CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

39.0050

CHEMICAL ENGINEER

HOWARD H. HEILMAN
NATIONAL OIL BUILDING
SIXTH AND GRAND
LOS ANGELES 17, CALIFORNIA

CONSULTING SERVICES

Mr. W. H. Crutchfield, Jr.
Mining Engineer

September 17, 1958

The Atchison, Topeka and Santa Fe Railway Company
Mining Department
121 East Sixth Street
Los Angeles, 14, Calif.

Dear Bill,

As per my telephone conversation of today I am enclosing a copy of our Report No. 2 concerning the Golconda Chemicals project.

This report No. 2 deals almost exclusively with the economic and geologic aspects of the non-ferrous reserves and their exploitation. As you will observe from the report the production of large tonnages of sulfuric acid and zinc oxide is indicated for the venture. I know that you are somewhat aware of our efforts during the past two years with regard to the development of major ore and chemical processing facilities for this area. I mention this to confirm our activities with various groups and companies through which it seems likely that we will arrange for complete exploitation of the reserves. Accordingly, and in keeping with the policy of your company, we would in no way be seeking your aid along such lines. On the other hand, in view of the magnitude of the freight business which is involved we consider that Santa Fe's interest and policy would both be served by your technical attention to our position, studies, etc. With this in mind we would welcome your review and comment - and we affirm that anything of this nature will be maintained totally within the knowledge of Golconda Chemicals Corporation and not disclosed in any fashion with other groups.

I will be in the Kingman area for practically all of October and will be arriving there about Monday September 29 just after the meetings of the American Mining Congress. I do hope you can make the opportunity of visiting with us in Kingman during that period.

Sincerely,

Howard

Howard H. Heilman

5.0050

MOHAVE COUNTY MINER
January 12, 1961

Mining

New Program For Golconda Is Announced

[redacted]

Bill
Thought this
might interest you
Dave W
1/19

39.0050-~~5.0050~~

October 18, 1957

Mr. Howard H. Heilman
Arcadia Lodge
Kingman, Arizona

Dear Howard:

Since I haven't heard from you since my visit to Kingman the middle of August, I am wondering how your project is progressing.

Any information that you may see fit to offer will be appreciated.

Sincerely,

W. H. Crutchfield, Jr.
Mining Engineer

Y4-0000.000
5.0050

HOWARD H. HEILMAN
CONSULTING CHEMICAL ENGINEER

NATIONAL OIL BLDG.
SIXTH AND GRAND
LOS ANGELES 17

MADISON 6-8655

GOLCONDA CHEMICALS CORPORATION

FOREWORD

Golconda Chemicals Corporation is an Arizona corporation, formally organized in April, 1957. It controls non-ferrous mineral reserves in Mohave County, near Kingman, Arizona.

The field office of Golconda Chemicals Corporation is at the Golconda mining property (see map on page 6). The Kingman, Arizona mailing address is Box 1190. Correspondence concerning this project should be addressed to Howard H. Heilman, 609 So. Grand Ave., Los Angeles 17, California.

INDEX

HISTORICAL BACKGROUND OF THE GOLCONDA MINE

The Golconda mine is located in the Cerbat Mountains of the Wallapai Mining District and is approximately fifteen miles north of Kingman, Arizona. It is included in the properties controlled by Golconda Chemicals Corporation.

The first discoveries in the area were in 1863. Until the turn of the century the only metals sought were gold and silver and mining operations were mainly near the surface.

The Golconda mine is credited with a production of approximately $6,500,000 up to 1917. Most of this was produced in a two year period into 1917. On October 4, 1917 a fire completely destroyed the mill. Due to material and equipment shortages at that time, rebuilding was postponed, but the mine was sold before any reconstruction work was started. Considerable work was done in the late 1920's on a low level haulage tunnel, but with the death of the owner, work was stopped. This tunnel, called the Peach Tunnel, had as its objective the recovery of the high quality ore which had been developed and blocked-out at the time of the fire. In the 1100 to 1400 feet levels remain some 60,000 tons of developed ore with an additional 20,000 tons at higher levels.

Some development work was conducted intermittently in the period 1935 to 1940. In 1954 - 1955 a program of development and reactivation was initiated but it did not succeed in its aims. (Refer to later text on the history of the mine.)

Total earlier production from the Golconda mine is reported by the United States Geological Survey as:

Gold	20,752	ounces
Silver	510,180	ounces
Copper	354,703	pounds
Lead	2,031,719	pounds
Zinc	56,226,020	pounds

Most of the foregoing production was obtained in the two year period of its major operation. At that time the Golconda mine was the largest zinc producer in Arizona and was noted for the high values of gold and silver occurring with the zinc.

OBJECTIVE

Golconda Chemicals Corporation controls large non-ferrous mineral reserves in Mohave County, near Kingman, Arizona. Important facilities now exist at its properties and extensive development work has been performed.

The objective of the Corporation is to achieve full exploitation of its minerals. This can proceed along one or all of the following lines:

1. Production of metal concentrates.

2. Manufacture of low cost sulfuric acid.

3. Manufacture of agricultural/industrial chemicals.

4. Production of non-ferrous metals.

The Corporation is interested in reviewing proposals for financial and technical development of its assets.

SUMMARY OF GOLCONDA'S ADVANTAGEOUS POSITION

The Corporation's position has many attractive features illustrated by the following:

1. The profit potentials from the Golconda minerals are realistic at the present depressed levels of metal prices.

2. Within the twenty one mining claims controlled by the company is an estimated reserve of 2,000,000 tons of high quality ore. This estimate is based on recovery only to a depth of 3500 feet. (Refer to estimate of ore reserves in Appendix A.)

3. The ore is of high quality averaging 14% zinc with $10 per ton in gold and silver values.

4. The metals occur as sulfides. By-product sulfuric acid can be produced at low cost.

5. From previous development work, there exist an estimated 80,000 tons of blocked-out ore.

6. Past operations have established that ore development costs are low.

7. The lease which the company holds on a substantial portion of the reserves extends to the year 2004. Its terms are exceptionally favorable, including low royalty payments.

8. The accessibility of the reserves is an outstanding feature. Some of the important tunnels represent a replacement value of over $500,000.

9. Large quantities of dump ore are on the property. The dump ore has been confirmed to be of high metal content. Large amounts were removed and processed through a mill in order to determine accurately the concentration of metals. The dump ore represents a significant quick asset.

10. Non-ferrous metals provide inflationary safeguards. The gold content affords a deflationary hedge or greater value should gold policies be modified in the decade ahead. Depletion allowances apply to the Golconda ores.

11. Adequate water exists within the Golconda property. Roads, transportation facilities, utilities, labor and community attitudes are all favorable.

12. Arizona and the adjacent areas of Southern California seem destined for high industrial, chemical and agricultural growth.

13. The technology required for mineral recovery or chemical production is established. On the other hand, the high quality of the Golconda ores will permit the use of new processes with a minimum of development costs.

14. The timing factors are favorable. Increased metal prices are foreseen for a number of political or economic reasons. The possibility of stepwise exploitation of the company's minerals is financially attractive.

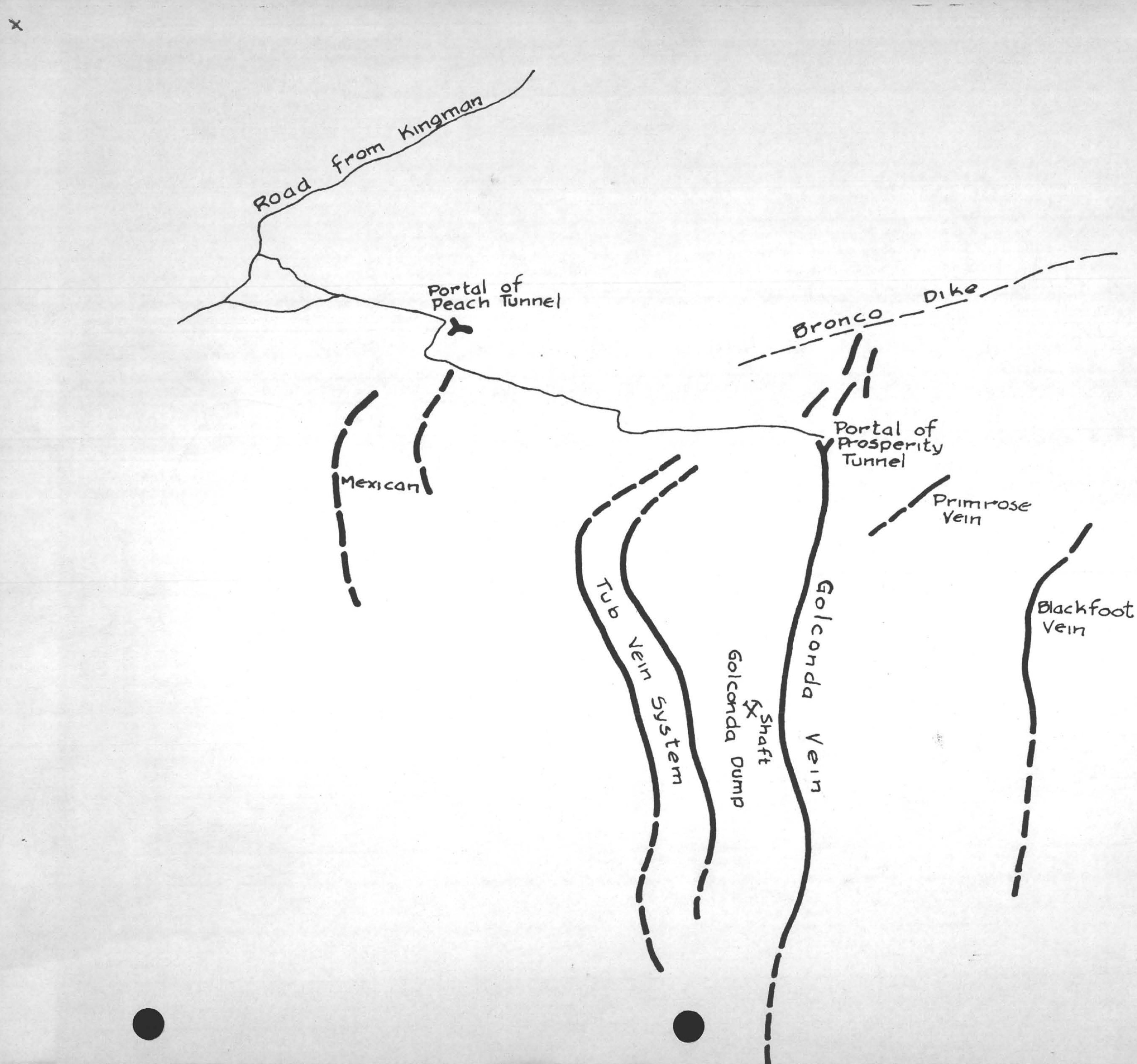
15. Golconda Chemicals Corporation possesses valuable personal property, is not involved in litigation, and has a corporate attitude favoring technical and business innovations.

