zone lies north of the Gold Hill group and is known as the Middle Mines. These are the Chollar-Potosi, Hale and Norcross, Savage, and Gould and Curry mines. The northernmost group, known as the North End mines, consisted of the Consolidated Virginia, California, and Ophir mines. The North end group, with the addition of the Mexican property, was consolidated under the name Consolidated Virginia Mining Company in the 1930's, and this is the area which is the subject of this report.

The Con. Virginia Group

The Con. Virginia group produced about 38% of the bullion and 60% of the dividends in the district.

Data on Comstock history and production must be approached with care, because of the frequent property amalgamations and splits which occurred, and which cause confusion in names and in records. The Con. Virginia group consists of a series of contiguous patented mining claims which run along the strike of the outcrop of the lode for a distance of about 2585 feet.

The original Consolidated Virginia Mining Company was organized in 1867 from a group of largely unproductive claims lying south of the Ophir property - Central: 150 ft., Old California: 300 ft., Central No. 2: 100 ft., Kinney: 50 ft., White and Murphy: 210 ft., Sides: 500 ft., for a total of 1310 feet on the strike of the lode.

Soon after the discovery of the Big Bonanza in 1873, the property was split into two companies, with the Con. Virginia retaining the south 710 feet and a new company, called the California Mining Co. taking the adjoining 600 ft. to the north. The split was made for the purpose of increasing the play on the stock market since the mines were always operated under the same management as a single unit. However, from 1873 to 1884, production and profits are segregated and listed separately in the records. The two properties were re-combined in November, 1884 under the name Consolidated California and Virginia Mining Co.

The Ophir Silver Mining Co., adjoining the Con. California and Virginia to the north, was organized in the spring of 1860 and originally held 1400 feet on the strike of the lode. This was later reduced to 675 feet immediately north of the Con. California and Virginia, and the Mexican Gold and Silver Mining Co. was formed out of the 600 feet adjacent to the north.

In the 1930's, the three existing corporate structures and their properties: The Con. California and Virginia, Ophir, and Mexican, were merged into a single corporation called the Consolidated Virginia Mining Co. It is this property which is referred to in this report as the Con. Virginia group.

PRODUCTION HISTORY OF THE CON. VIRGINIA GROUPGeneral

The total production of the Con. Virginia group to 1940 is listed as \$145,600,000 by Couch and Carpenter in their publication, "Nevada's Metal and Mineral Production." From research on a variety of records, I can account for the following yield broken down by location and time:

	<u>Bullion Yield</u>	<u>Approximate Recovery/Ton</u>
Ophir Bonanza (1859 - 65)	\$ 6,500,000	\$ 75
Big Bonanza (1873 - 82)	105,200,000	75
Ophir extension of Big Bonanza (1874 - 76)	4,000,000	40
Reworking of Big Bonanza area (1884 - 95)	16,400,000	19
Hardy Vein (1879 - 80)	1,500,000	58
East Vein (1899 - 1920)	6,300,000	20
Low Grade Surface Ore (1870 - 1940)	<u>2,500,000</u>	10
	<u>\$142,400,000</u>	

Ophir Bonanza

The Comstock Lode was discovered almost concurrently in two places in the spring of 1859 by placer miners working up two different canyons toward the outcrop of the lode. The northernmost discovery was called the Ophir Bonanza and led to the organization of the Ophir Silver Mining Co. in the spring of 1860.

The main Comstock fault, dipping east at about 45 degrees, outcrops on the flank of Ophir Hill in a line of bold, low grade quartz croppings. Several hundred feet to the east is a parallel, west dipping structure which is a complex of faults, vein matter, and crumbled quartz, with

pyrite, chalcopyrite, sphalerite, complex sulfides, argentite, and gold. This west dipping vein merged with and disappeared into the main east dipping vein at a depth of about 400 feet from the surface. The relationship of this hangingwall vein structure which contained the Ophir bonanza to the main vein-fault is most clearly shown in the atlas of Becker's "Geology of the Comstock Lode."

The high grade ore, up to 40 feet wide, was about 300 feet long and terminated at a depth of about 400 feet. The ore contained a high proportion of silver and was heavy in sulfide minerals. Some of it was very high grade. The first shipment of 38 tons, which went over the Sierra Nevadas on muleback, netted \$3,000 per ton.

The rich ore of the Ophir bonanza was largely mined out by 1864, and for the next 75 years the hangingwall vein from the south line of the Con. Virginia to the north line of the Ophir was sporadically mined for old stope fills and progressively lower grade ore. The last active mining in the area was done by Zeb Kendall by open pit methods in the early 1940's, in what is known as the Kendall cut.

Accurate production records from the earliest day mines are hard to find, but from a variety of sources, I estimate the total bullion production of the Ophir bonanza area at about \$9,000,000. The first \$6,500,000 coming from the early period of production from 1859 - 65, and averaged about \$75 per ton in recovered value. During subsequent years, another \$2,500,000, averaging about \$10 per ton in grade, was recovered. The total production for this area is not all credited to the Ophir, since some of it occurred in what is now Con. Virginia and in Mexican ground.

The Big Bonanza

To the south of the Ophir a group of claims was amalgamated into the Con. Virginia Mining Co. in 1867. Showings near the surface were not particularly encouraging, after the southern segment of the Ophir bonanza was quickly mined out.

In order to prospect the lode at greater depth, the vertical Con. Virginia shaft was started in 1871. This shaft was located ^{east} west of the outcroppings and was expected to

intersect the lode at a depth of about 1500 feet. As the shaft progressed downward, arrangements were made to provide ventilation by driving a drift north from the Gould and Curry shaft on its' 1167 level to connect with the Con. Virginia shaft on the 1200. The drift was started north in supposedly barren hangingwall country. As the drift crossed the Con. Virginia south line it intersected a northeast trending structure which contained porphyry, clay, and quartz assaying from \$7 to \$34 per ton and was about 7 feet wide. The drift was turned on this vein and was followed for a few hundred feet into what became the top of the Big Bonanza. This work is shown on sheet 2 of the attached set of Con. Virginia mine maps.

The Big Bonanza, which was discovered by accident in a totally unexpected location, proved to be one of the richest and most profitable oreshoots in mining history. As can be seen from the accompanying level maps and from the excellent descriptions in Becker and Smith, the Big Bonanza stood almost vertically in the hangingwall. It was shaped like a boomerang, with the southernmost leg striking to the northeast, and the north leg striking north, parallel to the main Comstock fault. The ore extended from just above the 1200 foot level to the 1750 foot level where it disappeared into the east dipping main vein. On the 1550 level the ore shoot was 1000 feet long with a maximum width of 200 feet. Becker gives an excellent description of the Big Bonanza in his Monograph "Geology of the Comstock Lode," pg. 269-272, as does Smith, in "The History of the Comstock Lode." Smith also gives the most accurate analysis of the total production of the Big Bonanza. The mineralogy of the Big Bonanza ore is described by Bastin in "Bonanza Ore of the Comstock Lode."

The productive history of the Big Bonanza is divided into three periods, as shown in the preceeding tabulation of the Con. Virginia group production.

The first period, from 1873 to 1882 saw the mining of the richest portion of the Bonanza. Combined production of the Con. Virginia and California for that period is shown below:

Wet tons (12% moisture)	1,398,000 tons
Gold bullion at \$20.67 per oz.	\$52,563,000
Silver bullion at \$1.29 per oz.	<u>59,422,000</u>
	111,985,000
Less discount to market price of silver	<u>6,817,000</u>
Bullion receipts	\$105,168,000
 Average recovery, dry basis	 74%

The above statistics are those that are supported by sworn statements, and is the normal manner of presenting production figures at that time. To calculate the gross value of the ore, I have assumed that the 74% overall recovery resulted from a recovery of 80% of the gold and 69% of the silver. This split seems reasonable in view of the pan amalgamation process then in use for milling.

Using these assumptions for recovery, I calculate the following gross assay value for the first Big Bonanza production period from 1873 - 1882:

Dry tons	1,248,000 tons
Gold	3,179,000 ounces
Silver	66,760,000 ounces
Average assay value	2.55 oz/ton Au 53.5 oz/ton Ag.

Ninety-five percent of this production occurred in the six years from 1874 through 1879. During this six year period the property declared \$74,000,000 in dividends. At present gold and silver prices, the value of the ore mined would exceed \$200 per ton.

In 1881, a fire broke out in the heavily timbered Big Bonanza stopes, and it was not until 1884 that the fire was brought partially under control. The area was re-entered and

the extraction of low grade ore in and about the old stopes was begun. Thereafter, from 1884 to 1895 inclusive, 861,000 tons of ore were mined yielding \$16,400,000, for an average of about \$19 per ton. From this production additional dividends were paid amounting to \$3,900,000.

To the north of the Con. Virginia 1600 foot level, on the Ophir 1465, a small northward extension of the bonanza was mined from 1874 to 1876 and about \$4,000,000 was extracted.

Hardy Vein

In 1877 the Hardy vein was discovered in the Ophir mine. This narrow, small oreshoot in the hangingwall and very close to the East vein produced \$1,500,000 averaging \$58 per ton in a two year period.

Production came from the 1900 to the 2200 foot level. The relationship of the Hardy vein to the East vein is discussed in my report of 1948, and by Stoddard and Carpenter. The Hardy vein of itself is of little importance, but it and the East vein are most important in understanding the formation and structural control of the Big Bonanza.

East Vein

To the northeast of the Big Bonanza, there is a strong, persistent structure in the hangingwall known as the East vein. It strikes northeast and dips east at a steeper angle than the main fault. This structure was explored from about the center of the Con. Virginia claim on the 1800 foot level northward through the Mexican to the 2500 foot level. It extended into the Sierra Nevada, to the north of the Mexican, for a total explored distance of 3800 feet. A series of narrow, disconnected oreshoots, which had a pronounced rake to the northeast, were mined from this vein from the 1800 foot level of the Con. Virginia to the 2500 foot level of the Mexican. Production from the East vein, from its discovery in 1899 to 1920, was \$6,300,000, with the grade of ore averaging about \$20 per ton in recovered value.

As with the Hardy vein, the importance of the East vein lies not in its productive history, but in its relationship to the formation of the Big Bonanza, which will be discussed later.

GEOLOGY

Reference Works

The writer is not a geologist and will only discuss that part of the general geology which is relevant to the purposes of this report. Those interested in the geology and structural features of the area should refer to the following sources:

Becker's "Geology of the Comstock Lode," published in 1882, is the most thorough and comprehensive work up to that date, and contains an atlas showing all important mine openings in the district up to about 1880. He thoroughly reviewed the earlier work of Von Richtofen in 1865, King in 1868, and Church in 1877. He gives very good descriptions of the major orebodies, and the plans and cross sections in his atlas are invaluable in understanding the economic geology of the district. Although Becker identifies practically all the major rock types in the district, his lithology is colored by the geological fashions of the 1880's, as is his analysis of the structural history and ore genesis. Nevertheless, his work remains the single most important source of information on the Comstock. A copy of Becker's work is on file at the Mines library of the University of Nevada, as are all the other references cited.

Gianella, who published the "Geology of the Silver City District and the Southern Portion of the Comstock Lode, Nevada," in 1936, established the lithologic nomenclature that is in use today, and worked out the structural history based on modern concepts. Gianella established the only known criteria for determining the total displacement of the Comstock fault. He also demonstrated for the first time the existence of extensive post mineral faulting, and pointed out the importance of dikes and hangingwall structures in the formation of oreshoots.

Calkins in "The Geology of the Comstock Lode District, Nevada," published in 1944, largely confirmed Gianella's work and plotted the surface geology on a much more accurate and broader topographic base.

Those interested in the regional geology should refer to Thompson's "Geology of the Virginia City Quadrangle," published in 1956.

A good description of the minerology of the Comstock ores can be found in Bastin's "Bonanza Ores of the Comstock Lode, Virginia City, Nevada." He concludes that no secondary enrichment occurred below a depth of 300 feet, and that most of the values even above that depth were of primary origin. He gives good descriptions and shows illustrations of ore specimens from the Big Bonanza, the East and the Hardy veins.

Geologic Features of Interest

Some of the geologic features which relate directly to the purposes of this report are discussed below. The conclusions which follow are partly from the sources referred to above and partly from my own experience in mapping ore occurrences on the Comstock.

The Comstock fault is the main structural feature along which the mineralization occurred. The fault is Tertiary in origin. Gianella estimates the total vertical throw to be about 3,400 feet, of which about 2,000 feet is premineral and 1500 feet post mineral. The early writers, including Becker, believed that very little post mineral faulting had taken place. This writer has seen many examples of post mineral faulting in the ore horizons mapped by him. Gianella's summary (p 11) is worth quoting:

"The earlier Tertiary volcanics, and older rocks, have been intruded by andesite dikes and a stock of diorite. The rocks were then displaced by normal fault movements, with throws as much as 2,000 feet. Along faults veins were deposited. The early Tertiary volcanics have been tilted westward, with dips averaging 35°, throughout a considerable part of the district.

Faulting continued during mineralization, and further movement crushed many of the veins after the ore was deposited. All scarps, which may have been formed, were effaced by a long interval of erosion, which removed about 2,500 feet of rock. The region was reduced to one of moderate relief.

Lavas were extended during the Pliocene, and these were largely removed by later erosion. Toward the close of the Pliocene, or in the early Pleistocene, faulting was renewed on a grand scale in the

Basin and Range province. At this time the Virginia Range was uplifted, forming a scarp 1,500 to 2,000 feet high, along its eastern front. This scarp is the upward prolongation of the footwall of the Comstock Lode, at Virginia City, and forms the eastern slope of Mount Davidson."

The rocks on both sides of the Comstock fault in the Con. Virginia group are Tertiary in age. The Alta andesite, a thick (2,700 feet) volcanic flow which is described by Gianella, and by Calkins, forms the hangingwall, and the later intrusive Davidson diorite lies along the footwall. The orebodies are also Tertiary in age, and are classified as epithermal by Lindgren.

Some Guides for Exploration

The writer has observed the following features relating to ore control that should be of interest to those seeking new orebodies.

1. The period of economic precious metal mineralization is short compared to the total period of mineralization and rock alteration, and in most instances occurs very late in the process. There is much mineralization on the Comstock which is too low grade to be of economic interest. The paying ore occupies but a fraction of the total mineralized area. In many instances that I have mapped, the commercial ore cuts across and through earlier quartz and mineralized bodies, but there is little or no evidence of later mineralization or alteration superimposed on the pay ore. In some cases, however, post mineral faulting is quite evident. I feel that part of the answer for the apparently erratic distribution of the pay ore on the Comstock is that ore-shoots were formed only on those parts of the fault system which were open and active during the relatively short period of commercial mineralization.
2. The primary ore control on the Comstock is structural control. There is little or no evidence of lithologic control or of selective replacement. The most common feature observed in ore shoots is brecciation of the wall rock with infilling of quartz. Becker's description of

the Big Bonanza mineralization (P.270) follows:

"The bonanzawas composed of crushed quartz, including fragments of country-rock, and carried a few hard, narrow, vein-like seams of very rich black ores, consisting of stephanite and similar minerals, while nearly the whole mass of 'sugar quartz' was impregnated to a moderate extent with argentite and gold, the latter probably in a free state. The immense volume of these soft ores more than compensated for their moderate tenor, and much the greater part of the entire yield of the bonanza was derived from them. They carried a moderate amount of pyrite. A great part of the space stoped out consisted of fragments of country-rock, impregnated, however, with ore, and assaying well. These fragments were highly decomposed, but perfectly recognizable by their green color and traces of porphyritic structure. They were not rounded, and I never saw traces of the concentric structure which any process of replacement must have imparted to them. On the contrary, they were as sharply defined as if freshly broken. Comb structure was not visible in the bonanza on a large scale, but where masses of country-rock were favorably placed, the space between them often showed this peculiarity, indicating that the fragments had acted as centers of crystallization for the quartz."

3. Structural intersections are primary locations for ore-shoots. Many of the ore zones on the Comstock Lode can be recognized as intersections of veins with faults, shear zones, or dikes. The Big Bonanza is the prime example. (Kendall). Gianella recognized the importance of structural intersections in the south end of the Lode, and the writer became convinced of it in mapping the hangingwall oreshoots in the New York mine, in Gold Hill.
4. The influence of intrusive dikes in the hangingwall as a locus for structural control has been only faintly recognized. This is due partly to the intensive rock alteration which makes identification difficult, and partly because of lack of interest in geologic mapping during practically the whole of the active history of the district.