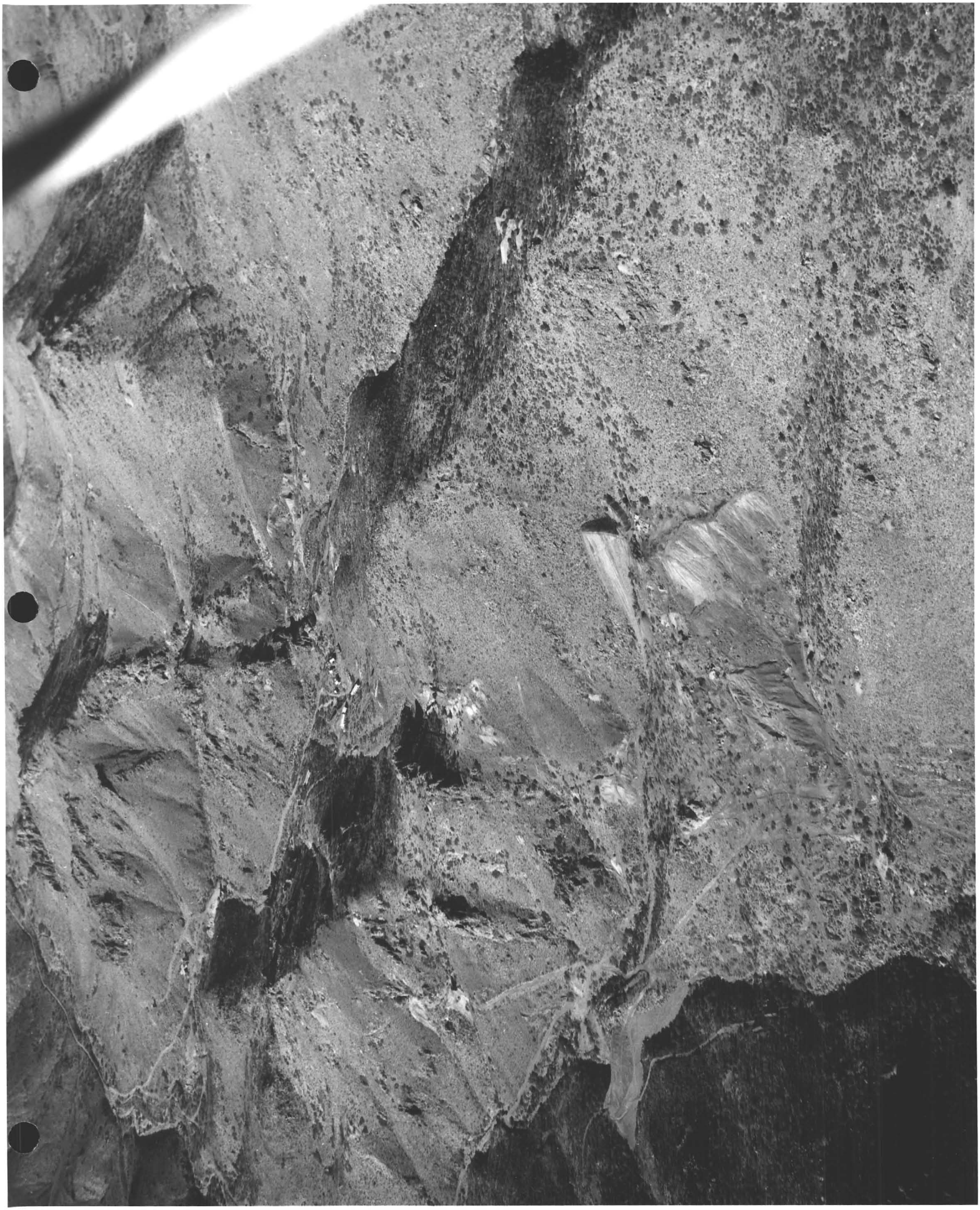
Aerial Photograph

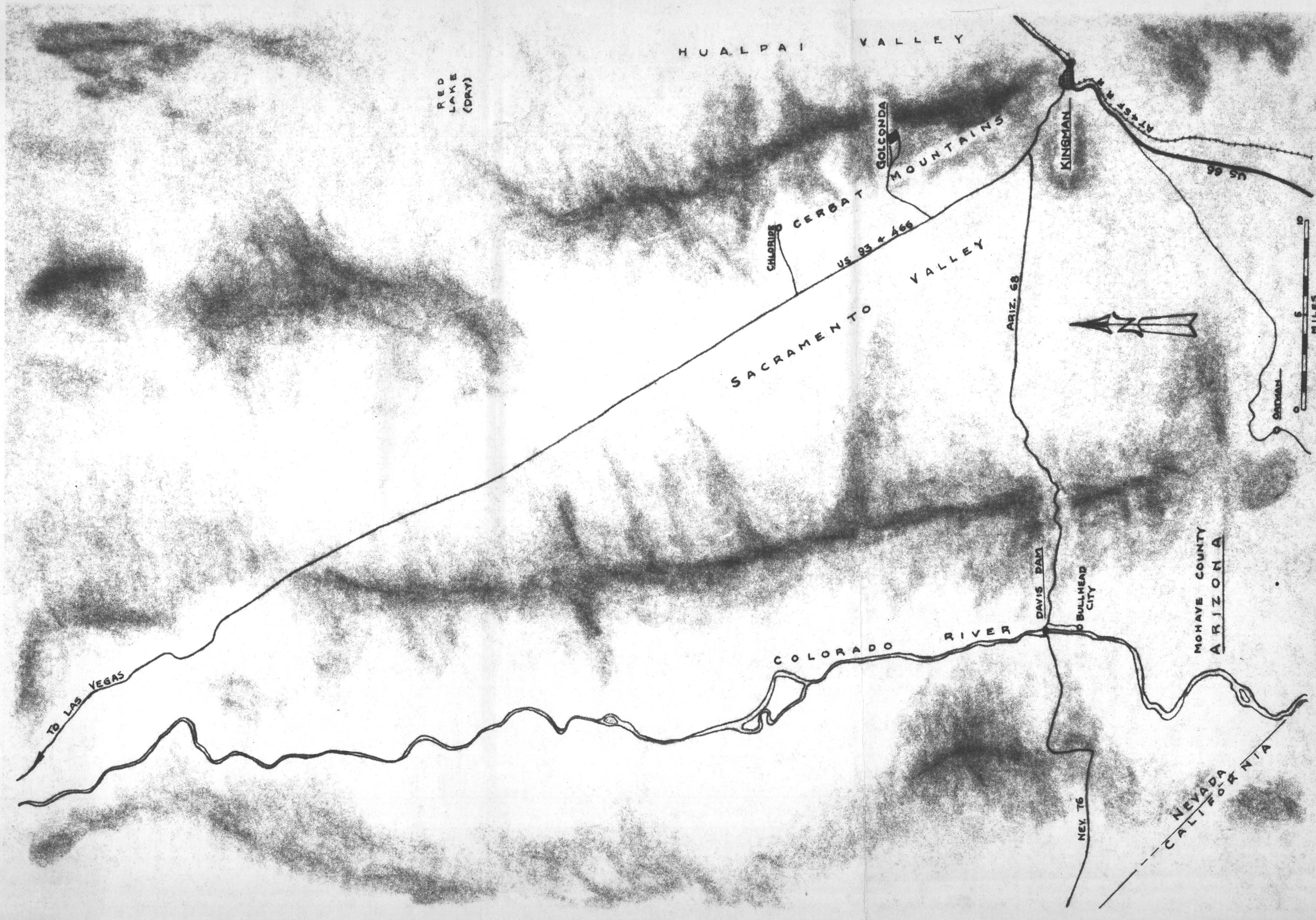
of

Golconda Properties

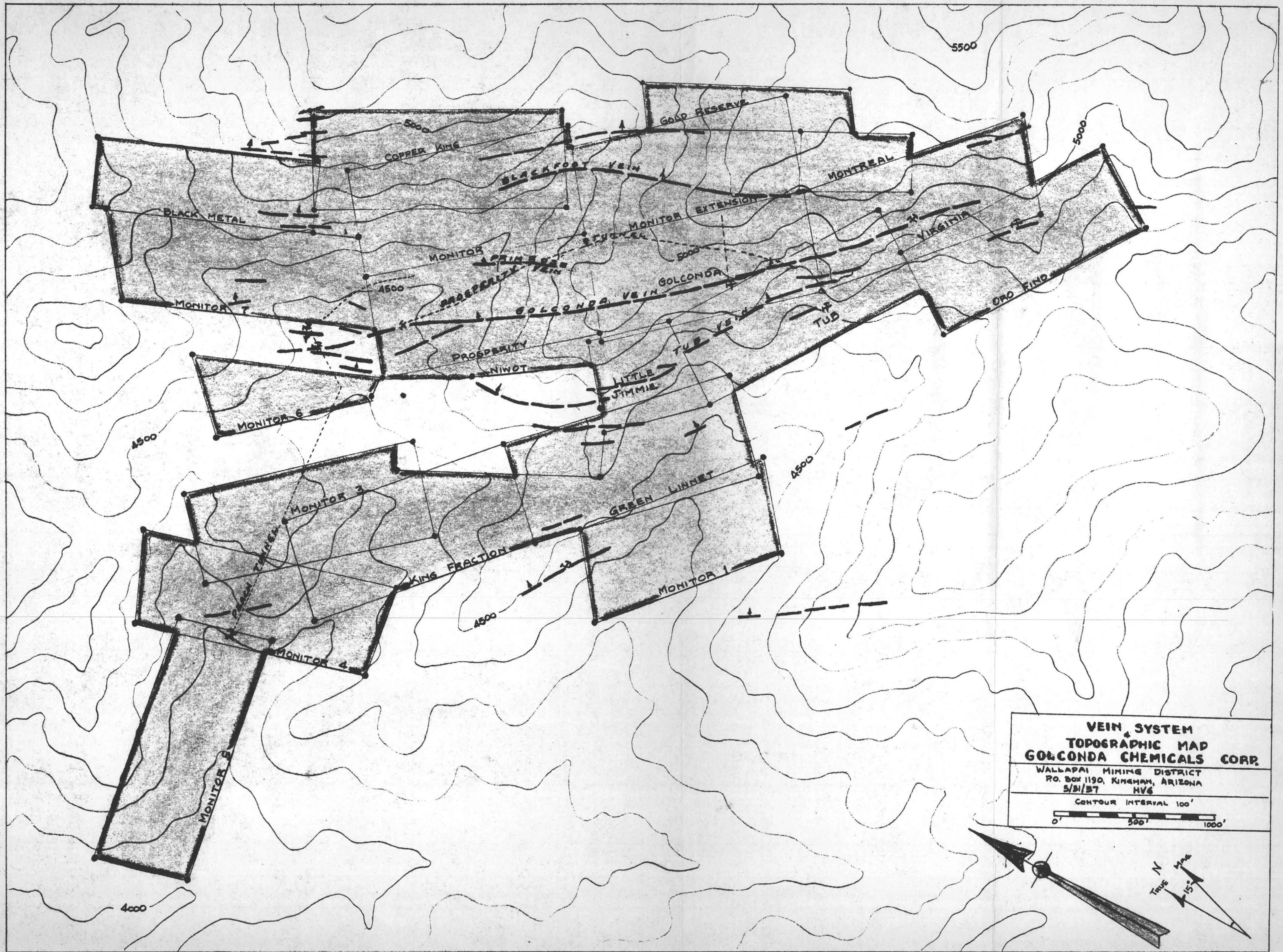
Immediately following is an aerial photograph of the Golconda area. On the opposite page is a drawing which should be compared with the photograph in order to illustrate the location of important items in the photograph.


x
Road from Kingman
Portal of Peach Tunnel
Bronco Dike
Mexican
Portal of Prosperity Tunnel
Primrose Vein
Tub Vein System
Golconda Dump
Shaft
Golconda Vein
Blackfoot Vein





HUALPAI VALLEY
RED LAKE (DRY)
GOLCONDA
CERBAT MOUNTAINS
CHLORIDE
KINGMAN
AT&SF RR
US 66
US 93 & 466
SACRAMENTO VALLEY
ARIZ. 68
N
OATMAN
0 5 10
MILES
MOHAVE COUNTY
ARIZONA
DAVIS DAM
BULLHEAD CITY
COLORADO RIVER
TO LAS VEGAS
NEV. 76
NEVADA
CALIFORNIA


5500
5000
4500
4000
GOLD RESERVE
COPPER KING
BLACKFOOT VEIN
MONTREAL
MONITOR EXTENSION
BLACK METAL
TUNNEL
MONITOR
PRIMROSE
PROSPERITY VEIN
VIRGINIA
GOLCONDA
GOLCONDA VEIN
MONITOR 7
ORO FINO
TUB
TUB VEIN
PROSPERITY
NIWOT
LITTLE JIMMIE
MONITOR 6
MONITOR 3
GREEN LINNET
KING FRACTION
MONITOR 1
MONITOR 4
MONITOR 5
VEIN & SYSTEM
TOPOGRAPHIC MAP
GOLCONDA CHEMICALS CORP.
WALLAPAI MINING DISTRICT
P.O. BOX 1190, KINGMAN, ARIZONA
5/31/57 HVG
CONTOUR INTERVAL 100'
0' 500' 1000'
N
TRUE
MAG
15°

FINANCIAL ABSTRACT

This section is intended only to illustrate the general magnitude of financial values, income levels and capital requirements. A later section contains more detailed financial analyses.

1. The dump ore is most conservatively estimated at 100,000 tons.

   The dump ore, if processed through heavy media separation and roasting operations, should provide a net profit from $3.00 to $5.00 per ton.

   Although the net return would be much reduced, a simplified processing of the dumps alone (no new ore) can be profitably conducted. Approximately $10,000 capital cost would be required to process the dump ore in this manner with an indicated net profit of $1.00 to $1.50 per ton.

2. $2,000,000 would cover the equipment and capital requirements for a mining and recovery operation with an annual profit, before depletion, and before taxes, of $1,800,000. The plant would produce oxide metal concentrates and sulfuric acid (no revenue credited to the acid).

3. The rate of return on investment is obviously governed by the final choice of capacity vs. operation costs vs. capital involved. The reference estimate of 2,000,000 tons of Golconda ore is an adequate base for exploitation. The recoverable metal and sulfur components in 2,000,000 tons represent a <u>gross</u> value approximating $100,000,000.

DISCUSSION

The basic theme justifying the development of the company's present position visualizes increased long-term values and profitability of non-ferrous minerals, particularly in the western United States. Various persons associated with Golconda Chemicals Corporation have studied the minerals and the economics of western areas for some years. These studies have uniformly confirmed, from important economic standpoints, the profit potential and competitive security of high-quality zinc reserves in accessible, well-located western areas.

A high-quality, non-ferrous, mineral reserve, when developed into an integrated recovery enterprise, provides a business which is of outstanding merit, particularly in light of the foreseeable political and economic environment of the United States. It offers an investment safeguard against inflation and notable tax benefits. The high quality of reserves and the economic factors, which are true for the Golconda minerals, indicate a return on investment which is favorable among other major fields. The co-existence of good values of gold is also of interest with regard to any potential deflation or change in the gold policy.

The projection of excellent investment return does not require an increase in the price levels for zinc. While such an increase in lead or zinc prices would result in higher profit, the attractive investment conclusions are based on making a profit and meeting competition at the present depressed prices.

The main zinc ore bodies of the Golconda average 14 per cent zinc as the metal element. This is favorable compared to most existing, competitive reserves. New developments in northwestern United States or in New Brunswick are considered economic for zinc recovery with the ore quality lower than that of the Golconda. Of key importance, from a financial standpoint, is the presence of approximately $10 per ton of gold and silver with the zinc. This value of gold and silver should equal the mining and development costs at the Golconda.

Since the ores are sulfides, the Golconda can produce low cost sulfuric acid. The ores have no troublesome characteristics from a technical standpoint. The production of sulfuric acid as an adjunct to the manufacture and sale of concentrates in oxide form enables the Golconda project to offer sulfuric acid of exceedingly low cost for Arizona and Southern California consumption. Ignoring markets outside the State of Arizona, the availability of sulfuric acid is a cornerstone for future chemical/agricultural operations in Northern Arizona. The industrial and population growth, and particularly the higher demand which should later be experienced for fertilizer phosphates and nitrogen in Northern Arizona, will demand drastically increased amounts of sulfuric acid. The land areas adjacent to the Golconda are now experiencing important water discoveries. The advent of agricultural and industrial operations, sufficient to require much larger quantities of sulfuric acid and associated chemicals, seems in the near future. Southern Arizona is now a populous area, with a relatively heavy concentration of industry and agriculture.

It is definitely visualized that one feature of the Golconda program would be the production of sulfuric acid for use in agricultural and industrial chemicals. The mining of Golconda ores, followed by concentration and change to the oxide form, through a sulfuric acid system, will provide (1) low cost sulfuric acid and (2) profitable return on the sale of metal concentrates in oxide form.

As is discussed elsewhere in this report, there are a number of stepwise process procedures which could be undertaken in sequence if this is of benefit from a financial standpoint or pending the final design for an integrated operation. For example, ore dressing facilities, plus a heavy media concentration system, can be introduced and will provide a profitable return. These metal concentrates, as sulfides, would be shipped to outside smelters. The next additional step would be the introduction of the roasting plant and sulfuric acid facilities. These additions would notably increase the return on investment and the return per ton of ore mined. The roasting process, and the production of sulfuric acid, results in metal concentrates in the oxide form. The concentrates are then higher in metal content, and the oxides of iron are magnetic thus permitting economic removal. A next step is the addition of facilities for the recovery of primary metals, the recovery of gold and silver, and probably the production of zinc oxide.

At any step in this sequence, direct and profitable recovery of the dump ores can be obtained. Because of their relatively high concentration of gold and silver and zinc, they will be the source of much revenue. Being above ground, it would only require approximately $1 per ton to prepare and deliver them to the recovery facilities. Generally speaking, they range between $4 and $5 per ton in gold and silver, and between 5% and 6% zinc. There are also revenues to be obtained from the chats (partially processed ore) which exist on the properties.

The residue tailings from the 1917 operation of the Golconda are concentrated in one area and are accessible. Conservatively, the tailings represent one quarter of a million tons, and there is strong evidence that little processing would be required to produce a salable product for direct use in western soils. There is not now available what might be termed an average analysis for these tailings, but confirmation has been obtained by the samples thus far procured that important values of iron sulfides do exist. Ferrous iron is in the tailings, along with the ferric iron, and this is an important feature in its agricultural use. Similarly, the existence in the tailings of smaller quantities of zinc, copper, manganese, etc., would give to the soil these so-called trace elements which are important to commercial crops.

While the Golconda properties are, in themselves, adequate reserves for a metal recovery system, an integrated recovery plant could undertake a profitable custom recovery business. There are a number of smaller mines in the area which could be reactivated if the Golconda supported the project by its large reserves. Along these lines, it is noteworthy that the Golconda Chemicals Corporation also has the ability to acquire some additional reserves which, while limited in amounts, do represent profitable ore.

The program of the Corporation envisions the possibility of possessing the most efficient processing in the industry. In an effort to obtain this end result, Golconda Chemicals Corporation is prepared to undertake cooperative technical development programs which may use the Golconda mineral assets for semi-commercial or experimental procedures. It is important to observe that the development of new technology is not at all necessary for the Golconda minerals since profit can be made using existing processes, due to the high quality of the ore. The Golconda ores are undoubtedly of unusual quality, but they are, nevertheless, representative of the complex sulfide ores upon which future world-wide exploitation for non-ferrous metals will be made. A good reference in support of this point is the work under way in the New Brunswick area. Accordingly, technical process developments which originate from the Golconda program could be licensed on a world-wide basis.

Confirmed by engineering studies, development work, and actual operation, the minerals in the Golconda are available with unusually low development costs. This feature, together with the availability of water and the existence of thousands of feet of workable tunnels, enables the Golconda operations to be initiated without a high financial burden which would otherwise be necessary to establish new ore and points of access.

The reference estimate of 2 million tons of zinc ore is believed to be conservative. This estimate is in terms of 14% zinc and $10 per ton in gold and silver. The two million ton reserve assumes recovery only to the 3500 feet level whereas various geological factors indicate rich ores below this depth. No consideration has been given to the tonnages of ore available from other veins whose outcrops are clearly visible at the surface. This estimate also ignores such potentials as open pit mining of the mammoth Tub vein. The Tub vein is known to be 50 feet wide in places and contains 7% zinc. Because of its great width and lower recovery costs, the Tub vein may be of unusual value. The reference Golconda estimate of ore reserves also does not include the probable occurrence of other important veins within the properties containing high concentrations of lead, or gold and silver, or profitable amounts of copper.

Generally south of the Golconda shaft, where the Golconda and Tub veins do intersect, the occurrence of high lead deposits seems most likely. Similarly, the exposed veins in the Peach tunnel, while small, are high in lead content. In some tunnel areas, at the northern end of the properties, there are showings of good copper content. The geologic history of the area and some recovery operations in the past confirm the anticipated values from copper.

All the evidence points to the consistency of the large amounts of gold and silver. The investigations confirm the probable increase in these gold and silver values with increasing depth. This feature is referred only in connection with zinc recovery. On the other hand, the Blackfoot vein, and others near the Golconda, have had gold and silver contents sufficient to permit recovery even at today's gold price versus labor cost relationship.