However, the old timers had an empirical rule that "porphyry makes ore." The old reports show numerous examples of so called porphyry zones which were followed into oreshoots. The writer believes that these may well be andesite porphyry dikes which formed a favorable environment for faulting or shearing during the period of mineralization. These dikes can be seen on the surface to the east of the main fault in the hangingwall if one gets far enough away from the intense rock alteration to recognize them. I believe their influence in the structural control of oreshoots has largely gone unrecognized, but that careful mapping from the less altered fringes in toward the more highly altered zones might unlock an important key to the localization of bonanza ore.

Some of the later writers have recognized the possible importance of dikes. Gianella (P54) says, "In the Comstock region dikes are plentiful in the neighborhood of the ore bearing veins..... Dikes have been encountered in the mine workings of the Sutro Tunnel, and especially in the north lateral. Some of the intrusions are certainly closely related in time of occurrence with faulting and vein formation. Becker, who has made the most exhaustive study of the Comstock, recognizes but few dikes in the region. In several of the geologic sections of Becker, structural relations strongly suggest intrusive phenomena."

Calkins states: (P 19), "Intrusion of these dikes may have been closely followed by the formation of the Comstock fault and that of the Lode, the northern part of which largely follows dikes."

PREVIOUS EXPLORATION

Techniques Formerly in Use

Modern exploration techniques have never been applied to the properties under discussion. In the days of widespread underground exploration, from the 1860's through about 1920, no geological mapping was done in the mines. In fact, the mine maps are practically barren of geological notations and the Superintendents written reports contain more geological information than do the maps. One sees on the maps an occasional line showing a strike or dip, but these are very sparse and unsystematic so far as structure is concerned, and there is no lithology noted on the maps at all. Samples of course were taken but I have never seen these plotted on a map. The earliest assay map that I have seen is dated 1934, and covers only near surface workings at the Ophir outcrop.

The men who operated the mines were skilled practical miners, who persistently explored the Lode to great depths under the most difficult conditions. However, they seem to have had no interest in the systematic observation and notation that is the basic requirement of modern mine geology.

Nevertheless, a great deal can be inferred from careful examination of the mine maps and records. Drifts generally followed structures, and crosscuts generally ceased when structures became uninteresting. Study of the mine maps along with careful mapping of the surface will disclose many of the important structural features which controlled ore deposition.

Why They Kept Going Deeper

Early in my association with the North End mines I was puzzled with the question of why the old timers did so much deep, expensive exploration when so much shallow ground around rich targets like the Big Bonanza went unexplored. Partly from conversations with my father, and partly from careful reading of the literature, I formed the following conclusions:

The Comstock Lode was the first silver district of any importance to be discovered in the United States. It created great excitement and for many years the potential of the district was grossly exaggerated. At the height of the Big Bonanza, "experts" were predicting a production for the district of \$1,500,000,000. The more conservative observers were ignored. The fashion of the time was to believe that the Lode was a "true silver vein," and that it would produce indefinitely to great depths.

This theory played into the hands of the speculators and stock brokers who controlled the mines for most of their history. The mines were all assessable corporations, and none of them ever retained any of their earnings. When a bonanza played out, the mines had to operate on assessments. The success of collecting an assessment against the stockholding public depended entirely on the generation of encouraging news by the insiders, and so the myth of opening up new and deeper ground was kept alive for years. It was much easier to collect an assessment to open up a deeper level of the mine in the hope of finding an entirely new bonanza than to go back and re-explore territory that had previously been bypassed.

The system of ownership also mitigated against systematic, long range exploration. After the bonanza period ended in the 1880's control of the mines fell to a group of brokers on the San Francisco mining exchange. For 50 years most of the Comstock stocks were short traded, wash traded, and bucketed by the brokers. They retained management control without owning stock since it was the practice of the time for the broker to be the owner of record and to act as trustee for the real owner. Stocks were bought and sold only for speculation, and the brokers manipulated prices to their own advantage. The result was that the Comstock in its latter days developed a very unsavory reputation in legitimate mining circles, and it is one of the few major mining districts in the west that has not been systematically re-examined in recent years.

The final reason is that the Comstock ore deposits were not really recognized until recent times for what they are -- hypothermal in origin and therefore relatively shallow in depth. By the time this was understood, the steam had gone out of the exploration effort.

Exploration Around the Big Bonanza

The Big Bonanza is such a rich oreshoot that it is an obvious target for further exploration. For this reason I have taken particular pains to research and identify all the openings on all sides of it. In my report of 1948, which was written before I had researched all the data, I concluded that the uppermost workings directly above the stopes were on the 1200 foot level, and that the top of the oreshoot may have been displaced by a post mineral fault. This supposition was based on two pieces of "evidence": first, the apparent and mysterious lack of any workings above the stoped ground, and second, a statement in the Superintendent's annual report for 1878 which in discussing the 1200 foot level said "The orebody has been followed to the south and east, connecting with the old stopes, and up for a distance of 114 feet, at which point the caprock of the ore body was reached."

Later, when I had the time to thoroughly review the mountain of raw material available, I located mapped workings on the 1100 and 1000 foot levels, which appear as solid lines on the attached maps. Further workings on these levels and on the 850 foot level did not appear on any extant maps, but were described in considerable detail in various Superintendents' reports. These workings I located to the best of my judgement and plotted on the maps as dashed lines. I therefore believe that these maps - particularly in the Big Bonanza area - can be used with a considerable degree of confidence.

These later identified workings do not note any marked change in structure or rock type at least up to the 1000 foot level above the Big Bonanza.

Surface Drilling in 1964

In 1964 a company undertook a surface drilling program of the Con. Virginia properties. There follows a brief description of the work done and the results.

Fourteen vertical rotary drill holes were drilled in and around the Kendall pit, which straddles the old Ophir bonanza. The drilling was done dry with a vacuum sampling system. These were shallow holes to test the possibilities of open pit mining in the area. The report states "The assay

results from all holes were disappointingly low," and continues, "It is considered that the zone was well tested, but the work did not indicate any possibility of open pit ore near the Kendall pit or along its northern extension." Two inclined diamond drill holes 700 and 800 feet in length were located several hundred feet west of the Big Bonanza stopes. They were drilled to the northwest, toward Ophir ground and bottomed in hard andesite. No values were encountered. Projections show that they bottomed at about the 500 foot level of the Con. Virginia and Ophir. Although they did traverse previously unexplored ground, neither of these holes were long enough to intersect the hangingwall of the main vein.

An attempt was made to drill vertical holes directly over the Big Bonanza stopes with a dry rotary drill. Six holes were drilled, three of these caved at shallow depth, and the other three were 420, 200, and 220 feet deep. Water causing the holes to cave forced their abandonment. The report states in part, "The material drilled consisted of andesite, sometimes fresh but often altered to clay or nearly to clay. Some sections of the andesite and clay contained pyrite in thin seams or scattered throughout, The amount and degree of mineralization was promising, but the scarcity of values was disappointing and the drilling was stopped."

My comments on this drilling program are as follows:

1. Kendall pit area: From the descriptions the sampling appeared to be well done. In view of the extensive surface prospecting and mining already done in this area, I would be surprised if shallow drilling had turned up any ore.
2. Inclined holes toward west country: The two holes prove very little, since they were collared west of Bonanza projections and terminated before reaching the main Comstock Vein.
3. Vertical holes over the Big Bonanza: The holes are far too short to prove anything.

4. In conclusion, the drilling program appears to have been done on a more or less random basis without any real understanding of the important targets.

Copies of the report of this drilling by the engineer in charge, location of the drill holes on a surface topographic map, composite map, and section, and a detailed log of the two inclined holes are attached as an appendix to this report.

OPPORTUNITIES FOR EXPLORATION

The Big Bonanza Area

In any exploration program, the risks must be commensurate with the potential rewards. The Con. Virginia property was actively worked for a period of about 70 years and at present has no developed ore. However, it contained a rich, compact, highly profitable oreshoot isolated in its hangingwall. This type of orebody is indeed an enticing target for further exploration.

The control for the localization of the Big Bonanza appears quite clear to me. My interpretation follows:

The control is structural. A near vertical hangingwall structure parallel in strike to the main vein-fault, and probably caused by drag along the irregular plane of the fault, forms the north-south leg of the Bonanza. The northeast trending structures represented by the East and Hardy veins intersected this north-south structure and the intersection formed the locus of mineralization. The projected East vein structure forms the southwest leg of the Bonanza. Whether it displaced the north-south structure is not known. It seems probable that the north-south structure continues north through the Ophir ground although it veers easterly along with the general trend toward the east of the main vein as it extends north. Evidence of this can be seen on the maps of the Ophir 1465 foot level. What happens to the north-south hangingwall structure south of the Big Bonanza is not known.

Targets for exploration in the Big Bonanza area are:

1. The Bonanza stopes terminated just above the 1200 foot level. The ground above it is entirely unexplored from the 1000 foot level to the surface, with the exception of the Latrobe Tunnel, which was driven before the discovery

of the Bonanza and crossed over the top of it in a single entry at a depth of about 200 feet. The only other work is the drilling which has been previously discussed.

2. The ground to the southeast of the Bonanza is unexplored, along its flanks and above.
3. The projection of the south leg of the Big Bonanza, running southwest through Con. Virginia and into Best and Belcher ground is unexplored. The 700 to 1000 foot interval of virgin ground along this projection from the discovery drift on the 1200 to the nearest Best and Belcher workings would seem particularly attractive, since the upward rake of the Bonanza projects directly into this area.

While no positive proof can ever be forthcoming, I have a high degree of confidence that all the important previous exploration in the areas of interest have been identified and plotted.

The Main Lode at the 500 Foot Level

The Ophir bonanza terminated about 100 feet above the 500 foot level, at which point the hangingwall vein merged into the east dipping main vein. The 500 foot levels in the Con. Virginia and Ophir were explored before the discovery of the Big Bonanza in the late 60's and early 70's. The vein structure in the Con. Virginia is about 150 feet wide, and in the Ophir, crosscutting indicates a possible maximum width of 550 feet. This level is unusually well developed in both properties with regular and systematic crosscutting, indicating that something maintained the interest of the operators.

No original records exist which disclose the the value of the ground on this level, although it is known that no ore was extracted. Smith in describing the work in the Con. Virginia says, (P 147), "Again long drifts were extended north and south, and again nothing of value was found. The lode had narrowed in that level to 150 feet of practically barren quartz and porphyry." Where he got his information about the grade I do not know. Certainly the vein matter was well below the commercial grade of that day, and too low to entice the operators of the 80's and 90's who did considerable exploration in the upper levels, but not on the 500.

In 1879 the main lode was again penetrated in a west crosscut from the Con. Virginia shaft on the 850 foot level. This work never appeared on any extant map, but it is thoroughly described in the annual report for that year, and I have plotted its approximate location on the map. The report describes the last 100 feet west of the west wall as "soft vein porphyry with clay and quartz streaks". A south drift and another west crosscut 170 feet south of the first was run, encountering the same formation. No mention of grade is given. When "strong indications of water having found, work was temporarily discontinued, fearing an increased flow. Work will be resumed at an early date at these points." It never was.

The only other work on the 500 foot level that took place after the original development was the reopening of the crosscut from the Ophir to the Mexican Shaft in 1920. This is shown on the map as a bypass around the old crosscut at the footwall fault gouge. Nothing of interest showed up here and again water discouraged further development. The vein appears to be disturbed at this point and may be displaced by the Ophir Ravine fault.

I mention this area because persistent but unverified stories have come down from the past that the vein on the 500 foot level contained ore that was too low grade to mill at the time, but would be profitable now. It is true that in those days the cut off was about \$30 - \$40 per ton, since milling charges were \$15 per ton and recoveries were about 70%. However, it is also true that in later years the operators reopened old levels and mined \$10 ore even though much of it was mined at a loss.

Much wild speculation has been made about immense quantities of low grade ore on this level. I will not be a party to this kind of speculation, but I mention the story only because it cannot be disproved, and I believe it a fact that the 500 foot level has not been examined except in the one location noted in the Ophir for over 90 years.

Reconnaissance Exploration

The structural relationships of the Big Bonanza and the existence of hangingwall orebodies in the Ophir, and at other locations along the lode should make surface

investigation with modern exploration tools attractive. The solutions which produced the Big Bonanza must have vented to the present surface. If they did, then geochemical prospecting combined with detailed trenching and mapping should disclose their location. Careful mapping of the hangingwall well away from the intensely altered core should produce a knowledge and understanding of structural and other patterns that can then be applied to the more difficult close-in areas. Dikes should be closely watched for. It is possible that the East vein and other controlling structures run along dikes. The sensible application of these tools should narrow the targets to manageable size before drilling or underground work is undertaken. I can state unequivocally that this type of approach has never been applied to this property, or indeed to the whole district.

I believe that the possibility of finding segments or extensions of the Big Bonanza, or locating similar occurrences nearby, are sufficiently attractive to warrant a thoroughly organized and well financed exploration program.

RE Kendall

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EXPLORATION OPPORTUNITIES ON THE NORTH END
OF THE COMSTOCK LODE, NEVADA

By Robert E. Kendall

ROBERT E. KENDALL

Professional Qualifications

- 1948: B.S. in Mining Engineering from Mackay School of Mines, University of Nevada.
- 1948-50: Mine Engineer, Dayton Consolidated Mines, Virginia City, Nevada. Gold-Silver
- 1950-52: Mining Engineer, Mine Superintendent, Resurrection Mine, Leadville, Colorado. Lead-Zinc.
- 1952-54: Resident Engineer, Leviathan Mine, Alpine County, California. Sulfur.
- 1954-present: with U.S. Borax and Chemical Corporation.
- 54-61:
Planned and put into production open pit borax mine at Boron, California.
- 61-62:
Project Manager, drilling program and feasibility study for proposed potash mine in Saskatchewan, Canada
- 62-64:
Resident Manager, potash mine and refinery, Carlsbad, New Mexico.
- 64-68:
Project manager for construction and start-up of \$75,000,000 potash mine and refinery Saskatchewan, Canada. Made Vice-President of Canadian Potash Department in June, 1968.
- Jan. 1, 1969:
Transferred to Los Angeles. Vice President for mining and manufacturing.

ROBERT E. KENDALL
1802-14th St. E.
Saskatoon, Sask.
Canada

November 15, 1968

Mr. John C. Kahn, President
Mining Corporation of America
First National Bank Building
Denver, Colorado 80202

Dear Mr. Kahn:

It is my understanding that the Mining Corporation of America holds long term leases on the mining properties formerly owned by the Consolidated Virginia Mining Company in Virginia City, Nevada.

Because of my previous association with these properties, you have asked me to supply you with reports and maps in my possession, and to suggest the possibilities which I believe exist for the exploration and development of new orebodies on the property.

Attached is a report entitled "Exploration Opportunities on the North End of the Comstock Lode, Nevada." As appendices to this report I also attach my report written in 1948 entitled "A Study of the Hangingwall Vein Systems on the North End of the Comstock Lode, Nevada," and a set of mine plans - compiled from original maps and records covering the mine workings of the Consolidated Virginia group from near surface to the 2200 foot level.

Very truly yours,


R.E. Kendall

rek/es
enc

ROBERT E. KENDALL

November 10, 1968

EXPLORATION OPPORTUNITIES

ON THE NORTH END

OF THE

COMSTOCK LODGE, NEVADA

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EXPLORATION OPPORTUNITIES ON THE NORTH END
OF THE COMSTOCK LODGE, NEVADA

SUMMARY

The Consolidated Virginia properties on the north end of the Comstock Lode have produced \$145,000,000 in gold and silver. Of this amount \$125,000,000 came from a single isolated oreshoot in the hanging wall, called the Big Bonanza. In a six year period the Bonanza oreshoot produced \$102,000,000 in bullion and paid \$74,000,000 in dividends.

A thorough study has been made of all available maps and records, the results of which are compiled in this report.

A program of exploration in and around the Big Bonanza area is recommended for the following reasons:

1. The importance and richness of the known orebody makes the area attractive for further exploration.
2. It can be demonstrated that favorable unexplored ground exists adjacent to and above the known orebody.
3. It is believed that the structural control which localized the known orebody is understood, and can be applied to the search for extensions of it or for new orebodies.

Favorable locations are pointed out and a graduated program for reconnaissance and exploration is proposed.

INTRODUCTION

My interest in the Comstock Lode stems from the fact that my father, Zeb Kendall, was associated with the Consolidated Virginia Mining Company from 1920 until his death in 1954.

As I grew up in Virginia City I became familiar with the history of the district and interested in the geology of the ore deposits. While attending the Mackay School of Mines in Reno and during the several years that I worked in the district after graduation, I had an opportunity to study a great many of the original maps and records then on file in the office of the Consolidated Virginia Mining Company and at the Mackay School of Mines library. My work as a mining engineer for the Consolidated Virginia Mining Company in the north end and later for the Dayton Consolidated Mining Company in the south end of the district enabled me to become familiar with the geology and structural control of the then exposed oreshoots of the district.