It is a basic premise of the Golconda project that not only can its zinc be recovered profitably under any competitive conditions, but, more important, that zinc usage will grow and its economics are favorable. The West Coast offers an important and profitable market for zinc oxide, metallic zinc, sulfuric acid, etc. Thus far, in the Golconda projections, no values have been assigned to manganese, uranium, or other minerals. These are being ignored in line with establishing the competitive and profitable position of the Golconda zinc ore independent of these other commodities.

The Golconda program appears competitively secure and capable of outstanding return on investment. The factors which justify this conclusion are those listed in a preceding section. The Corporation is actively interested in a number of potential arrangements for development of its assets. There are several different procedures which present themselves for consideration. These include joint ventures or cooperation in separate ventures for ore processing and the sale of sulfuric acid, investment underwriting, requirements contracts as a basis for financing, or direct financial participation by new companies in order to secure chemical and mineral raw materials. Golconda Chemicals Corporation is evaluating these avenues of exploitation and invites proposals or expressions of interest along these lines.

HISTORY AND DESCRIPTION OF GOLCONDA CHEMICALS CORPORATION

Golconda Chemicals Corporation is an Arizona corporation and was formed in April 1957.

The Corporation is now the single entity controlling the Golconda mine area, a number of important adjoining mining claims, and the personal property located on the premises. Into the company have been incorporated the technical knowledge, operating information, legal rights and the physical assets derived from the work and efforts of John S. Bagg, Howard H. Heilman, and others during the last several years.

The personal property owned by Golconda Chemicals Corporation is conservatively in excess of $25,000 in value. The tunnels which exist on the property and which are usable exceed $500,000 in replacement value.

The company owns eight unpatented claims which by location and their tunnel facilities are a necessity for the profitable exploitation of the mineral reserves, particularly those existing within the five patented and eight unpatented mining claims which are owned by Pontiac Mines, Inc. The Corporation has a lease with Pontiac Mines, Inc. extending into the year 2004 covering Golconda's exclusive use of the Pontiac claims.

The legal address of the Corporation is Kingman, Arizona, and its mailing address is Box 1190, Kingman, Arizona.

John H. Rice, 900 Wilshire Boulevard, Los Angeles, is the General Counsel for the Corporation and Frank X. Gordon, Jr., Masonic Temple Building, Kingman, Arizona, is the Resident Counsel.

The officers and directors of the Corporation are as follows:

Howard H. Heilman, President and Director
(Consulting Chemical Engineer)
609 So. Grand Ave.
Los Angeles 17, Calif.

T. F. Harms, Vice-President and Director
(Vice-President, Refiner's Marketing Co.)
Statler Center
Los Angeles 17, Calif.

H. V. Gilmore, Secretary-Treasurer and Director
(Technical Consultant)
426 Ultimo
Long Beach, Calif.

Robert S. Ray, Assistant Secretary-Treasurer
(Vice-President, Collier Carbon & Chemical Co.)
714 W. Olympic Boulevard
Los Angeles, Calif.

The total stockholders number 15.

HIGHLIGHTS OF GOLCONDA LEASE WITH PONTIAC MINES, INC.

Golconda Chemicals Corporation has a lease with Pontiac Mines, Inc. dated April 2, 1957 with the term extending to January 31, 2004.

The lease covers the five patented mining claims designated as the Golconda, Virginia, Prosperity, Tub, Little Jimmy and eight unpatented mining claims which are located nearby. The "Golconda" mining claim is that located directly on the site of the original Golconda mine shaft.

The lease requires that Golconda Chemicals pay the property taxes and perform the assessment work.

Golconda Chemicals Corporation owns eight unpatented mining claims which are adjacent to or intermingled with the 13 Pontiac Mines' claims. Those claims owned by Golconda Chemicals are required for the economic exploitation of the Golconda vein and other nearby mineral deposits. The royalty arrangement requires a minimum monthly rental of $100 to Pontiac, to which any royalties do apply. Golconda Chemicals Corporation, on production from the entire group of 21 claims, agrees to pay Pontiac a royalty of 10% of net revenue (after deduction of treatments, etc.) up to a maximum of $250.00 per month. Above this figure, a 5% royalty applies.

In the event Golconda Chemicals Corporation ceases all operations on the premises for a period of 60 consecutive months, then Pontiac does have the option to cancel the lease arrangement.

STATUS OF PROPERTIES

During 1957 the Corporation spent approximately $50,000 in the evaluation, development and the investigation of its properties and assets. This amount does not include any cost for professional services of members or associates in Golconda Chemicals Corporation. Some of the activities in 1957 of the Corporation can be summarized as follows:

1. The full corporate organization under Golconda Chemicals Corporation of all property titles, leases, ownership of personal and real property. The resolution of all litigation. The Corporation is a complete entity in direct control of its assets and possessions.

2. The acquisition, rehabilitation, and better deployment of equipment and personal property such as air locomotive, mining cars, automatic mucking machine, track, etc.

3. Studies of the economics and markets. Evaluation of the data and of the historical information resulting in confirmation of the asset values and the probable profit.

4. Assessment work has been performed for the earlier year and is also completed until June of 1959. Extensive rehabilitation of roads within the property limits was made.

5. Intensive geological studies were undertaken with equal emphasis on surface reconnaissance, underground investigation, and past operating data.

6. A number of tunnels and existing facilities were rehabilitated.

7. Track and piping were rehabilitated or installed in several thousand feet of the Primrose, Prosperity and Peach tunnels. A full sized commercial loading facility for ore was constructed at the Prosperity portal.

8. In order to establish beyond any doubt the quality of the dump ore, a commercial jig mill and table was installed. A large number of representative samples of ore from different locations was obtained. Analytical and other laboratory evaluations confirmed the minerals value and the physical character of the minerals as being capable of efficient processing by standard metal recovery methods.

9. The program of study and development in 1957 has established many features of value. In order to be specific, the text of this report refers consistently to an estimated reserve of 2,000,000 tons of ore of 14% zinc and $10.00 in gold and silver per ton. While this reserve estimate seems reasonable and firm, it does not alone convey the true picture of the Golconda properties and its assets nor does it adequately describe the

results from the 1957 activities. These can be illustrated further by the following items which further confirm the profit potentials of the Golconda assets.

A. Reserves. The estimate of 2,000,000 tons is specific. Added to this estimate must be the value represented by the accessibility factor. Many thousands of feet of tunnels exist in excellent condition providing low cost access and low cost mining. Some of these main tunnels are described in the text following, namely the Peach, Prosperity and Primrose. In addition to these, access to other areas is provided by the Bethel, Iron Door, Blackfoot, Tub, etc.

   Although the quantities are indeterminate, some of the earlier mining emphasized the removal of only the veins of highest gold and silver. Accordingly residual veins do exist containing other important mineral values.

   Adequate water does exist and even reservoir capacities are now available. The tunnels throughout most of the Golconda properties are outstandingly safe, requiring little maintenance. The large portion of the important tunnels do not require timbering. The appearance of other major outcrops, the potentials of higher copper deposits in some locations, the recovery of high gold and silver from the Blackfoot, all of these are additive to the reference estimate of reserves.

B. Peach Tunnel. This tunnel is rehabilitated for some 3500 feet and is in excellent condition. During the last 500 feet it provides access to the Golconda vein north of the original Golconda shaft. Depending on the exact amount of drifting from the original Golconda shaft, the Peach tunnel face may be from 400 to 800 feet from the original Golconda mine workings. The original reason for the Peach tunnel was to provide a low cost transportation tunnel for recovering the blocked out ore in the lower levels of the original Golconda mine.

   Perhaps the Peach tunnel will ultimately be used for transportation from the lower levels (it is at the 1000 feet level). It also offers immediate access to mining the Golconda vein from the last 500 feet of the tunnel. There also exist strikingly high quality small lead veins in the Peach tunnel.

   The Peach tunnel requires no further rehabilitation whatsoever and it is excellently ventilated.

C. Prosperity Tunnel. Early in 1957 the Prosperity (600 feet level) tunnel was open for only some 900 feet. Beyond this point two major cave-ins existed representing in themselves some 500 feet of tunnel length. Since the

Prosperity tunnel was known to have reached the Golconda shaft, it became important to determine the ore structures within it and also to determine that it was capable of being reopened to the shaft without unreasonable cost.

The Corporation in 1957 reopened the Prosperity tunnel to a point approximately 1650 feet from its portal. Due to the unusually high mineralization within the last 500 feet, the caved ground was extensive. Several hundred feet of timbering was necessary. This was done utilizing the best current practice so that the tunnel area is now suitable without maintenance for many years ahead. It was also determined by complete inspection that the rest of the Prosperity tunnel, while mucked up, will offer little trouble in reopening to the Golconda shaft. Direct personal investigation disclosed no difficult conditions for rehabilitation in the 300 feet from the present face of the Prosperity toward the shaft. In this additional distance, representing a total of some 1900 feet from the portal, it is known that a winze does exist. This winze will permit auxiliary access via the 700 foot level to the Golconda workings. (The Prosperity level is 600 feet.)

In the area of 1200 to 1500 feet in the Prosperity, many intermittent deposits of high mineral content exist. This may be in a fault zone or a result of the proximity of the Primrose and the Golconda veins resulting in enrichment of the minerals and the local instability of the ground. (This is the portion now fully timbered.)

Much closer to the portal of the Prosperity, three faces indicating important ore shoots were disclosed containing about 12% manganese.

The Prosperity tunnel is fully tracked and piped up to its present face and it offers several profitable alternates. It is obviously a low cost point of access to the Golconda shaft and workings. It also has deposits of minerals in the ore shoots within it. In conjunction with the Peach and Primrose tunnels, the Prosperity tunnel also provides access to many thousands of tons of ore at low development cost and without regard to recovering the blocked out reserves in the Golconda workings.

D. <u>Primrose tunnel</u>. This tunnel has been rehabilitated completely on its 500 foot level and in portions of its 600 foot level. It is tracked and piped and these facilities exist also in the crosscut between the Primrose 600 level and the Prosperity tunnel. In the Primrose 600 there is evidence of additional lenses of ore in either northerly or southerly directions which would justify development costs.

E. Blackfoot. Historically this vein provided exceedingly high contents of Gold and Silver. The original tunnels are narrow and no adequate road now exists to this site. The company has discovered the Blackfoot outcrop (beneath little overburden) at a lower elevation just a short distance up-canyon from the Primrose portal. The vein is several feet wide and even though weathered has notable gold-silver and zinc content.

F. Dump Ore. It is not uncommon to apply a value to the dump ore which is related to the value obtained in the older mining operations. It is often true, however, that the surface and shallow depth evaluations of dump ore are misleading. Inasmuch as the Golconda original ore was of such high quality it seemed likely that much of the dump ore would itself be of notably high quality compared to most other dumps. During the 1957 program, the dump ore and the chats of the Golconda were evaluated and their quality determined beyond any question. A photograph which is later enclosed illustrates part of the method used in determining with certainty the metal content of the dump ore.

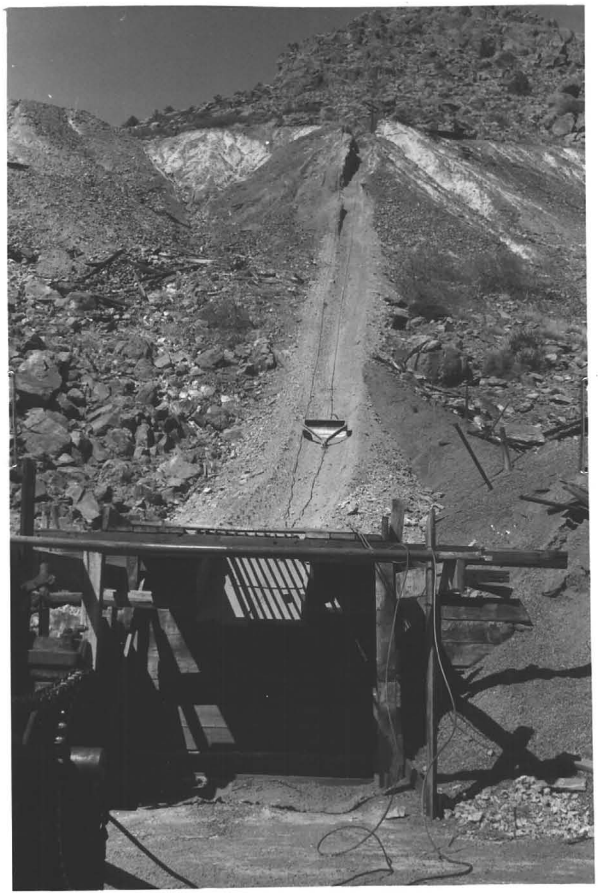
Different dump areas were cut down through the middle by a slusher. In this fashion cuts were obtained which varied from 15 to 30 feet in depth, 8 to 15 feet wide, and 50 to 200 feet long. In making these cuts, the dump ore which was removed was passed through a jig mill and sampled constantly during this operation. These methods established clearly, and as conservative, the compositions given for the dump ore and the chats in the analytical table of this report.

* * *

Facing the Golconda program is the decision as to the priority of operations, assuming that a step-wise program may be inaugurated compared to the initial construction of an integrated facility. For example, each of the potentials listed below has merit of itself and strong evidence of independent profitability.

1. Recovery of the dump ore.
2. Direct mining in the Peach tunnel.
3. Continue the Prosperity tunnel to the shaft.
4. Further crosscuts from the Prosperity toward the Primrose.
5. Mining of the Blackfoot in new areas.
6. Development of the areas south of the Golconda shaft.
7. Recovery of the Tub vein where open pit mining may be possible.
8. Recovery of ore from the Prosperity.
9. Development of further ore by drifting in the Primrose.

GOLCONDA DUMP ORE



This photograph was taken in September of 1957. It shows the method used to obtain precise knowledge of the quality of the dump ore. The bucket is being pulled down through the dumps. The dump ore thus obtained is then discharged into trucks at the loading platform illustrated. From the point of truck loading to the top of the dump is approximately 500 feet. The cut in the dumps which is shown in this picture is about 35 feet deep and 100 feet long.

CHARACTERISTICS OF THE GOLCONDA ORE

Following in this section is a table giving reference analyses for important veins, dump ore, etc.

There is no need to document further the composition of ore from the Golconda vein. The extensive, actual operations during earlier years and the valid data for these recoveries give information subject to no question concerning its quality. In addition, confirmation has been obtained by later sampling and the quality of the dump ore certifies the average value chosen for the minerals in the Golconda vein.

In connection with sampling and analyses, Golconda Chemicals Corporation engaged the Arizona Testing Laboratories in Phoenix to do most of its analytical work and to act as a referee in holding indefinitely samples submitted to it. Accordingly samples are being held under the authority of the Arizona Testing Laboratory so that they will be available for reference and the determination of other components which will later be of interest in the design of the metal recovery program.

In recognition of the fallacy of spot sampling, Golconda Chemicals installed a leased jig mill and later added a table to it. Although the equipment limitations and the high maintenance presented a difficult problem during operations, the jig mill fully performed its function. It reached the objective of providing precise analytical bases and proved the adaptability of the ore to standard separation methods. The jig mill still exists on the property.

The Primrose 600 and 700 foot levels were rehabilitated and cleaned out and facilities arranged so that ore and waste removal could be made through the Prosperity. The old stopes of the Primrose were cleaned and milling operations were conducted on the total ore and waste removed from the Primrose. This procedure resulted in the milling of much waste material. Intermittently, however, the Primrose ore quality confirmed the earlier recovery of good gold and silver and copper values in the Primrose.

Reference is made elsewhere to the occurrence of the 12% manganese ore shoots in the Prosperity and the occurrence of sporadic but highly mineralized areas in the broken up structure in part of the Prosperity.

The dumps and chats were evaluated by removal of large quantities of the material from the different piles and by processing through the jig mill.

During the course of 1957 certain other samples, usually in 50-100 pound lots, were sent for evaluation to such companies as Magma, American Smelting and Refining Co., U.S. Smelting, Bunker Hill, etc. These samples provided confirming results for those values given in the attached table and they further confirmed the satisfactory processing characteristics of the minerals.

REFERENCE ANALYSES

ORE	Gold $/Ton	Silver $/Ton	% Zinc	% Copper	% Lead	Origin
Golconda Ore	6.65	3.78	14.0	0.4	0.4	Average of 1917 Operations
Blackfoot Ore	133.00	141.00		8.7		Spot Vein Sample from Tunnel
Blackfoot Ore	8.40	7.35	28.2	0.9		Outcrop at Creek Level
Blackfoot Dumps	3.03	3.70	4.7			8 Spot Samples
Golconda Dumps	3.23	1.46	5.3	0.3	0.5	Average of Feed to Mill
Golconda Chats	3.15	1.20	6.08	0.2	0.62	Average of Feed to Mill
Golconda Dump	7.00	2.50	8.0			2-Ton Sample After Going Through 1-1/4" Screen
Golconda Dump Concentrate	12.60	7.74	27.8		3.0	After Milling Dump Ore
Primrose Ore	7.20	4.70		0.6		Feed to Mill
Prosperity Dump						0.113 U_3O_8 by A.E.C.
Peach Tunnel Lead Veins	7.00	10.21	23.0		27	Spot Samples
Primrose Ore	12.95	20.70	35.6	1.5	0.9	Average of 50-Lb. Samples of Exposed Vein - Limited Tonnage

COSTS AND PROCESSES

This section is intended only to illustrate the general magnitude of capital involvement or operating costs and revenues. Quite obviously the exact estimates for any of these costs or revenues, depend, among other factors, on the final choice of step-wise vs. integrated operations, timing, capacity, and the sales of concentrates, final metals, chemicals, or sulphuric acid. All of these will be dependent on the financial program which is derived for Golconda Chemicals Corporation. Furthermore, additional engineering evaluation and economic comparison need to be made in order to ascertain the best deployment of investment and highest return per dollar invested.

In reviewing illustrative costs it is both pertinent and interesting to refer to some of the earlier financial evaluations as prepared by independent mining engineers or consultants. One study, prepared in 1955, estimated the Golconda ore to be worth $33.00 per ton in terms of recoverable values for the zinc, copper, gold and silver. This estimate used 12¢ per pound as the zinc price. With a 10¢ zinc price and using the same premises, the recoverable value per ton would be $29.00. If we assume that $10.00 per ton will cover mining costs and development as referred to the original ore, and $8.00 to $9.00 operating costs and amortization, etc., this leaves an indicated $10.00 per ton as profit referred to the original ore. If a capacity of 400 tons per day is obtained this profit equals a revenue of 1-2/3 million dollars per year before taxes or depletion. It is likely that this profit margin per ton is realistic and conservative. It will be interesting to refer at this point to the operating and financial experience of American Smelting & Refining Company. Referring to the 4 years of 1952-55 inclusive, American Smelting and Refining Co. realized a profit of about $18.00 per ton of ore which was mined by them. During this period, the arithmetic zinc price was 11.75¢ per pound. American Smelting & Refining Co., as is true of other companies, also does custom processing upon ores delivered by outside corporations. As a matter of fact, during the reference period American Smelting and Refining Co. processed through its facilities 60% of its own ore and 40% originated from outside sources. Comparing this total tonnage processed with the income obtained, the net profit per ton of total ore processed equalled $11.00. This latter value is obviously not comparative with the proposed mining and processing of Golconda ores, but it does illustrate what might be termed a base, value and minimum for an existing major operation.

The foregoing income levels and profits per ton for American Smelting and Refining Co. become of far greater interest when it is realized that the quality of their own mining production is far inferior to that of the Golconda. For example, in 1955 American Smelting & Refining Co. mined its own ore which averaged 3% zinc, 1.7% lead, 0.7% copper, silver $2.00 gross value per ton, and gold 21 cents gross value per ton.

All of the foregoing values for American Smelting and Refining Company represent their income levels per ton before taxes, depreciation and depletion, etc.

Reference can be made to another evaluation prepared in 1955. This study estimated a 500 ton per day operation would require \$2,000,000 investment (including operating capital) and should return between \$1,000,000 and \$1,500,000 before taxes. These values indicate a profit margin of \$6.00 to \$9.00 per ton, but they involve use of dump ore.

In 1955, studies were made of the step-wise procedure for utilization of the Golconda minerals. It was estimated that the ore dressing and heavy media facilities would require \$100,000 in order to handle 400 tons per day. This study contemplated the use of only 40 tons per day of new ore and 360 tons per day of dump ore. This provided an estimate of \$9.50 cost for each ton of concentrate produced. In this projection the concentrate was considered too complex for shipment to a zinc smelter and the profit was therefore calculated on the basis of shipping to a lead smelter where penalties would be involved and no credit for the zinc. This case showed a net profit of \$10.00 per ton of concentrate with 150 tons being produced per day. It is important to recognize again that this is an operation where the material processed is contemplated to be 90% dump ore.

If the foregoing figures are modified downward to reflect lower prices of copper, etc., it would be more than safe to say that such a concentrate from the heavy media system would net back at least \$5.00 per ton of concentrate. This would give a gross revenue before taxes of \$750.00 per day. This is equivalent to a net profit per ton of material <u>charged</u> of over \$2.00. Since the charged material is 90% dump ore, this is again a confirmation of the recoverable asset value of the dump ore (in spite of the recovery of only part of the metals).

Western Machinery Company has currently confirmed the general values used above for the capital costs of a heavy media system. For example, in one instance derived for other purposes, Western Machinery provided an outside estimate of \$41,000.00 for a heavy media plant to process 200 tons of ore per day.

In Appendix A of this report are included observations by Harold V. Gilmore concerning the gross values for the components in a reserve of 2,000,000 tons. Gilmore obtains a gross value approximation of \$100,000,000 for these minerals and sulphuric acid. The latter is evaluated at commercial price and this item plus certain others require qualification, but nevertheless this illustration is pertinent when a review of the value of existing mineral assets is the motive.

Of outstanding importance in an appraisal of the Golconda program is the financial attractiveness of producing sulphuric acid as part of the process.

Current estimates from Chemical Construction Corporation, for a 400 ton per day plant, involve \$1,000,000 for complete ore dressing and concentration and \$1,100,000 for roasting and acid production. The 400 tons per day of ore would produce 100 tons per day of sulphide concentrate and this in turn would produce 100 tons per day of sulphuric acid.

Chemical Construction Corporation estimates further that operating cost up to the point of acid production would be \$3.50 per ton of ore. They estimate also, for the 100 ton acid plant, its operating costs would be \$4.80 per ton of acid produced.

The attractive feature of acid manufacture is evident. The \$3.50 per ton is a cost always involved in ore concentration and in the acid plant case it represents the cost to obtain and deliver the concentrate to the acid plant. If for purposes of illustration, we eliminate the \$4.80 per ton against sulphuric acid we would than have to apply this \$4.80 per ton as an additional concentration cost against the concentrate. If this concentrate is so charged the quality improvement which is experienced in the concentrate by virtue of roasting and acid production is realistic. Prior to roasting and acid production the concentrate exists as sulfide. Following these operations the concentrate exists in oxide form with corresponding increase in the actual concentration of zinc metal. The sulphur in zinc sulfide is approximately 1/3 of the total weight whereas the oxygen in zinc oxide is only 1/5 of the total weight. Furthermore the iron sulfide has been converted to iron oxide. Since the latter is magnetic its removal can be obtained at nominal cost with an increasing improvement in zinc concentration. Thus the removal of the iron oxide and the increase in zinc concentration, in oxide form, result in a much better settlement if the oxide concentrate is sent to outside smelters or if it would be processed in Golconda facilities. The freight charges are much reduced per ton of metal involved and similarly smelting or processing charges per ton of metal are notably reduced.

The foregoing clearly illustrates that on high sulphur ores, of the quality of the Golconda ores, a balance of capital costs and operating costs can be so assigned that the sulphuric acid can be made available at much below normal cost and yet concurrently profit can be obtained from the metals. It is this financial feature, made possible by the high quality sulfide ores of the Golconda, that makes a sulphuric acid plant outstandingly attractive. Low cost acid is thus available for sale or for use in an integrated operation by Golconda for metal recovery and the production of chemicals.

In all of the preceding discussion, approximations have been used but any possible error seems low in its degree of influence compared to the indicated profit margins. These financial estimates do demonstrate the magnitude of profit which is anticipated by comparison with existing operating companies, current capital costs, and realistic values for the metals. It should also be noted that no credit is given to the recoveries which may be possible or desirable from indium, manganese or uranium, etc.

A full analysis of the project producing electrolytic zinc, etc., is beyond the immediate purpose of this report. Although the manufacture of actual zinc or other metals may be a final decision, the various cases of producing concentrates, sulphuric acid, etc., are of more primary interest. These cases appear highly profitable and their realization does not depend on the decision to manufacture the metals. Preliminary study also indicates that the profit margin on zinc metal production will <u>not</u> be greater than in these earlier steps to concentrates and acids.

In connection with the ore processing required, a number of proven and profitable systems are available. For example, either the heavy media or the flotation systems are efficient for the Golconda ores. There exists no doubt about the profitability of standard plants for complete metal recovery on Golconda ores. In spite of the acceptability of the standard processes for the Golconda ores, another theme of the Golconda program is worthy of consideration. This visualizes that the Golconda project should strive for advances in technology resulting in higher recovery efficiencies and lower capital and operating costs. The Golconda ore reserve offers an excellent medium for such process development. The high quality of the Golconda ore gives an unusual safety factor. It can insure the success of new processes and thus permit without excessive cost the adaptation of these same processes for use on lower grade ores. The availability of improved efficiencies and lower capital costs for lower grade ores would offer a source of income from royalties on plants which could be constructed throughout the world.

There are a number of technical developments which have shown progress recently or which appear on the horizon. Some of these processes need development work but the metals industry world-wide will require process improvements to meet the competitive picture ahead wherever low grade ores are involved. For example, reference can be made to the possible use of the blast furnace method for zinc vs. retort, electrolytic, etc. Imperial in England has gone this route. A variety of leaches may be important economically and technically. In addition to the so-called acid or ammonia leaches, recent German research is based on a strictly neutral leach. This German process has supposedly almost eliminated corrosive effects. Many other process sytems have potential application for improved metal recovery including ion exchange, solvent extraction, chlorination, etc. Indeed, the entire field of so-called chemical metallurgy offers a profitable field for newcomers. The adaptation of proven methods of the chemical industry to the commercial practice in minerals seems inevitable.

HISTORY OF GOLCONDA MINE

Reference should also be made to the geological and appraisal reports by various individuals which are in Appendix A.

Briefly stated, the Golconda and Tennessee Mines produced the large majority of the metal and the dollar income from the entire mining region for its entire history. This point demonstrates the superb mineral reserves and their quality of the Golconda mine. Its production still ranks this high even though its real operating period was only approximately two years. Compared to this, the Tennessee - the other big mine in the area - has had a history of operation for many more years. The fact that it was a co-operative venture involving many individuals limited its truly proper exploitation and resulted in destructive mining and poor maintenance.

The Golconda mine produced its great volume of minerals in approximately two years. In the World War I period, its mill and accessories were destructively burned at the height of its production.

Following World War I, efforts to reactivate the Golconda were influenced by the peaks and valleys of the general economy. The entire area was influenced by the two mines; namely the Tennessee and the Golconda. The failure earlier to reactivate the Golconda, plus the limitations imposed upon the Tennessee through its being a co-operative, tended to prevent the full development of the area in spite of its extent of mineralization. It is interesting to note that in reality little fundamental knowledge did exist regarding the entire area even though it is a familiar name to mining men and even though it is written up in Government and trade literature. Major companies, for example, do in fact possess only the most sketchy information on the area. Surveys in the last three decades by Government mining groups were casual through the absence of information beyond some old production records. Speaking currently, the major mining companies acknowledge their lack of real information on the Cerbats as a mineral source. They have recognized to Golconda Chemicals Corporation that this situation exists and that the position of the Corporation and its program may well force careful study of the area by major mining interests.

The co-operative characteristic of the Tennessee and the idleness of the Golconda mine therefore were key points in preventing the installation of smelters in the area. With smelting capacity in the area or other recovery methods available, the Corporation believes the Golconda mine and its area can have a competitive position inferior to no mining location in the United States. Regarding the Golconda properties specifically, another factor beyond changes in the economy and in mining technology had an important bearing upon its failure to be reactivated. The Golconda was directly and almost continuously influenced for many years by the strictly personal situations of individuals or by legal involvement. For example, the Peach tunnel was driven by an individual named Peach and his purchase commitment for the Golconda property plus the cost of driving the Peach tunnel exceeded a million dollars. This work and program was stopped by his death.

Following World War II, the properties now encompassed by Golconda Chemicals Corporation did not exist under one ownership. Principally through the activities of John S. Bagg, the Pontiac properties and various adjacent claims were acquired by legal action or lease. At this time John S. Bagg, et al., entered into arrangements with a group known as Arizona Golconda Metals, Inc., a Delaware corporation.

Arizona Golconda Metals, Inc., possessed a lease from Pontiac Mines, Inc. for the Pontiac properties, under a royalty arrangement, but with a minimum monthly rental of $500.00 per month. A public underwriting sponsored by Baruch Brothers of New York City was undertaken in 1955. Compared to an objective of $299,000.00 the underwriting raised a gross of approximately $120,000.00. From this gross some $70,000.00 was made available during a portion of 1955 for actual development work at the mine. Even though such a limited sum as $70,000.00 was in hand, it was expended in driving the Peach tunnel several hundred feet further toward the main Golconda shaft. With the depletion of these funds, and with dissension of the principal stockholders, and with the inability to raise additional funds under the then existing unfavorable circumstances, Arizona Golconda Metals, Inc. went deeper into debt for equipment arrearages, taxes, and in failure to pay the $500.00 minimum monthly rental to Pontiac.

A series of administrative, legal and financial actions over the course of approximately 18 months resulted in the final acquisition by Golconda Chemicals of all the personal and real property, leases, etc, as described in this report.

Most of the year 1957 was used by Golconda Chemicals Corporation in the implementation of its position, development work, and the evaluation of reserves and the quality of the ores.

ECONOMIC DISCUSSION

The economics of zinc and its associated metals are self-evident as far as those of Golconda Chemicals Corporation is concerned. First, there is no longer any cheap zinc or lead in the United States. Secondly, the lowest priced competitive or foreign zinc is a threat to the highest cost zinc producer in the United States and not to the average of the industry nor to the lowest cost producer. (See Appendix B.)

The domestic zinc industry cannot fail nor cease to grow for the obvious United States necessities for the security in minerals and the industries and for political reasons. There seems little likelihood that some tariff or some subsidy will not be provided within the immediate year. The addition of 1¢ or 2¢ is critical to the highest cost zinc producers but it would be further profit to the Golconda project.

The zinc industry in Mohave County needs only adequate recovery facilities to be profitable and competitively secure vs. either domestic or foreign producers. This is the program of Golconda Chemicals - to obtain competitive and profitable recovery facilities. Reference to the expenditures for zinc in New Brunswick should show that the growth of zinc will continue and that these future demands will have to be served by higher cost zinc. Each of these major mining companies in New Brunswick is planning to meet much of the future zinc demand from these higher cost reserves in New Brunswick and which are far away from the United States markets. Similarly the Bunker Hill Company has in recent years spent millions of dollars in furthering their position in Pend Oreille Mines. The zinc reserves of the latter company are lower quality than the Golconda.

The success of a new project requires that it meet three fundamental economic factors. The success will depend on security in raw materials, know-how, and markets. Each of these three factors is outstandingly favorable in the instance of Golconda Chemicals Corporation.

A number of tables are given later in the appendix sections B, C, D. These tables show various aspects of zinc production, market patterns, etc.

Several excerpts are presented from the studies by Kerr & Co., Engineers. (Appendix B.) This company acts as a consultant and serves groups principally in investment banking houses and financial underwriters. While its reports are essentially their own independent views, nevertheless their conclusions do reflect the judgment of investment groups. The Kerr opinions then seem of unusual importance and confirmation for the Golconda program. The Kerr reports on the Zinc Industry, and on the New Brunswick area establish clearly the demands for zinc, its growth, and the inevitable higher prices for zinc.