During this period I began a systematic study of the literature of the district and the original records and maps relating to the Consolidated Virginia Mining Company. Quite early in this study I was struck by the fact that there appeared to be large blocks of unexplored ground immediately above and adjacent to the rich and immensely profitable Big Bonanza in Consolidated Virginia ground.

In 1948 I wrote a preliminary report of my findings and drew some conclusions about exploration possibilities for extensions of the Big Bonanza. The original of this report, entitled "A Study of the Hangingwall Vein Systems in the North End of the Comstock Lode, Nevada," is on file at the Mines Library of the University of Nevada, and a copy is attached.

The validity of the recommendations contained in that report hinges on whether or not in fact the ground above and adjacent to the Big Bonanza was left unexplored. In an old mining district with a long history this is often a difficult case to prove. In order to verify my preliminary conclusions, during the next four years I made a systematic study of all available

mine maps, annual reports, superintendents weekly and monthly reports, and data from other sources from the period of the discovery of the Big Bonanza to the present time. At the time of my study the records of the Consolidated Virginia Mining Co. were still largely intact and accessible to me, and this was supplemented by a search of the extensive records in the Mines Library at the University of Nevada, much of which has been donated to the library by my father.

One of the problems in examining the maps of an old mining district is the multiplicity of scales and coordinate systems in use over the years. This makes direct use of the original maps nearly impossible for generalized work. In order to facilitate the study, I set out to consolidate all the maps in the area of interest on a single coordinate grid and to a uniform scale. This was done in draft form during the period 1948 to 1952. Since not all past exploration activity is necessarily plotted on an existing map, I read all the available company annual and Superintendent's reports for the period 1875 to 1952 and made notes on the relevant information contained in these documents. Workings which did not appear in any map but which were described in the Superintendent's reports were plotted on the map in dashed lines in my best estimate of their direction and location. Since my files contain all the annual Superintendent's reports for Consolidated Virginia consecutively from 1874 to 1913, I believe this is the most complete compilation made to date for the property.

This work remained in draft form from 1952 until the present. I have recently completed the consolidated mine maps into usable form, and they are attached to this report. They consist of a series of 14 sheets of the Consolidated Virginia - California claims from the 500 foot level to the 2150 foot level, and a series of 9 sheets of the Ophir-Mexican claims from the 500 foot level to the 2100 foot level. They show all the important mine workings in this vertical interval known to exist. Particular care was taken not to miss any mine openings which might occur in an area of potential interest for exploration.

There are mine workings extending about a thousand feet below the bottom level shown on the attached maps. These are of less interest because they are all below the really productive areas of the mine and are considerably below any zones which I believe are worthwhile exploring in the initial phases of my program.

HISTORICAL SKETCH

General

The Comstock Lode, situated in Storey County, Nevada, is located about 28 miles south of Reno at an elevation of 6200 feet. It lies along the east flank of Mount Davidson in a normal fault zone striking south and dipping to the east. Its' productive length extends for a distance of about four miles, from the northern edge of the town of Virginia City to Silver City on the south.

The Comstock Lode is one of the major precious metal mining districts in the West. Discovered in 1859, it produced \$381,000,000 in gold and silver up to 1940 (Couch and Carpenter-see Bibliography). About 55% of the bullion production was in silver and 45% in gold. Reworking of mill tailings have probably added another \$15,000,000 to this figure. About \$300,000,000 of this production occurred in the 17 year period between 1863 and 1879.

The ore typically occurs in discreet oreshoots separated laterally and vertically by large areas of low grade or waste vein matter. Only a small percentage of the mineralized area contained profitable ore, but many of the oreshoots were so profitable that they are locally called bonanzas. The district has three major productive zones along its strike.

To the south are the Gold Hill group of bonanzas, situated in the Belcher Crown Point, Yellow Jacket, and Imperial mines. The second bonanza zone lies north of the Gold Hill group and is known as the Middle Mines. These are the Chollar-Potosi, Hale and Norcross, Savage, and Gould and Curry mines. The northernmost group known as the North End mines, consisted of the Consolidated Virginia, California, and Ophir mines. The North end group, with the addition of the Mexican property, was consolidated under the name Consolidated Virginia Mining Company in the 1930's, and this is the area which is the subject of this report.

The Con. Virginia Group

The Con. Virginia group produced about 38% of the bullion and 60% of the dividends in the district.

Data on Comstock history and production must be approached with care, because of the frequent property amalgamations and splits which occurred, and which cause confusion in names and in records. The Con. Virginia group consists of a series of contiguous patented mining claims which run along the strike of the outcrop of the lode for a distance of about 2585 feet. /

The original Consolidated Virginia Mining Company was organized in 1867 from a group of largely unproductive claims lying south of the Ophir property - Central: 150 ft., Old California: 300 ft., Central No. 2: 100 ft., Kinney: 50 ft., White and Murphy: 210 ft., Sides: 500 ft., for a total of 1310 feet on the strike of the lode.

Soon after the discovery of the Big Bonanza in 1873, the property was split into two companies, with the Con. Virginia retaining the south 710 feet and a new company, called the California Mining Co. taking the adjoining 600 ft. to the north. The split was made for the purpose of increasing the play on the stock market since the mines were always operated under the same management as a single unit. However, from 1873 to 1884, production and profits are segregated and listed separately in the records. The two properties were re-combined in November, 1884 under the name Consolidated California and Virginia Mining Co.

The Ophir Silver Mining Co., adjoining the Con. California and Virginia to the north, was organized in the spring of 1860 and originally held 1400 feet on the strike of the lode. This was later reduced to 675 feet immediately north of the Con. California and Virginia, and the Mexican Gold and Silver Mining Co. was formed out of the 600 feet adjacent to the north.

In the 1930's, the three existing corporate structures and their properties: The Con. California and Virginia, Ophir, and Mexican, were merged into a single corporation called the Consolidated Virginia Mining Co. It is this property which is referred to in this report as the Con. Virginia group.

PRODUCTION HISTORY OF THE CON. VIRGINIA GROUP

General

The total production of the Con. Virginia group to 1940 is listed as \$145,600,000 by Couch and Carpenter in their publication, "Nevada's Metal and Mineral Production." From research on a variety of records, I can account for the following yield broken down by location and time:

	<u>Bullion Yield</u>	<u>Approximate Recovery/Ton</u>
Ophir Bonanza (1859 - 65)	\$ 6,500,000	\$ 75
Big Bonanza (1873 - 82)	105,200,000	75
Ophir extension of Big Bonanza (1874 - 76)	4,000,000	40
Reworking of Big Bonanza area (1884 - 95)	16,400,000	19
Hardy Vein (1879 - 80)	1,500,000	58
East Vein (1899 - 1920)	6,300,000	20
Low Grade Surface Ore (1870 - 1940)	<u>2,500,000</u>	10
	<u>\$142,400,000</u>	

Ophir Bonanza

The Comstock Lode was discovered almost concurrently in two places in the spring of 1859 by placer miners working up two different canyons toward the outcrop of the lode. The northernmost discovery was called the Ophir Bonanza and led to the organization of the Ophir Silver Mining Co. in the spring of 1860.

The main Comstock fault, dipping east at about 45 degrees, outcrops on the flank of Ophir Hill in a line of bold, low grade quartz croppings. Several hundred feet to the east is a parallel, west dipping structure which is a complex of faults, vein matter, and crumbled quartz, with

pyrite, chalcopyrite, sphalerite, complex sulfides, argentite, and gold. This west dipping vein merged with and disappeared into the main east dipping vein at a depth of about 400 feet from the surface. The relationship of this hangingwall vein structure which contained the Ophir bonanza to the main vein-fault is most clearly shown in the atlas of Becker's "Geology of the Comstock Lode."

The high grade ore, up to 40 feet wide, was about 300 feet long and terminated at a depth of about 400 feet. The ore contained a high proportion of silver and was heavy in sulfide minerals. Some of it was very high grade. The first shipment of 38 tons, which went over the Sierra Nevadas on muleback, netted \$3,000 per ton.

The rich ore of the Ophir bonanza was largely mined out by 1864, and for the next 75 years the hangingwall vein from the south line of the Con. Virginia to the north line of the Ophir was sporadically mined for old stope fills and progressively lower grade ore. The last active mining in the area was done by Zeb Kendall by open pit methods in the early 1940's, in what is known as the Kendall cut.