The management of the Bunker Hill Company advised various investment groups that it held strong opinions as to higher growth rates for the zinc industry in the years ahead. These studies by the Bunker Hill Co. visualize increased growth rates for zinc, outstanding increases in the use of zinc for die casting, and an unusually high increase in per capita consumption of zinc in Europe. This latter factor in itself would have a bearing on the availability of foreign zinc regardless of tariff or political control.

In late 1957, as part of the Government conferences on lead and zinc, the Daily Metal Reporter staff painted a strong picture for the future demands of zinc, lead and copper and the inevitable increase in prices. In all, the great majority of industry groups visualize a lack of domestic production to meet a large portion of United States demands and forecast that world-wide economics will result in higher prices.

All of the discussions and evaluations of the Golconda project is based on reference to gold at $35 per oz. We see no reason for changing this basis in the evaluation of the program. Included in Appendix B is an article on gold released in August 1957 which is worthy of review. This article forecasts by 1960 one of several so-called middle-of-the-road steps which either directly or indirectly will raise the price of gold.

REGIONAL FACTORS

In Appendix C there are presented a number of tables which give data on the economy, population, etc., of Arizona.

Mohave County appears to be a good area for industrial development. Obviously the County is now underdeveloped from an industrial standpoint. Consequently the local government groups and business people will give aid and special advantages to the initial new industrial enterprises.

For industrial purposes water is not a problem and utilities are favorable or comparable to many other districts. The El Paso Natural Gas Company's pipeline is in the immediate area. While high gas consumption appears not to be a Golconda requirement, this pipeline represents assurance of its availability. The electric power rates are reasonable but no discussion will be presented in this report concerning the power rates. This latter seems an appropriate procedure since there is evidence that downward revision of rates or special rates are possible in the future following the recent Supreme Court decision that Mohave County was entitled to a portion of the low cost Boulder Dam power.

Labor supply is good and rates are low. The climate and recreation facilities, roads and transportation, are unusually favorable.

During 1957 important water reserves were discovered in the Red Lake area not far from the Golconda. These water reserves apparently are of major volume and it is believed this one development will lead to commercial agriculture in this Red Lake area within the next few years. There are also increased agricultural activities in areas nearer the Colorado River. In all, the demands of agriculture can be expected to increase at high rates in the immediate future years both in northern Arizona and in southern California. Mohave County operations also can serve efficiently certain markets in southern California.

The southern half of Arizona, particularly around Phoenix, is now an important agricultural and industrial community. Without any developments in northern Arizona, the Golconda project can serve the rapidly increasing demands of both industry and agriculture in southern Arizona. This growth in the area near Phoenix is high and the increasing sulphuric acid and chemical demands will be demonstrated from both the general industry and the agriculture there existing.

The Golconda project will be admirably placed with regard to the market for materials in southern California. The demand in southern California for zinc is another competitive feature for the Golconda location. In addition, with the continued expansion of aircraft, electronics and other industries <u>within</u> Arizona, the market for zinc for die casting and other uses will be profitable.

In passing, it should be noted that Kerr-McGee is currently undertaking an extensive drilling program in the Red Lake area. At the time of the water discoveries in 1957 in the Red Lake area, salt deposits were observed. Kerr-McGee is supposedly interested in minerals recovery "associated with salt deposits". They have leased many thousands of acres for mineral rights. While they have given royalty rights on other minerals, they have withheld any royalties based on any oil discoveries. Whether the success of the Kerr-McGee program is in uranium or potash or oil, its success (or that of other companies) will demand sulphuric acid, other chemicals, and bring further industry to northern Arizona.

APPENDIX A

GOLCONDA CHEMICAL CORPORATION

ESTIMATE OF ORE RESERVES *

		Tons	Tons
Primary Ore Blocked Out:			
Golconda Ore Shoot	900-1400 foot level	80,000	
Primrose	500-700 foot level	9,000	
			89,000
Probable Ore:			
Golconda	1400-2500 foot level	220,000	
Prosperity	900-2500 foot level	80,000	
Tub	700-2500 foot level	180,000	
Tub-Golconda Intersection	500-2500 foot level	400,000	
Blackfoot	0-1800 foot level	180,000	
Primrose	700-2500 foot level	81,000	
			1,141,000
Possible Ore:			
Golconda	2500-3500 foot level	200,000	
Tub	2500-3500 foot level	200,000	
Primrose	2500-3500 foot level	50,000	
Blackfoot - extension of vein		200,000	
Undeveloped ore shoots in Peach and Prosperity tunnels		120,000	
			770,000
Total Primary Ore:			2,000,000
Dump Ore - approximately 6% Zinc			40,000 Min.

It is to be noted that a depth of 3500 feet has been arbitrarily set. This has been selected merely as a prudent limiting figure. There is no evidence to indicate that this is the limit - to the contrary, with values increasing at 1400 feet, the depth to which mining may be extended will most likely be limited by factors other than the value of the ore.

* Prepared by H. V. Gilmore

GEOLOGY

The property controlled by the Company is over 400 acres in extent and consists of 21 claims of which 5 are patented. It is located in the Cerbat Mountains and is approximately 15 miles north of Kingman. The highway from Kingman to Las Vegas is about 4 miles from the property, and the main line of the A. T. & S. F. Railway is at Kingman. Henderson, Nevada, is about 65 miles to the north. Good roads to the property are maintained by the county.

The first discoveries in the area were made in 1863 by soldiers from Fort Beal which was located near Kingman. Production was slow and from the oxidized zone near the surface until after the turn of the century. The only metallic values sought for were gold and silver.

Two mines in the district, which is known as the Wallapai Mining District, have outstsnding production records and the Golconda is one of these.

The Golconda Mining Area is credited with a production of approximately 6.5 million dollars up to 1917 most of which was in a 2 year period into 1917. On October 4, 1917, a fire completely destroyed the mill. Due to material and equipment shortages at the time, rebuilding was postponed, but the mine was sold before any reconstruction work was started. Considerable work was done in the late 20's on a low level haulage tunnel, but with the death of the owner, work was stopped. Some production occurred in 1940, the extent of which is not known. A development program was started in 1955, but did not succeed in its aims. Total earlier production from the Golconda Mine is reported by the U. S. Geological Survey as:

Gold	20,752 ounces
Silver	510,180 ounces
Copper	354,703 lbs.
Lead	2,031,719 lbs.
Zinc	56,226,020 lbs.

At the time of its major operation the Golconda Mine was the largest zinc producer in Arizona.

The topography of the area is somewhat rugged with elevations from 3500 feet in the Sacramento Valley to 6973 feet at the highest point of the Cerbat Range. At the Golconda mine elevations range from 3500 to 5000 feet.

The climate, although arid, is pleasant and healthful. Rainfall is about 5 inches and snow about 1 foot per year. Temperatures are not extreme and consequently there is no difficulty in maintaining operations on a 12-month schedule. The area is subject to infrequent flash floods in the summer. The Golconda mine has a flow of approximately 35 gallons per minute and it is quite likely that this will increase with depth. Vegetation is sparse and of the desert type.

The Cerbat Mountains, in which the Wallapai Mining District is located, is a fault-block range 6 to 10 miles wide that extends northwestward from Kingman for a distance of about 30 miles. With the exception of the Quaternary alluvium, rocks in the range are igneous or metamorphic and consist mainly of a pre-Cambrian series intruded by a granite porphyry of late Mesozoic or Tertiary age. There are minor sections of Tertiary and Quaternary volcanics on the flanks of the range.

The mineralized zone covers an area of about 45 square miles. It is an elongated shape about 14 miles long that is slightly oblique to the trend of the Cerbat Range, so that it spans the range to the south but is entirely on the western side at its northern section. Mineralization appears to be associated with a period of intense earth movement during the Tertiary period at which time there was considerable faulting with the probable formation of the Cerbat Range. The dominant mineralization is base metal, chiefly iron, lead and zinc, however centrally located is a "porphyry copper" in the Mineral Park area. Considerable values of gold and silver also occur. Primary ores are sulfides and are associated with gangue minerals that are chiefly quartz and carbonates with some fluorite. Manganese occurs as the mixed carbonates - manganocalcite and manganiferous siderite.

The Golconda property is found in the southern section of the district. Mineralization is dominantly sphalerite with local concentrations of pyrite, chalcopyrite, galena and manganocalcite. Substantial values of gold and silver occur.

There are three major veins on the Golconda claims. These are known as the Golconda, Tub and Blackfoot. A fourth vein, the Primrose, appears to be an offshoot of the main Golconda. Another vein, the Mexican, cuts across one claim on the western side. Of these the Golconda is the strongest and can be easily traced for several miles. It has an average width of about 5 feet and has been opened to a slant depth of 1400 feet from the collar of the main shaft.

The Tub vein, although considerably wider than the Golconda with widths up to 50 feet, is much shorter and may be a splinter of the longer vein with a horst between the two. It traces an arc on the surface and appears to terminate at the Golconda at both ends, which are about three-fourths of a mile apart.

Little is known of the Blackfoot as it has scarcely been worked. It is parallel to the Golconda but with a steeper dip. It is reported to intersect the Golconda in depth, but the only evidence of this is a marked increase in gold and silver in the lower levels of the mine, a phenomenon that could also be due to other factors not apparent at the surface.

In addition to these veins there are other smaller veins that are probably offshoots of the Tub or the Mexican, a vein system that is found on the western side of the property.

The ore in the vein systems is not uniformly distributed but is concentrated in ore shoots of which there are at least seven on the property. Of these, the Golconda has been the one from which most of the values have been derived. It is approximately 1200 feet long, 5 feet wide and has been developed to a depth of 1400 feet. The Golconda ore shoot produced about 20,000 tons of ore per 100 feet of depth. Development work had been carried to the 1400 foot level, however stoping was still at the 1100 foot level when the fire occurred, so consequently there are about 60,000 tons of concentrating ore blocked out at the lower levels. This ore may be assumed to be equal to or better than the average. Concentrates for the last 9 months of operation assayed:

Zinc	42.12%
Gold	0.57 oz/ton
Silver	12.70 oz/ton
Iron	9.93%
Manganese	0.66%
Lead	1.38%
Copper	1.33%
Insoluble	12.13%
Concentration Ratio	3.41:1

During the last 9 months of operation in 1917, 33,786 tons of ore were mined with an average assay of 14.3% zinc going to the mill and 6% in the tailings. Reports of operations during this period tell of one high-grade body of pure sulfide ore that was 6 feet wide and 60 feet deep. Recollections of miners who worked here indicate that there were other ore-bodies such as this. It is interesting to note from these early reports that gold and silver values increased from $2.57 per ton average of ore mined in 1915 to $9.46 per ton average of 1917 ore (1917 values), - the difference being due to higher values from the lower workings. From this it appears that the lower limit of the Golconda shoot has not been approached

Also at the Tennessee increase 3 Au w/depth and value is increasing in depth. These same reports, and also surface outcrops, point to either a continuation of this ore shoot to the south or the existence of another important body of ore. This is in the area where the Tub and Golconda veins come together at the southern extremity of the Tub, a type of structure that is usually favorable to the formation of major ore shoots.

The Tub vein has been worked to a lesser extent in the vicinity of the Golconda. It has been developed to a depth of 700 feet for about 400 feet along the strike. Although widths vary from 8 to 50 feet, the ore is not in the full width. There appear to be several ore shoots on this vein.

The Primrose vein has been worked for about 150 feet along the strike and about 200 feet in depth. This is a smaller ore-body but one that may show high values in silver and copper. It is also quite possible that the Primrose vein parallels the Golconda for 1500 or more feet providing either additional separate ore or the occurrence of junction of high value.

The value of the Blackfoot vein has, both literally and figuratively, been merely scratched at the surface. The highest surface outcrop is accessible only by a trail; the ore was mined by hand-drilling, then hand-sorted and packed out on mule back. The shallow workings date back prior to 1915. The outcrop indicates excellent possibilities of an ore shoot of considerable size and value. The vein itself can be traced for better than one-half mile and is probably much longer. The lower outcrop, at creek level several hundred feet from the Primrose portal, shows all indications of being a major shoot of unusually high metal values. Whether the Blackfoot vein meets the Golconda in depth is not known, but this could be the case if judged from the steeper dip. Such an intersection would be approximately 1800 feet below the collar of the Golconda shaft, and could be a highly productive zone.

What may be an extension of the Golconda ore-body has been termed the Prosperity ore shoot. It has been mined for about 200 feet in the Prosperity Tunnel. It is of the same grade as the adjacent Golconda shoot and should carry a substantial tonnage of concentratable ore.

Several other showings of ore are found in the Prosperity and Peach Tunnels. It is quite likely that these are indications of additional ore-bodies of unknown size.

The property is developed by one main shaft of 1400 feet slant depth and other minor shafts for a total of approximately 2000 feet of shaft; two main tunnels, drift and cross cuts aggregating over 15,000 feet. One of the two tunnels is clear and in excellent shape. The other has been cleared and re-timbered where necessary for a distance of about 1800 feet. The exact condition of the shaft is not known but no cave-ins are apparent from the surface. The mine is flooded to the 650-foot level. Dewatering is being postponed pending utilization in large scale operations.

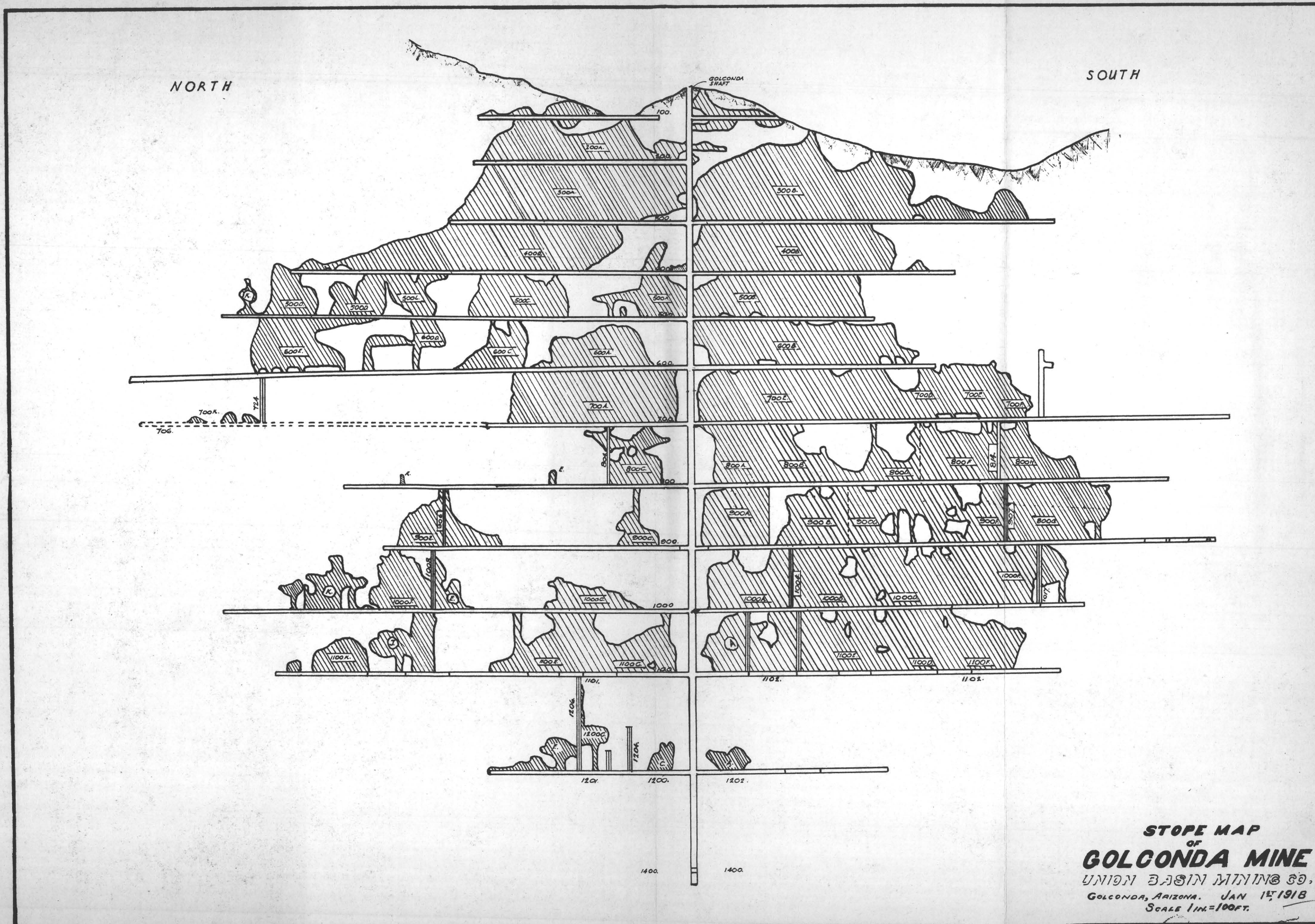

NORTH
SOUTH
GOLCONDA SHAFT
100.
200.
300.
600.
700.
800.
900.
1000
1100
1101.
1102.
1200.
1201.
1202.
1400.
STOPE MAP
OF
GOLCONDA MINE
UNION BASIN MINING CO.
GOLCONDA, ARIZONA. JAN 1ST 1918
SCALE 1 IN. = 100 FT.

ILLUSTRATION OF COSTS AND VALUES

GOLCONDA CHEMICALS CORP.

By - H. V. Gilmore

The expected recovery from 2,000,000 tons of primary ore would result in the following elemental values:

Gold	355,000	ounces
Silver	7,910,000	ounces
Zinc	243,000	tons
Lead	8,400	tons
Copper	8,100	tons
Sulfur	207,000	tons
Iron	60,000	tons

The separation of gold and silver is routine and requires no further comment, other than to note that they comprise approximately 20% of the total value and present no difficulty in recovery or sale.

Gold	355,000 ounces @	$ 35.00	$ 12,425,000	$350.00 $124,250,000
Silver	7,910,000 ounces @	$ .95	7,514,000	

Zinc has a number of interesting markets in addition to the metal - uses that consume approximately 10% of the total consumption of the metal. At 13¢ per pound the metal would return,

Zinc	243,000 tons @	$260.00	$ 63,180,000

With the exception of zinc oxide, the zinc chemicals are produced directly from the ore.

1,000 tons zinc is contained in:

1240 tons zinc oxide	(14 1/2¢/lb.)
1920 tons leaded zinc oxide	(15 1/2¢/lb.)
1550 tons zinc chloride	(10.7¢/lb.)
2480 tons zinc sulfate	(8 3/4¢/lb.)
4750 tons zinc chromate	(29¢/lb.)
3720 tons lithopone	

In a roasting process for the recovery of sulfuric acid from the basic sulfide ore, zinc would be in the form of zinc oxide, a compound that would be ideal as a starting point for the production of these chemicals.

Lead and copper tonnages are too small to warrant the construction of separate recovery equipment and would be disposed of to custom smelters in concentrate form:

Lead	8,400 tons @ $240	$ 2,016,000
Copper	8,100 tons @ $500	4,050,000

Sulfur is converted to sulfuric acid:

Sulfur	207,000 tons 634,000 tons of sulfuric acid @ $23.50	$ 14,899,000

Iron would find a ready market in western agriculture as ferrous sulfate or in paints as a pigment:

	Iron	60,000 tons - Ferrous sulfate
		298,000 tons of Ferrous sulfate @ $34.50
or:		
	Iron	60,000 tons - Ferric oxide
		77,200 tons of Ferric oxide @ $80.00

COST SHEET

Mining 2,000,000 tons @ $6/ton	$ 12,000,000	
Concentration (flotation) @ $4	8,000,000	
Transportation - Concentrates to Refinery 600,000 tons @ $1.50	900,000	
Cost of Raw Materials:		$ 20,900,000
Cost of Recovery @ $17/ton	10,200,000	10,200,000
TOTAL COST		$ 31,100,000

Gross Values:

Precious metals	$ 20,939,500
Lead and Copper	6,066,000
Sulfuric acid	14,899,000
Zinc (as metal)	63,180,000
TOTAL VALUES:	$ 105,084,500

Depletion Allowance applicable.

Los Angeles, California
March 28, 1919.

Mr. C. B. Bell,
Chloride, Arizona.

Dear Mr. Bell: Re: Sale of Golconda Mine.

In accordance with our conversation of March 26th, I am handing you herewith data on the Golconda Mine, with statements of our operations and mine and property maps.

As shown on the first statement, the Golconda Mine produced thirty-one million pounds of zinc, with gold and silver values, during the three years we operated it, for which we were paid $2,117,433.00, and received $1,761,126.00 net from the smelter after deducting freight and smelting charges. You will note a great increase in the residue (gold and silver) values; during 1915 we received $34,765.78 for residues in 13,513 dry tons shipped, an average of $2.57 per ton, and in 1917 we received $111,003.02 for residues in 11,735 dry tons shipped, an average of $9.46 per ton. This high precious metal value is a factor of great moment in the operation of a zinc mine.

A statement of our 1917 operations giving the tonnage mine, milled and produced is also attached, so that you may have actual data of our last operations up to the time of the destructive fire, which destroyed the entire milling plant and mine bins on October 4th, 1917. We immediately engaged mill designers and proceeded to draw up plans and specifications for a new mill, but after nearly three months' time, in which these plans were practically completed, it was finally decided not to rebuild the plant at that time, due to the very greatly increased cost of labor, machinery and materials brought about by the war, the uncertainty of equipment deliveries and consequent unusual length of time it would take to rebuild the plant under the extraordinary conditions at that time, the uncertainty of the spelter market and the high cost of producing spelter. It was not considered likely that mine operations would be resumed until after the war and before conditions were again normal, which it was then believed would require four or five years' time; and we, therefore, dismantled the entire mine plant and disposed of the equipment with the idea or resuming mine operations with a plant at the 500 tunnel level, instead of at the collar of the shaft, and with new and more modern equipment suitable for our mine operations.

Regarding ore reserves, we did not make any detailed estimate, owing to the fact that development work had not been sufficiently advanced, and the mine is not in shape for any one to estimate actual ore reserves. Perhpas you will understand this better if I mention that during the high price of zinc, we made every effort to produce every pound the mine could stand, sacrificing development work for the momentarily high prices of zinc, and at the time of the fire the development work was just reaching a stage where we would be able to block out larger areas than had ever been done in the history of the mine. By referring to the stope map, you will note that the shaft is below the 1400 level, thus making available 300 feet of ground below the 1100 level and we were just ready to start drifting on the 1400 level when the fire terminated operations.

In line with former ore estimates, we based our conclusions of ore reserves on the continuance of the ore zone and past operations of the mine, which had been borne out by our results. The Golconda vein has produced about 20,000 tons of concentrating ore for each 100 feet of depth, along the vein below the 700 level, using this basis for the ore zone opened for more than 300 feet below the 1100 level, there should be 60,000 tons of concentrating ore in the stoping zone along the Golconda vein above the 1400 level. The Tub vein also offers attractive possibilities, and while it is true that we did not work along this vein during the last year of our operations, our final study of this vein (when we had more time for such investigations after the fire) lead us to believe that the Tub workings of the 700 level were unattractive due to being in a fault zone which closely follows in dip and strike the course of the Tub vein. Further development of this vein will undoubtedly show a continuance of the large ore-bodies opened above, also an extension of the Golconda vein southward beyond the intersection with the Tub fault shown on the 700, 800, 900, 1000, and 1100 levels.

As far as ore reserves are concerned, when we took over the property we estimated slightly over 5000 tons of concentrating ore as actually blocked out - not much more than one months' operations, but this did not discourage us as we were well aware of the previous history of the mine as far as ore reserve was concerned, and it is a fact that we mined at the rate of more than 4000 tons a month for nearly three years after taking over the property.

The results of development work so far on the 1200 level - the lowest level in the mine - were disappointing but not altogether discouraging as we had seen similar conditions on practically every one of the lower levels, such as the 900, 1000, and 1100 levels, and yet obtained our full quota of ore from the stoping areas above these levels. It is a singular fact that development headings all told at Golconda were rarely attractive or conducive of any great expectations of ore returns, and yet the mine has produced fully 70,000,000 pounds of zinc with gold and silver values. Against the unattractiveness of the 1200 level drifts is the fact that about 15 feet below the 1200 level a body of high grade was entered in the shaft which opened to a width of 6 feet of solid high grade ore and continued for about 60 feet in depth. This exemplifies a condition which is found throughout the mine, and the fact that these ore bodies are usually continuous in the ore zone and have only local pinches, is the reason that the entire ore zone is eventually stoped out in the operations above each level.

On the property map attached, the Virginia, Tub, Golconda and Prosperity claims are already patented. We are awaiting patent papers on the Little Jimmie claim, and the other claims have all been surveyed for patent and are now in process of being patented.

Yours very truly,

(signed) John D. Wanvig, Jr.

Supt. Union Basin Mining Co.,

Golconda, Ariz. P. O. Chloride, Arizona.

SMELTER RETURNS AND PRODUCTION
OF UNION BASIN MINING COMPANY.

Amt paid for Zinc shipped	$684,486.83	$718,640.90	$488,958.66	$1,892,086.39
Amt paid for Residues	34,765.78	79,578.12	111,003.02	225,346.92
Total paid for Metals	719,252.61	798,219.02	599,961.68	2,117,433.31
RR Freight to Smelters	130,486.82	126,708.76	99,111.34	356,306.92
Net Smelter Returns	$588,765.79	$671,510.26	$500,850.34	$1,761,126.39

TWO YEARS NINE MONTHS WORK

SMELTER RETURNS AND PRODUCTION

	1915	1916	9 Mos. 1917	Total
Amt paid for Zinc ship'd	684,486.83	718,640.90	488,958.66	1,892,086.39
Amt paid for Residues "	34,765.78	79,578.12	111,003.02	225,346.92
Total paid for Metals	719,252.61	798,219.02	599,961.68	2,117,433.31
R. R. Frt. to Smelters	130,486.82	126,708.76	99,111.34	356,306.92
Net Smelter Returns	$588,765.79	671,510.26	500,850.34	1,761,126.39
Dry Tons Shipped	13,513	13,410	11,735	38,658
Pounds Zinc Contained	10,601,501	10,689,576	9,884,829	31,175,906
Ounces Silver	106,308	130,196	149,028	385,532
Ounces Gold	4,547	6,216	6,735	17,498
Av'ge Spelter Quot. per lb ¢	11.017	11.678	9.046	10.619
Av'ge Silver " per oz ¢	50.002	67.558	79.980	

Dear Mr. Brunner:

The attached are complete copies of the statements attached to original letter to Bell in 1919 and the additional data may be useful to you. This was obtained from the copy of the original letter which I was able to find in my files. I have initial each sheet JW. Also corrections on your copy.

J. D. Wanvig Jr.

Los Angeles, California

February 26, 1935

Mr. H. B. Lawrence
Pontiac Mines, INcorporated
2007 Wilshire Blvd.
Los Angeles, California

Dear Sir:

Pursuant to your request, I herewith submit to you my report on the properties owned by your company near Kingman, Arizona.

I have made several trips to your property in the preparation of this report.

In the back of this report you will find copies of a statement by Mr. John Wanvig, Jr., to Mr. Matt Brunner, one of the directors of your company, giving the results obtained during the last two years and nine months' operations. This statement can be depended upon, and in my estimation shows that your property is potentially a better mine than it ever was in the early days.

Respectfully yours,

H. G. Humes

LOCATION: The property of the Pontiac Mines, Incorporated, is situated in the Union Basin and Todd Basin sections of the Wallapai Mining District, 17 miles northerly from Kingman, the county seat of Mohave County, State of Arizona, a town of 1,500 population on the main line of the Santa Fe R. R. The highway from Kingman to the mine is an excellent automobile road, being the main highway connecting Kingman and the Hoover Dam.

HISTORY: The district was first discovered in the '60 s by soldiers from old Fort Beale, which was about two miles northerly from where the town of Kingman is now situated.

The first production of any note started in 1908 when the property was opened up by Mr. John Boyle, Jr., the first car of ore being shipped in April of 1908. Production from then on steadily increased. In 1915, under the management of Mr. H. B. Lawrence, the mine was producing 150 tons per day, and at this time the property was sold to Mr. N. L. Amster, of Boston, and the American Metals Company of New York for $300,000.00 cash. The new owners continued operations on an increased scale and the last two years and nine months' operation netted the company $1,761,126.39. In October, 1917, a disastrous fire completely destroyed the milling plant, and due to unsettled conditions of the country during the world war, and the difficulties and uncertainties of being able to get deliveries on new equipment for another plant, operations ceased. The mine was sold to the Golconda Mining Company in 1919.

Total production is approximately $6,000,000.00. The average value of the ore since production started in 1908 has been from $20 to $26 per ton of mine run. The values in gold and silver during the last operation from the lower levels increased over 270%.

More than twenty-five mines have produced from shallow depths of 100 feet or more, down to depths of 1800 feet in the Tennessee Mine, and 1400 feet in the Golconda Mine, without reaching the limits of the known ore bodies. NB

WATER: Water for mining, milling and domestic purposes is obtained from the mine and nearby springs. There is sufficient water from the Golconda, and Peach tunnel for an operation of 200 tons per day. More water can be obtained by drilling in the nearby valley if it becomes necessary, although as the shafts have been deepened the supply has increased, and with added depth greater supply may be expected.

GENERAL GEOLOGY: The Wallapai Mining District, "Located in the middle part of the Cerbat Mountains, extending from a point just south of Stockton Hill and Cerbat to a point north of Chloride, a distance of about 12 miles. The rocks of this district are essentially of the pre-Cambrian complex, and consist of gray granite, gneissoid granite, and dark schists. They are intruded by distinctly younger masses of granite porphyry. Furthermore, they are locally cut by dikes of pegmatite, aplitic granite (muscovite granite), vogesite (syenite porphyry), minette (mica syenite) and rhyolite." The above covers the general geological formations at the Pontiac Mines, Inc. properties. (Schrader U.S.G.S. Bulletin - 340.)

VEIN SYSTEM: The deposits are well defined fissure veins of which there are two well defined main veins, the Golconda and the Tub, with a general strike of N. 40°W. and dip 60° to the northeast. There are several other veins namely the Little Jimmie, Blackfoot, Gold Reserve, Primrose, and the East and West Bethel veins. Besides these veins there is a series of cross veins in the district of little known value at present, due to the lack of development work.

The Tub vein and Golconda vein will intersect on their strike at some point in the Virginia claim. The Little Jimmie, as well as the East and West Bethel veins, seem to be offshoots from the Tub vein. The Primrose vein is an offshoot from the Golconda.

The Golconda vein has as average width of five feet and can be traced through the company's property and adjoining property for over one mile.

The Tub vein is from 8 to 50 feet wide, and has been mined to widths of 12 feet and more. It can be traced through the property for a distance of 5000 feet.

The other veins of the district, though not as large as either the Tub or Golconda, have widths from 1 to 5 feet and all have been producers, and are persistent on their strike.

ORE GEOLOGY: The primary ore is composed of mixed sulphide minerals and quartz gangue. The sulphide minerals comprise sphalerite, pyrite, small amounts of galena and chalcopyrite. The gold and silver values appear to be associated with the sphalerite. No values of any amount seem to be contained in the iron. There is very little lead and copper, the concentrates have only averaged around 1.5% of each.

Au/Ag ↓ ZNS

ORE DEPOSITS: At present there are seven known ore shoots on this property, only three of which have been mined to any extent, viz: the Golconda, Prosperity and Tub. The Little Jimmie, Blackfoot, Gold Reserve and King have been mined to shallow depths.

The Golconda ore shoot is 1200 feet long, with an average width of five feet. This shoot has produced the largest amount of ore probably due to it being developed more extensively than any of the others. It has been mined and developed down to the 1400 level and is just as strong as ever at this depth. No ore has been stoped below the 1100 level; approximately 60,000 tons are available from this level to the 1400. The last two years and nine months production from the Golconda ore shoot was $1,761,126.39 net.

The Tub ore shoot has been mined for approximately 400 feet on its strike and 700 feet on its dip and widths from 12 to 20 feet in the Golconda claim. It has not been developed below the 700 level in this section. Through the Peach tunnel the Tub vein has been opened up to a certain extent and indications point strongly to a very large ore shoot here. This point is over 300 feet lower than the section opened in the Golconda claim, and to the north over 5,000 feet.