Accurate production records from the earliest day mines are hard to find, but from a variety of sources, I estimate the total bullion production of the Ophir bonanza area at about \$9,000,000. The first \$6,500,000 coming from the early period of production from 1859 - 65, and averaged about \$75 per ton in recovered value. During subsequent years, another \$2,500,000, averaging about \$10 per ton in grade, was recovered. The total production for this area is not all credited to the Ophir, since some of it occurred in what is now Con. Virginia and in Mexican ground.

The Big Bonanza

To the south of the Ophir a group of claims was amalgamated into the Con. Virginia Mining Co. in 1867. Showings near the surface were not particularly encouraging, after the southern segment of the Ophir bonanza was quickly mined out.

In order to prospect the lode at greater depth, the vertical Con. Virginia shaft was started in 1871. This shaft was located ^{east} west of the outcroppings and was expected to

intersect the lode at a depth of about 1500 feet. As the shaft progressed downward, arrangements were made to provide ventilation by driving a drift north from the Gould and Curry shaft on its' 1167 level to connect with the Con. Virginia shaft on the 1200. The drift was started north in supposedly barren hangingwall country. As the drift crossed the Con. Virginia south line it intersected a northeast trending structure which contained porphyry, clay, and quartz assaying from \$7 to \$34 per ton and was about 7 feet wide. The drift was turned on this vein and was followed for a few hundred feet into what became the top of the Big Bonanza. This work is shown on sheet 2 of the attached set of Con. Virginia mine maps.

The Big Bonanza, which was discovered by accident in a totally unexpected location, proved to be one of the richest and most profitable oreshoots in mining history. As can be seen from the accompanying level maps and from the excellent descriptions in Becker and Smith, the Big Bonanza stood almost vertically in the hangingwall. It was shaped like a boomerang, with the southernmost leg striking to the northeast, and the north leg striking north, parallel to the main Comstock fault. The ore extended from just above the 1200 foot level to the 1750 foot level where it disappeared into the east dipping main vein. On the 1550 level the ore shoot was 1000 feet long with a maximum width of 200 feet. Becker gives an excellent description of the Big Bonanza in his Monograph "Geology of the Comstock Lode" pg. 269-272, as does Smith, in "The History of the Comstock Lode." Smith also gives the most accurate analysis of the total production of the Big Bonanza. The mineralogy of the Big Bonanza ore is described by Bastin in "Bonanza Ore of the Comstock Lode."

*Becker
Smith
Bastin*

The productive history of the Big Bonanza is divided into three periods, as shown in the preceeding tabulation of the Con. Virginia group production.

The first period, from 1873 to 1882 saw the mining of the richest portion of the Bonanza. Combined production of the Con. Virginia and California for that period is shown below:

Wet tons (12% moisture)	1,398,000 tons
Gold bullion at \$20.67 per oz.	\$52,563,000
Silver bullion at \$1.29 per oz.	<u>59,422,000</u>
	111,985,000
Less discount to market price of silver	<u>6,817,000</u>
Bullion receipts	\$105,168,000
 Average recovery, dry basis	 74%

The above statistics are those that are supported by sworn statements, and is the normal manner of presenting production figures at that time. To calculate the gross value of the ore, I have assumed that the 74% overall recovery resulted from a recovery of 80% of the gold and 69% of the silver. This split seems reasonable in view of the pan amalgamation process then in use for milling.

Using these assumptions for recovery, I calculate the following gross assay value for the first Big Bonanza production period from 1873 - 1882:

Dry tons	1,248,000 tons
Gold	3,179,000 ounces
Silver	66,760,000 ounces
 Average assay value	 2.55 oz/ton Au 53.5 oz/ton Ag.

Ninety-five percent of this production occurred in the six years from 1874 through 1879. During this six year period the property declared \$74,000,000 in dividends. At present gold and silver prices, the value of the ore mined would exceed \$200 per ton.

In 1881, a fire broke out in the heavily timbered Big Bonanza stopes, and it was not until 1884 that the fire was brought partially under control. The area was re-entered and

the extraction of low grade ore in and about the old stopes was begun. Thereafter, from 1884 to 1895 inclusive, 861,000 tons of ore were mined yielding \$16,400,000, for an average of about \$19 per ton. From this production additional dividends were paid amounting to \$3,900,000.

To the north of the Con. Virginia 1600 foot level, on the Ophir 1465, a small northward extension of the bonanza was mined from 1874 to 1876 and about \$4,000,000 was extracted.

Hardy Vein

In 1877 the Hardy vein was discovered in the Ophir mine. This narrow, small oreshoot in the hangingwall and very close to the East vein produced \$1,500,000 averaging \$58 per ton in a two year period.

Production came from the 1900 to the 2200 foot level. The relationship of the Hardy vein to the East vein is discussed in my report of 1948, and by Stoddard and Carpenter. The Hardy vein of itself is of little importance, but it and the East vein are most important in understanding the formation and structural control of the Big Bonanza.

East Vein

To the northeast of the Big Bonanza, there is a strong, persistent structure in the hangingwall known as the East vein. It strikes northeast and dips east at a steeper angle than the main fault. This structure was explored from about the center of the Con. Virginia claim on the 1800 foot level northward through the Mexican to the 2500 foot level. It extended into the Sierra Nevada, to the north of the Mexican, for a total explored distance of 3800 feet. A series of narrow, disconnected oreshoots, which had a pronounced rake to the northeast, were mined from this vein from the 1800 foot level of the Con. Virginia to the 2500 foot level of the Mexican. Production from the East vein, from its discovery in 1899 to 1920, was \$6,300,000, with the grade of ore averaging about \$20 per ton in recovered value.

As with the Hardy vein, the importance of the East vein lies not in its productive history, but in its relationship to the formation of the Big Bonanza, which will be discussed later.

GEOLOGY

Reference Works

The writer is not a geologist and will only discuss that part of the general geology which is relevant to the purposes of this report. Those interested in the geology and structural features of the area should refer to the following sources:

Becker's "Geology of the Comstock Lode," published in 1882, is the most thorough and comprehensive work up to that date, and contains an atlas showing all important mine openings in the district up to about 1880. He thoroughly reviewed the earlier work of Von Richtofen in 1865, King in 1868, and Church in 1877. He gives very good descriptions of the major orebodies, and the plans and cross sections in his atlas are invaluable in understanding the economic geology of the district. Although Becker identifies practically all the major rock types in the district, his lithology is colored by the geological fashions of the 1880's, as is his analysis of the structural history and ore genesis. Nevertheless, his work remains the single most important source of information on the Comstock. A copy of Becker's work is on file at the Mines library of the University of Nevada, as are all the other references cited.

Gianella, who published the "Geology of the Silver City District and the Southern Portion of the Comstock Lode, Nevada," in 1936, established the lithologic nomenclature that is in use today, and worked out the structural history based on modern concepts. Gianella established the only known criteria for determining the total displacement of the Comstock fault. He also demonstrated for the first time the existence of extensive post mineral faulting, and pointed out the importance of dikes and hangingwall structures in the formation of oreshoots.

Calkins in "The Geology of the Comstock Lode District, Nevada," published in 1944, largely confirmed Gianella's work and plotted the surface geology on a much more accurate and broader topographic base.

Those interested in the regional geology should refer to Thompson's "Geology of the Virginia City Quadrangle," published in 1956.

A good description of the minerology of the Comstock ores can be found in Bastin's "Bonanza Ores of the Comstock Lode, Virginia City, Nevada." He concludes that no secondary enrichment occurred below a depth of 300 feet, and that most of the values even above that depth were of primary origin. He gives good descriptions and shows illustrations of ore specimens from the Big Bonanza, the East and the Hardy veins.

Geologic Features of Interest

Some of the geologic features which relate directly to the purposes of this report are discussed below. The conclusions which follow are partly from the sources referred to above and partly from my own experience in mapping ore occurrences on the Comstock.

The Comstock fault is the main structural feature along which the mineralization occurred. The fault is Tertiary in origin. Gianella estimates the total vertical throw to be about 3,400 feet, of which about 2,000 feet is premineral and 1500 feet post mineral. The early writers, including Becker, believed that very little post mineral faulting had taken place. This writer has seen many examples of post mineral faulting in the ore horizons mapped by him. Gianella's summary (p 11) is worth quoting:

"The earlier Tertiary volcanics, and older rocks, have been intruded by andesite dikes and a stock of diorite. The rocks were then displaced by normal fault movements, with throws as much as 2,000 feet. Along faults veins were deposited. The early Tertiary volcanics have been tilted westward, with dips averaging 35° , throughout a considerable part of the district.