The Prosperity ore shoot, an extension of the Golconda vein to the north, was opened up and mined to a depth of 200 feet in the Prosperity tunnel. The ore averaged from 3 to 5 feet wide and was of the same grade as in the Golconda shoot. This shoot should be found 300 feet lower down when the Peach tunnel is extended to connect with the Golconda workings.

The Primrose ore shoot has been opened up for 150 feet in length and average width of 3 feet in the Big Bethel tunnel, from a crosscut in the Prosperity tunnel, and from the Highland tunnel a vertical distance of approximately 300 feet. Very little stoping has been done in this ore shoot. There are approximately 9,000 tons here.

The other known and apparent ore shoots on this property have had very little development work done.

In the adjoining Middle Golconda, and Golconda Extension Mining Company's properties, other extensive ore shoots have been opened up and mined on extensions of the Golconda and Tub veins, or in veins that are offshoots from these veins.

Indications point very strongly to an ore shoot at the point of intersection of the Golconda and Tub veins on their strike, at about the middle of the Virginia claim.

The Primrose, Blackfoot and Gold Reserve veins should be explored by means of crosscuts or diamond drilling from the level of the Peach tunnel when it is extended in to the Golconda workings.

AVAILABLE TONNAGE:	Golconda ore shoot	- 1100 to 1400 level	- 60,000 tons
	" " "	- 900 to 1100 level	- 20,000 "
	Golconda Dump	- - -	- 40,000 "
		Total	120,000 tons
PROBABLE TONNAGE:	Tub ore shoot	- 900 to 1400 level	- 100,000 tons
	" " "	- Peach tunnel	- 100,000 tons
	Little Jimmie ore shoot	- -	- 30,000 "
	Primrose " "	- -	- 9,000 "
	Prosperity " "	- -	- 40,000 "
		Total	279,000 tons

DEVELOPMENT: The property is developed by the Golconda shaft, 1400 feet deep. The Prosperity tunnel, Peach tunnel, various other tunnels and shafts aggregating over 2,000 feet of shafts and 15,000 feet of drifts and crosscuts.

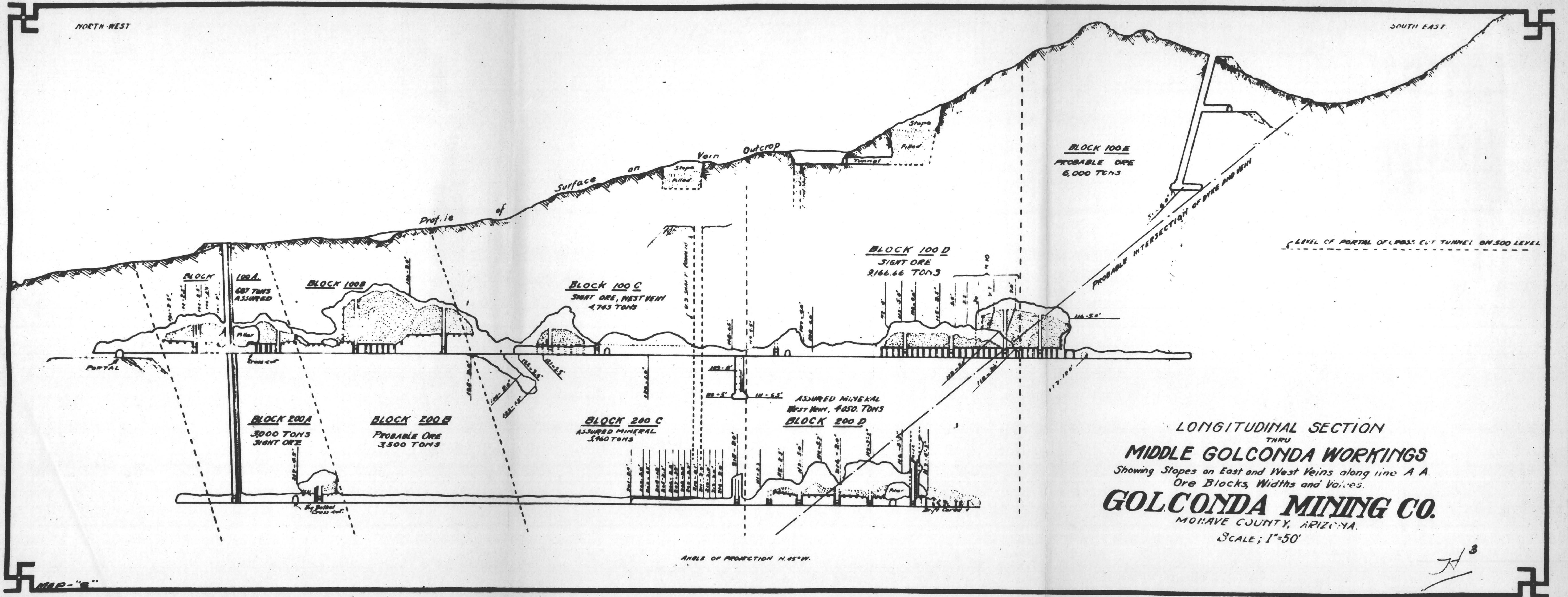
The most of this work is now available for future operations in the mining of the known and possible ore shoots.

During the last nine months' operations under the management of Mr. John Wanvig, development work amounted to 3,857 feet and produced 8,650 tons of ore. The total tonnage during this time from development and stoping operations was 33,786 tons; in other words over 25% of production came from development, which is a remarkable fact, and points to there being very little work done in barren ground.

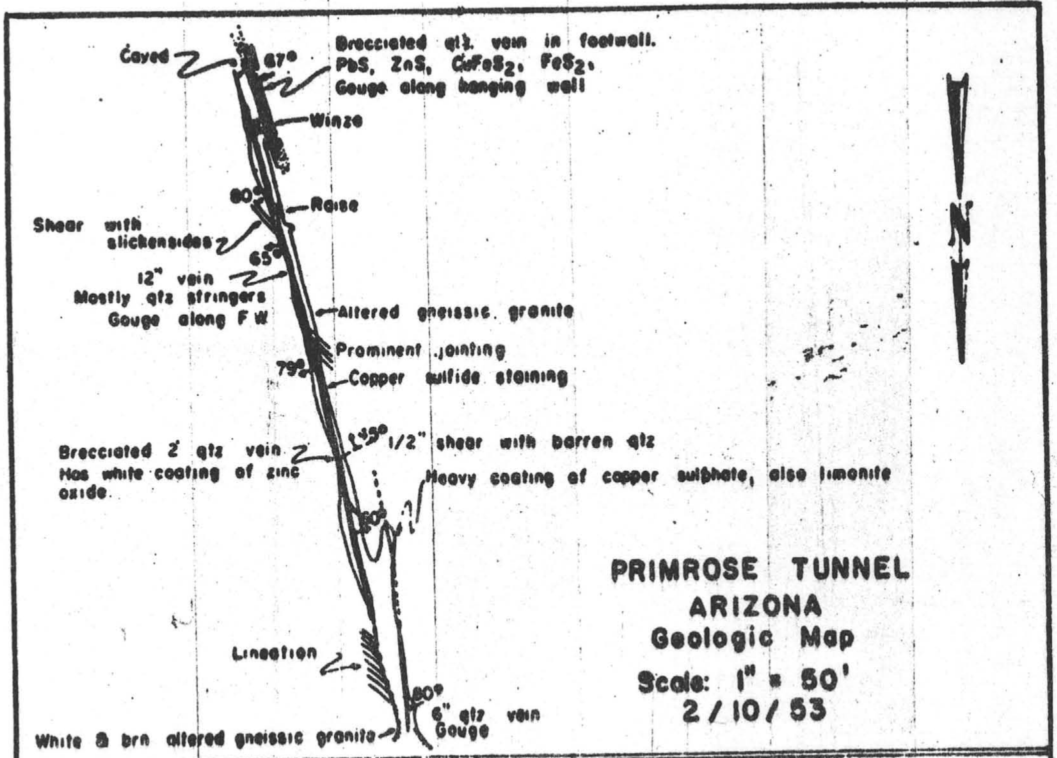
CONCLUSIONS: The ore bodies have been developed along the strike of the veins for a distance of 20 miles and down to depths of 1800 feet.

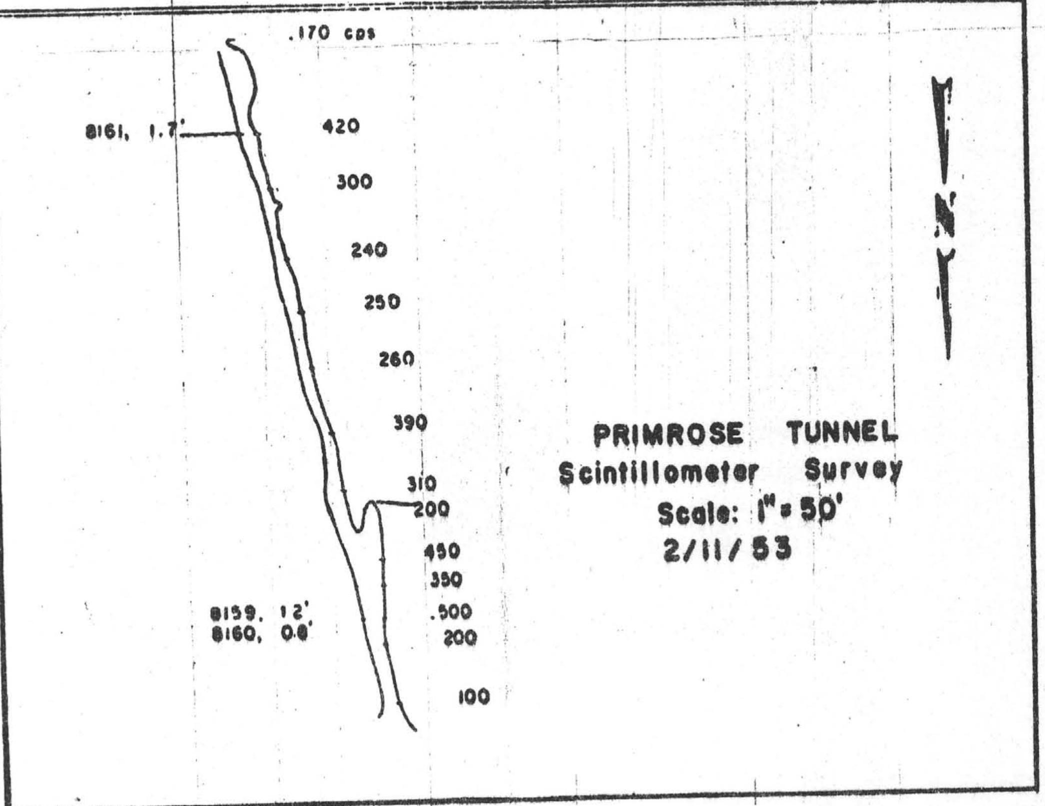
The property controlled by the Pontiac Mines, Inc., covers the apex rights of several major veins that have been developed to depths of from 100 feet to 1400 feet and at the deepest point the ore showins are equal to or better than in the upper levels. All told in this property there are seven different ore shoots and very strong indications of several more.

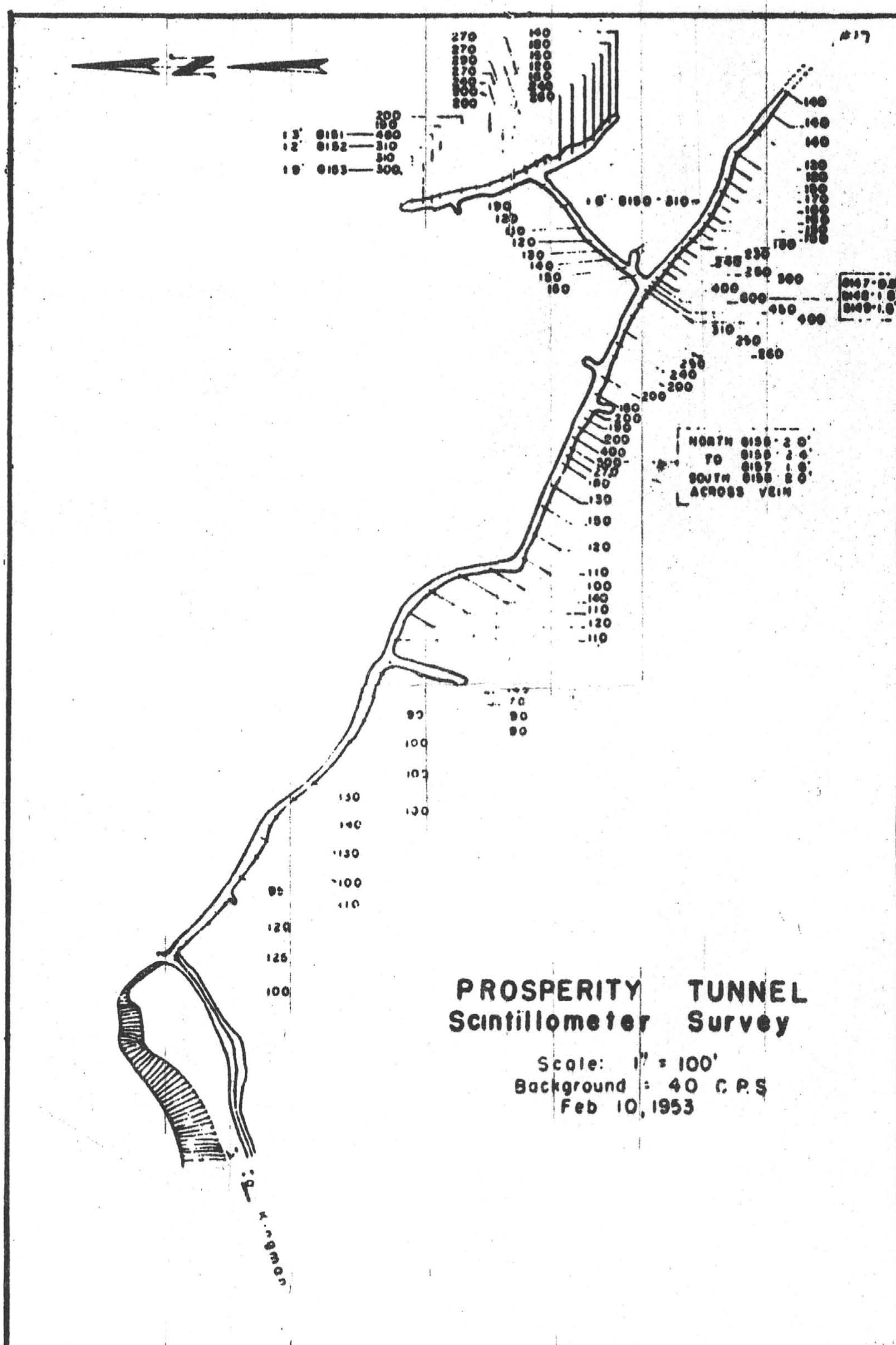
There is no apparent reason why the present ore bodies in the Golconda and Tub veins, as well as the other veins, should not go to great depth.