Faulting continued during mineralization, and further movement crushed many of the veins after the ore was deposited. All scarps, which may have been formed, were effaced by a long interval of erosion, which removed about 2,500 feet of rock. The region was reduced to one of moderate relief.

Lavas were extended during the Pliocene, and these were largely removed by later erosion. Toward the close of the Pliocene, or in the early Pleistocene, faulting was renewed on a grand scale in the

Basin and Range province. At this time the Virginia Range was uplifted, forming a scarp 1,500 to 2,000 feet high, along its eastern front. This scarp is the upward prolongation of the footwall of the Comstock Lode, at Virginia City, and forms the eastern slope of Mount Davidson."

The rocks on both sides of the Comstock fault in the Con. Virginia group are Tertiary in age. The Alta andesite, a thick (2,700 feet) volcanic flow which is described by Gianella, and by Calkins, forms the hangingwall, and the later intrusive Davidson diorite lies along the footwall. The orebodies are also Tertiary in age, and are classified as epithermal by Lindgren.

Some Guides for Exploration

The writer has observed the following features relating to ore control that should be of interest to those seeking new orebodies.

1. The period of economic precious metal mineralization is short compared to the total period of mineralization and rock alteration, and in most instances occurs very late in the process. There is much mineralization on the Comstock which is too low grade to be of economic interest. The paying ore occupies but a fraction of the total mineralized area. In many instances that I have mapped, the commercial ore cuts across and through earlier quartz and mineralized bodies, but there is little or no evidence of later mineralization or alteration superimposed on the pay ore. In some cases, however, post mineral faulting is quite evident. I feel that part of the answer for the apparently erratic distribution of the pay ore on the Comstock is that ore-shoots were formed only on those parts of the fault system which were open and active during the relatively short period of commercial mineralization.
2. The primary ore control on the Comstock is structural control. There is little or no evidence of lithologic control or of selective replacement. The most common feature observed in ore shoots is brecciation of the wall rock with infilling of quartz. Becker's description of

the Big Bonanza mineralization (P.270) follows:

"The bonanzawas composed of crushed quartz, including fragments of country-rock, and carried a few hard, narrow, vein-like seams of very rich black ores, consisting of stephanite and similar minerals, while nearly the whole mass of 'sugar quartz' was impregnated to a moderate extent with argentite and gold, the latter probably in a free state. The immense volume of these soft ores more than compensated for their moderate tenor, and much the greater part of the entire yield of the bonanza was derived from them. They carried a moderate amount of pyrite. A great part of the space stoped out consisted of fragments of country-rock, impregnated, however, with ore, and assaying well. These fragments were highly decomposed, but perfectly recognizable by their green color and traces of porphyritic structure. They were not rounded, and I never saw traces of the concentric structure which any process of replacement must have imparted to them. On the contrary, they were as sharply defined as if freshly broken. Comb structure was not visible in the bonanza on a large scale, but where masses of country-rock were favorably placed, the space between them often showed this peculiarity, indicating that the fragments had acted as centers of crystallization for the quartz."

3. Structural intersections are primary locations for ore-shoots. Many of the ore zones on the Comstock Lode can be recognized as intersections of veins with faults, shear zones, or dikes. The Big Bonanza is the prime example. (Kendall). Gianella recognized the importance of structural intersections in the south end of the Lode, and the writer became convinced of it in mapping the hangingwall oreshoots in the New York mine, in Gold Hill.
4. The influence of intrusive dikes in the hangingwall as a locus for structural control has been only faintly recognized. This is due partly to the intensive rock alteration which makes identification difficult, and partly because of lack of interest in geologic mapping during practically the whole of the active history of the district.

However, the old timers had an empirical rule that "porphyry makes ore." The old reports show numerous examples of so called porphyry zones which were followed into oreshoots. The writer believes that these may well be andesite porphyry dikes which formed a favorable environment for faulting or shearing during the period of mineralization. These dikes can be seen on the surface to the east of the main fault in the hangingwall if one gets far enough away from the intense rock alteration to recognize them. I believe their influence in the structural control of oreshoots has largely gone unrecognized, but that careful mapping from the less altered fringes in toward the more highly altered zones might unlock an important key to the localization of bonanza ore.

Some of the later writers have recognized the possible importance of dikes. Gianella (P54) says, "In the Comstock region dikes are plentiful in the neighborhood of the ore bearing veins..... Dikes have been encountered in the mine workings of the Sutro Tunnel, and especially in the north lateral. Some of the intrusions are certainly closely related in time of occurrence with faulting and vein formation. Becker, who has made the most exhaustive study of the Comstock, recognizes but few dikes in the region. In several of the geologic sections of Becker, structural relations strongly suggest intrusive phenomena."

Calkins states: (P 19), "Intrusion of these dikes may have been closely followed by the formation of the Comstock fault and that of the Lode, the northern part of which largely follows dikes."

PREVIOUS EXPLORATION

Techniques Formerly in Use

Modern exploration techniques have never been applied to the properties under discussion. In the days of widespread underground exploration, from the 1860's through about 1920, no geological mapping was done in the mines. In fact, the mine maps are practically barren of geological notations and the Superintendents written reports contain more geological information than do the maps. One sees on the maps an occasional line showing a strike or dip, but these are very sparse and unsystematic so far as structure is concerned, and there is no lithology noted on the maps at all. Samples of course were taken but I have never seen these plotted on a map. The earliest assay map that I have seen is dated 1934, and covers only near surface workings at the Ophir outcrop.

The men who operated the mines were skilled practical miners, who persistently explored the Lode to great depths under the most difficult conditions. However, they seem to have had no interest in the systematic observation and notation that is the basic requirement of modern mine geology.

Nevertheless, a great deal can be inferred from careful examination of the mine maps and records. Drifts generally followed structures, and crosscuts generally ceased when structures became uninteresting. Study of the mine maps along with careful mapping of the surface will disclose many of the important structural features which controlled ore deposition.

Why They Kept Going Deeper

Early in my association with the North End mines I was puzzled with the question of why the old timers did so much deep, expensive exploration when so much shallow ground around rich targets like the Big Bonanza went unexplored. Partly from conversations with my father, and partly from careful reading of the literature, I formed the following conclusions:

The Comstock Lode was the first silver district of any importance to be discovered in the United States. It created great excitement and for many years the potential of the district was grossly exaggerated. At the height of the Big Bonanza, "experts" were predicting a production for the district of \$1,500,000,000. The more conservative observers were ignored. The fashion of the time was to believe that the Lode was a "true silver vein," and that it would produce indefinitely to great depths.

This theory played into the hands of the speculators and stock brokers who controlled the mines for most of their history. The mines were all assessable corporations, and none of them ever retained any of their earnings. When a bonanza played out, the mines had to operate on assessments. The success of collecting an assessment against the stockholding public depended entirely on the generation of encouraging news by the insiders, and so the myth of opening up new and deeper ground was kept alive for years. It was much easier to collect an assessment to open up a deeper level of the mine in the hope of finding an entirely new bonanza than to go back and re-explore territory that had previously been bypassed.

The system of ownership also mitigated against systematic, long range exploration. After the bonanza period ended in the 1880's control of the mines fell to a group of brokers on the San Francisco mining exchange. For 50 years most of the Comstock stocks were short traded, wash traded, and bucketed by the brokers. They retained management control without owning stock since it was the practice of the time for the broker to be the owner of record and to act as trustee for the real owner. Stocks were bought and sold only for speculation, and the brokers manipulated prices to their own advantage. The result was that the Comstock in its latter days developed a very unsavory reputation in legitimate mining circles, and it is one of the few major mining districts in the west that has not been systematically re-examined in recent years.

The final reason is that the Comstock ore deposits were not really recognized until recent times for what they are -- hypothermal in origin and therefore relatively shallow in depth. By the time this was understood, the steam had gone out of the exploration effort.

Exploration Around the Big Bonanza

The Big Bonanza is such a rich oreshoot that it is an obvious target for further exploration. For this reason I have taken particular pains to research and identify all the openings on all sides of it. In my report of 1948, which was written before I had researched all the data, I concluded that the uppermost workings directly above the stopes were on the 1200 foot level, and that the top of the oreshoot may have been displaced by a post mineral fault. This supposition was based on two pieces of "evidence": first, the apparent and mysterious lack of any workings above the stoped ground, and second, a statement in the Superintendent's annual report for 1878 which in discussing the 1200 foot level said "The orebody has been followed to the south and east, connecting with the old stopes, and up for a distance of 114 feet, at which point the caprock of the ore body was reached."

Later, when I had the time to thoroughly review the mountain of raw material available, I located mapped workings on the 1100 and 1000 foot levels, which appear as solid lines on the attached maps. Further workings on these levels and on the 850 foot level did not appear on any extant maps, but were described in considerable detail in various Superintendents' reports. These workings I located to the best of my judgement and plotted on the maps as dashed lines. I therefore believe that these maps - particularly in the Big Bonanza area - can be used with a considerable degree of confidence.

These later identified workings do not note any marked change in structure or rock type at least up to the 1000 foot level above the Big Bonanza.

Surface Drilling in 1964

In 1964 a company undertook a surface drilling program of the Con. Virginia properties. There follows a brief description of the work done and the results.

Fourteen vertical rotary drill holes were drilled in and around the Kendall pit, which straddles the old Ophir bonanza. The drilling was done dry with a vacuum sampling system. These were shallow holes to test the possibilities of open pit mining in the area. The report states "The assay

results from all holes were disappointingly low," and continues, "It is considered that the zone was well tested, but the work did not indicate any possibility of open pit ore near the Kendall pit or along its northern extension." Two inclined diamond drill holes 700 and 800 feet in length were located several hundred feet west of the Big Bonanza stopes. They were drilled to the northwest, toward Ophir ground and bottomed in hard andesite. No values were encountered. Projections show that they bottomed at about the 500 foot level of the Con. Virginia and Ophir. Although they did traverse previously unexplored ground, neither of these holes were long enough to intersect the hangingwall of the main vein.

An attempt was made to drill vertical holes directly over the Big Bonanza stopes with a dry rotary drill. Six holes were drilled, three of these caved at shallow depth, and the other three were 420, 200, and 220 feet deep. Water causing the holes to cave forced their abandonment. The report states in part, "The material drilled consisted of andesite, sometimes fresh but often altered to clay or nearly to clay. Some sections of the andesite and clay contained pyrite in thin seams or scattered throughout, The amount and degree of mineralization was promising, but the scarcity of values was disappointing and the drilling was stopped."

My comments on this drilling program are as follows:

1. Kendall pit area: From the descriptions the sampling appeared to be well done. In view of the extensive surface prospecting and mining already done in this area, I would be surprised if shallow drilling had turned up any ore.
2. Inclined holes toward west country: The two holes prove very little, since they were collared west of Bonanza projections and terminated before reaching the main Comstock Vein.
3. Vertical holes over the Big Bonanza: The holes are far too short to prove anything.

4. In conclusion, the drilling program appears to have been done on a more or less random basis without any real understanding of the important targets.

Copies of the report of this drilling by the engineer in charge, location of the drill holes on a surface topographic map, composite map, and section, and a detailed log of the two inclined holes are attached as an appendix to this report.

OPPORTUNITIES FOR EXPLORATION

The Big Bonanza Area

In any exploration program, the risks must be commensurate with the potential rewards. The Con. Virginia property was actively worked for a period of about 70 years and at present has no developed ore. However, it contained a rich, compact, highly profitable oreshoot isolated in its hangingwall. This type of orebody is indeed an enticing target for further exploration.

The control for the localization of the Big Bonanza appears quite clear to me. My interpretation follows:

The control is structural. A near vertical hangingwall structure parallel in strike to the main vein-fault, and probably caused by drag along the irregular plane of the fault, forms the north-south leg of the Bonanza. The northeast trending structures represented by the East and Hardy veins intersected this north-south structure and the intersection formed the locus of mineralization. The projected East vein structure forms the southwest leg of the Bonanza. Whether it displaced the north-south structure is not known. It seems probable that the north-south structure continues north through the Ophir ground although it veers easterly along with the general trend toward the east of the main vein as it extends north. Evidence of this can be seen on the maps of the Ophir 1465 foot level. What happens to the north-south hangingwall structure south of the Big Bonanza is not known.

Targets for exploration in the Big Bonanza area are:

1. The Bonanza stopes terminated just above the 1200 foot level. The ground above it is entirely unexplored from the 1000 foot level to the surface, with the exception of the Latrobe Tunnel, which was driven before the discovery

of the Bonanza and crossed over the top of it in a single entry at a depth of about 200 feet. The only other work is the drilling which has been previously discussed.

2. The ground to the southeast of the Bonanza is unexplored, along its flanks and above.
3. The projection of the south leg of the Big Bonanza, running southwest through Con. Virginia and into Best and Belcher ground is unexplored. The 700 to 1000 foot interval of virgin ground along this projection from the discovery drift on the 1200 to the nearest Best and Belcher workings would seem particularly attractive, since the upward rake of the Bonanza projects directly into this area.

While no positive proof can ever been forthcoming, I have a high degree of confidence that all the important previous exploration in the areas of interest have been identified and plotted.

The Main Lode at the 500 Foot Level

The Ophir bonanza terminated about 100 feet above the 500 foot level, at which point the hangingwall vein merged into the east dipping main vein. The 500 foot levels in the Con. Virginia and Ophir were explored before the discovery of the Big Bonanza in the late 60's and early 70's. The vein structure in the Con. Virginia is about 150 feet wide, and in the Ophir, crosscutting indicates a possible maximum width of 550 feet. This level is unusually well developed in both properties with regular and systematic crosscutting, indicating that something maintained the interest of the operators.

No original records exist which disclose the the value of the ground on this level, although it is known that no ore was extracted. Smith in describing the work in the Con. Virginia says, (P 147), "Again long drifts were extended north and south, and again nothing of value was found. The lode had narrowed in that level to 150 feet of practically barren quartz and porphyry." Where he got his information about the grade I do not know. Certainly the vein matter was well below the commercial grade of that day, and too low to entice the operators of the 80's and 90's who did considerable exploration in the upper levels, but not on the 500.

In 1879 the main lode was again penetrated in a west crosscut from the Con. Virginia shaft on the 850 foot level. This work never appeared on any extant map, but it is thoroughly described in the annual report for that year, and I have plotted its approximate location on the map. The report describes the last 100 feet west of the west wall as "soft vein porphyry with clay and quartz streaks". A south drift and another west crosscut 170 feet south of the first was run, encountering the same formation. No mention of grade is given. When "strong indications of water having found, work was temporarily discontinued, fearing an increased flow. Work will be resumed at an early date at these points." It never was.

The only other work on the 500 foot level that took place after the original development was the reopening of the crosscut from the Ophir to the Mexican Shaft in 1920. This is shown on the map as a bypass around the old crosscut at the footwall fault gouge. Nothing of interest showed up here and again water discouraged further development. The vein appears to be disturbed at this point and may be displaced by the Ophir Ravine fault.

I mention this area because persistent but unverified stories have come down from the past that the vein on the 500 foot level contained ore that was too low grade to mill at the time, but would be profitable now. It is true that in those days the cut off was about \$30 - \$40 per ton, since milling charges were \$15 per ton and recoveries were about 70%. However, it is also true that in later years the operators reopened old levels and mined \$10 ore even though much of it was mined at a loss.

Much wild speculation has been made about immense quantities of low grade ore on this level. I will not be a party to this kind of speculation, but I mention the story only because it cannot be disproved, and I believe it a fact that the 500 foot level has not been examined except in the one location noted in the Ophir for over 90 years.

Reconnaissance Exploration

The structural relationships of the Big Bonanza and the existence of hangingwall orebodies in the Ophir, and at other locations along the lode should make surface

investigation with modern exploration tools attractive. The solutions which produced the Big Bonanza must have vented to the present surface. If they did, then geochemical prospecting combined with detailed trenching and mapping should disclose their location. Careful mapping of the hangingwall well away from the intensely altered core should produce a knowledge and understanding of structural and other patterns that can then be applied to the more difficult close-in areas. Dikes should be closely watched for. It is possible that the East vein and other controlling structures run along dikes. The sensible application of these tools should narrow the targets to manageable size before drilling or underground work is undertaken. I can state unequivocally that this type of approach has never been applied to this property, or indeed to the whole district.

I believe that the possibility of finding segments or extensions of the Big Bonanza, or locating similar occurrences nearby, are sufficiently attractive to warrant a thoroughly organized and well financed exploration program.

RE Kendall

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