NORTH WEST
SOUTH EAST
Profile of Surface on Vein Outcrop
Stope
Filled
Tunnel
BLOCK 100E
PROBABLE ORE
6,000 TONS
LEVEL OF PORTAL OF CROSS CUT TUNNEL ON 500 LEVEL
PROBABLE INTERSECTION OF DYKE AND VEIN
BLOCK 100D
SIGHT ORE
9,166.66 TONS
BLOCK 100C
SIGHT ORE, WEST VEIN
1,743 TONS
BLOCK 100B
BLOCK 100A
687 TONS
ASSURED
Pillar
Cross-cut
Portal
BLOCK 200A
3000 TONS
SIGHT ORE
BLOCK 200B
PROBABLE ORE
3,500 TONS
BLOCK 200C
ASSURED MINERAL
3,460 TONS
ASSURED MINERAL
West Vein, 4050 TONS
BLOCK 200D
ANGLE OF PROJECTION N. 45° W.
MAP-"B"
LONGITUDINAL SECTION
THRU
MIDDLE GOLCONDA WORKINGS
Showing Stopes on East and West Veins along line A A.
Ore Blocks, Widths and Values.
GOLCONDA MINING CO.
MOHAVE COUNTY, ARIZONA.
SCALE; 1"=50'


Caved
67°
Brecciated qtz. vein in footwall.
PbS, ZnS, CuFeS2, FeS2.
Gouge along hanging wall
Winze
80°
Raise
Shear with slickensides
65°
12" vein
Mostly qtz stringers
Gouge along F W
Altered gneissic granite
Prominent jointing
79°
Copper sulfide staining
Brecciated 2' qtz vein
Has white coating of zinc oxide.
45°
1/2" shear with barren qtz
Heavy coating of copper sulphate, also limonite
Lineation
80°
6" qtz vein
Gouge
White & brn altered gneissic granite
N
PRIMROSE TUNNEL
ARIZONA
Geologic Map
Scale: 1" = 50'
2/10/53


170 cps
8161, 1.7'
420
300
240
250
260
390
310
200
450
350
500
200
100
8159, 1.2'
8160, 0.8'
N
PRIMROSE TUNNEL
Scintillometer Survey
Scale: 1" = 50'
2/11/53


PROSPERITY TUNNEL
Scintillometer Survey
Scale: 1" = 100'
Background : 40 C.P.S
Feb 10, 1953

APPENDIX B

KERR & COMPANY, ENGINEERS

1-23-56
SPECIAL FIELD REPORT

(Excerpts from)

PRESENT POSITION AND FUTURE PROSPECTS FOR THE ZINC INDUSTRY

One of the problems confronting investment analysts is that of evaluating the present position of zinc and its future prospects. Certain adverse developments of recent years have achieved headlines in the financial press and while the facts, as presented, are accurate, there are un-emphasized facts of the situation that require consideration. It will be recalled that only a few years ago the press released in financial papers predicted a decline for the copper industry because of fears over displacement by aluminum. Without questioning the excellent prospects for aluminum, it seemed very certain at the time that copper would continue to be essential in industry.

ZINC POSITION OF RECENT YEARS

When the Korean War started in 1950, there was a wild scramble on the part of major world powers to acquire additional zinc. Supplies were not large and heavy purchases sent prices skyrocketing to unprecedented levels. In the United States, prices at East St. Louis for prime western zinc advanced from 15¢ in July, 1950 to 17.5¢ by yearend. The price advanced thereafter to 19.5¢ in October, 1951 and stayed at this level until May, 1952. The U. S. quotation at East St. Louis was closely related to British Government prices which determined the controlled prices of home production in several countries. Non-controlled prices in 1951 included those for dollar transactions, f.a.s. Gulf Ports, which rose to about 32¢, while for soft currency transactions the price reached 38¢ per lb.

In 1950, under provisions of the Defense Production Act, the Defense Minerals Administration was established to stimulate production of critical minerals and metals needed for national defense. DMA was later succeeded, with respect to its exploration activities, by the Defense Minerals Exploration Administration and, with respect to procurement, by the Defense Materials Procurement Agency. The objective of the Defense Minerals Exploration Administration is to encourage and increase the production of strategic and critical metals, including lead and zinc, through loans to explore possible domestic sources. The Government financed up to 50 per cent of the total cost of approved exploration projects for lead and zinc. As of December 31, 1952, 151 mineral exploration projects involving lead and zinc were in force or executed.

In addition to the contracts involving lead and zinc exploration, there were some contracts for expansion and maintenance of supply of zinc calling for prices of 15.5¢ to 17.5¢ per lb. There were also loans under the Defense Production Act and numerous projects whereby Certificates of Necessity permitting fast write-offs of plants for tax purposes were approved. In Canada, Barvue Mines contracted to supply zinc concreteness to American Zinc of Illinois at 17 1/2¢ a lb. for three years.

Through various U. S. Government agencies contracts were made and assistance given to foreign zinc companies as follows: Cerro de Pasco, Peru; Zinc Nacional, S. A. Mexico; Societa Per Azioni Piombo E Zinco, Italy; Societe Anonyme des Mines de Sidi-Kamber, Algeria; Societe des Mines de Zellidja, French Morocco; Mediterranean Mines, Inc., Greece; Stolberger Zinc, Germany; Explorations Miniere au Congo, and Societe Miniere du Niari, French Equatorial Africa. A floor price development contract was signed with Volcan Mines Co., Peru, for purchase of 13,680 tons slab zinc for delivery by December, 1956, at 17 1/2¢ per pound.

Regardless of these high prices for zinc and the shortages that were then supposed to exist, a period of readjustment was on the horizon. The steel strike in 1952 hurt the galvanizing business and also helped create a temporary dislocation between supply and demand in the zinc industry. When the war ended in 1953, the large stocks of sinc accumulated in England were liquidated by dumping on the American market. Prices dropped precipitously and from a high of 19 1/2¢ in 1952 the decline contined for two years until 9 1/4¢ was reached in February, 1954. At these prices there was little, if any, profit in zinc mining in Mexico, Canada, Australia or the United States. Smelters continued to operate, however, as they took all ores offered at the market price and by maintaining volume they were able to hold losses at the smelter to a minimum.

Executive of domestic mining companies warned that the mines in the United States would have to close unless tariffs on lead and zinc were increased. They were insistent that imports should supplement but not supplant domestic production. Fifteen mines in Canada closed during 1954 and seven mines in Mexico reduced operations. All mining executives were agreed that there was too much zinc capacity in the world. But where was this capacity when it was needed in 1952? Why did the United States Government sign contracts for zinc exploration and development in Morocco, Peru, Mexico, Italy, Africa and the U.S. with 17 1/2¢ prices for zinc if there were world over-capacity?

The answer to the first question was that larger production required higher prices and the opening of marginal mines. Under war conditions, the U. S.

wanted larger domestic and free world zinc resources so it need not be entirely dependent on domestic zinc mines. Mr. Simon Straus, of American Smelting, states that the subsequent problem of excessive imports and demoralization was due to serious miscalculations of zinc requirements by Government officials. This is probably true, but it still seems evident that surplus zinc stocks were liquidated to obtain U. S. dollars regardless of replacement costs, and that the basic supply-demand situation was obscured by abnormal purchasing programs and sudden changes in anticipated wartime demands.

As far as the Free World is concerned, the major countries with producing mines are the United States, Canada, Australia, Mexico, and Peru.

ZINC CONSUMPTION (Short tons)*
(000's omitted)

	1947	1948	1949	1950	1951	1952	1953	1954	% Increase 1947-54
U. S.	786	818	712	967	934	853	956	876	11.45
Canada	51	47	41	54	61	52	51	46	-9.80
Mexico	7	5	8	10	18	10	9	12	71.42
Europe	641	639	680	729	784	731	719	956	49.14
India	34	32	33	27	30	27	24	29	-14.71
Japan	38	47	52	57	70	75	95	113	197.30
Africa	11	14	13	17	17	14	15	15	36.36
Australia	50	46	50	52	53	57	66	71	42.00
Satellites*	84	101	99	100	100	111	125	143	70.20
Total	1,724	1,774	1,713	2,047	2,102	1,960	2,120	2,307	33.81

The leading mines in these countries are well known and of major importance in supplying the largest proportion of the world's zinc. Metallurgical plants for treatment of zinc ores in retorts or by electrolytic processes are located mostly in the United States, Canada and western Europe. Thus, plants in the United States account for 33.3 per cent of the world's slab zinc production and 44.8 per cent of electrolytic zinc output. While the United States cannot supply all of the ores needed for its smelters, it still produces a large proportion of annual requirements whereas leading metallurgical plants in Europe are almost entirely dependent on imports. The largest zinc consuming nations are the United States, United Kingdom, Germany, France, Belgium and Japan.

Britain, the largest consumer outside the United States, is dependent on imports of both concentrates and metal. Only Italy, Spain and Yugoslavia have enough ore and metal production to meet home consumption. Belgium, the largest metal producer outside the United States, is entirely dependent on imports of concentrates. In Europe production is largely from horizontal retorts which recently accounted for very nearly two-thirds of total tonnage while 22 per cent is from the more modern electrolytic refineries and 14 per cent from vertical retorts.

The total capacity of zinc smelting works in foreign countries at the end of 1954 was 1,170,000 short tons of zinc (including Poland, Czechoslovakia and Yugoslavia). To this must be added electrolytic zinc plant capacity of 770,050 shorttons making a total of 1,949,050 short tons. In the United States electrolytic capacity is 425,500 short tons and that of distillation plants, 655,500 short tons or a total capacity of 1,081,000 short tons. Thus total world capacity for all plants is about 3,030,050 short tons. Many of these plants treat large tonnages of secondary material (new scrap and old scrap). It is well known that one of the major problems of many zinc plants throughout the world is that of obtaining sufficient custom tonnage ore production from controlled mines to maintain operations at a profitable rate.

Summing up, it seems very clear that declines in production in Poland and eastern Germany will be offset by new production in French Morocco, The French Congo and Rhodesia. Losses in production in Mexico due to ore depletion and unfavorable conditions are being made up by the increased output from Australia. The larger production of zinc from Canada will be needed to replace losses in production in the United States in such areas as New Jersey, Tri State and Utah.

All in all, there is no huge increase in capacity threatening the industry and each of the new ventures being developed at present-day costs will find it difficult to operate without high prices for zinc. Incidentally, despite the subsidies to increase domestic mine production with some prices for zinc as high as 17 1/2¢ per lb., the United States was only able to produce 465,245 short tons in 1954 because of the low prices, compared with 629,977 short tons in 1948.

Some of the new foreign mines are being financed by American capital. American companies are participating in many of these ventures and these mining concerns are not expected to "dump" excess supplies on our markets. While it is our view that foreign producers for the most part must have a satisfactory price for zinc and are not likely to flood our markets with any low-cost output, a higher flexible tariff, becoming effective when domestic prices drop below specified levels, is favored by most domestic mining companies.

The major zinc consumption problem in Europe is that of insufficient capacity for high purity zinc. As a result, the least developed use of zinc in Europe is die casting which is important only in the United States and Great Britain. In Europe the choice of zinc or aluminum depends more on price than in America, because wage costs are lower and the cost of the metal accounts for a larger proportion of the final price. Galvanizing is the major use of zinc in Europe. Brass (copper-zinc) is still relatively much more important in Great Britain than in the United States, but its production has been severely curtailed by shortages of copper. However, the future outlook for brass is favorable.

France, Belgium and Spain use over half their zinc for rolling. In Europe the use of zinc to repair the many old zinc roofs helps to maintain the demand. Galvanizing, unlike zinc rolling, is steadily increasing although its growth has been somewhat hampered in recent years by the steel shortages. In spite of talk of rivalry from aluminum coatings and processes for hot dip aluminizing, they do not yet show signs of becoming a serious threat in Europe.

Coating of steel with aluminum is growing rapidly in the United States. Increased consumption of zinc in Europe would quickly absorb any surplus production and a world smelter capacity of 3,030,050 short tons to meet an anticipated world consumption of 2,687,000 short tons is not believed to be excessive. With recovery continuing in Europe and the United States, a further increase in consumption should occur and the use of zinc should reach record levels.

CONCLUSIONS

1. Production at leading mines throughout the world, in such countries as the United States, Canada, Mexico and Australia, is not profitable with low zinc prices. There is no "cheap" zinc production of any proportions available in the world that is a threat to the industry.

2. Production cannot be expanded materially above 2,700,000 short tons without higher prices. World smelter capacity of 3,030,000 short tons would have to be materially expanded if production were to be increased.

3. There are huge stocks of "residue zinc" at leading smelting plants throughout the world that may some day be treated by fuming or other processes. However, much of this residue will continue to be worthless unless zinc prices were to reach unbelievable levels.

4. United States consumption has been at record levels. Consumption might rise substantially in Europe in the event a real demand develops. Moreover, the demand of Europeans for various consumers goods items such as refrigerators, vacuum cldaners, stoves, automobiles, etc. indicates that per capita consumption of sinc in Europe may be increased substantially in early future years.

KERR AND COMPANY, ENGINEER

MONTHLY RESEARCH LETTER
(Excerpt From)

August, 1957

METAL MARKET WEAK

Contrary to prevailing views throughout the world, the number of low cost mines capable of producing large quantities of nonferrous metals are limited. Mines in Peru, Canada, Mexico and Australia are announcing shut-downs due to low metal prices which tends to disprove the contentions of some observers that foreign mines can flood the markets with cheap metal. However, scrap lead and zinc from ruins in battle-scarred Europe have been dumped on the American market and are partly responsible for the recent excessive supplies in relation to demand for copper, lead, aluminum and zinc which is currently poor due to deferment of purchases for inventory. This is only a temporary situation unless the nation is entering a prolonged period of declining business activity. The outlook over the longer term is very favorable and considerably higher prices for base metals are a certainty. Otherwise there would be little incentive for leading American mining companies to allocate such huge amounts of capital for development in New Brunswick, Canada, the world's most active new mining area.

KERR & COMPANY, ENGINEERS

SPECIAL FIELD REPORT
(Excerpts From)
September 16, 1957

MINING IN NEW BRUNSWICK

The present weakness in non-ferrous metal prices indicates either: (1) The approach of a prolonged period of depression in industry or (2) A short period of adjustment such as is frequently experienced by metal producers. It is our conclusion that a serious depression is not in prospect at this time.

Here a rather unusual development of mining properties has been under way since 1954 which has created relatively little interest on the part of investors. The new developments at Bathurst were obscured by the spectacular profits reported by certain companies in 1955 and 1956, due to booming prices for copper, nickel and sulfur. However, the great mineral potentialities of the region are recognized by mining engineers throughout the world. Several American mining companies have acquired interests in the Bathurst area and are hastening in the development of their properties.

By 1960 to 1965, many of the present lead, zinc, copper camps will be depleted. The rather drab short term outlook for lead and zinc has not been deterrent to development of these new properties in New Brunswick despite the fact that present expense of equipment and refractory nature of the ores will mean that they will not be low-cost mines. The broader long term economic outlook for lead, zinc, and copper, as viewed by mining experts, is very favorable and fully justifies development of the rich, extensive but costly Bathurst orebodies.

Companies with the most important interests in the Bathurst mining area of New Brunswick are listed as follows:

American Metal Co.
(75% Heath Steele Mines)

St. Joseph Lead Co.
(40% Brunswick Mining and Smelting)

International Nickel
(25% Heath Steele Mines)

Texas Gulf Sulphur Co.
(Middle River Mng. Co.)

Anaconda
(Anaconda Co., Canada)

Billiton
(Nigadoo Mines

Kennecott
(Nipisiguit-Clearwater)

Strategic Materials
(Block 61-adjacent Heath Steele)

In this district, metallurgy is a serious problem, due not only to the very fine intergrowth of copper, lead, zinc and iron minerals, which is sub-micron in size, but also to the presence of certain products of oxidation. St. Joseph Lead has been studying the economics of various metallurgical processes for recovering the

Tennessee – Cooperative

History

B-26

Wm. H. Crutchfield, Jr.

valuable metals by furnace or chemical methods or combinations of the two. The final choice will depend not only on the metallurgical results but the capital costs involved. A measure of the importance of the project and the high regard in which it is held is the fact that St. Joe will spend such huge sums for development of these new properties.

Mining executives are in agreement that the new properties in the Bathurst area will become one of the major sources of lead, zinc and copper in the world.

Gold

B. BARRET GRIFFITH

By the time of the 1960 elections, foreign claims may equal the amount of our monetary gold reserves. Insofar as American citizens are concerned managed paper money will have completely and entirely replaced any semblance of hard money.

Twenty-five years of increasing federal budgets and spending by the political party in power has certainly established a trend, which also permeates state and local governments. High debts and increasing rates at all levels of finance may mark the approach to the limit of debt and borrowing—and indicate that we may be "borrowed up." If total direct and hidden taxes are consuming around 36% of each individual American citizen's annual income, it may indicate that we are about "taxed up." Personalizing the statistic for cost of living, most of us agree that our taxes and the cost of food have trebled within the last 25 years and we know that $20 gold pieces today cost us around $60 for our coin collections. By these measures, apparently, we have a 35 cent dollar compared to some 25 years ago. Problems arise in government finance when a high-spending nation cannot readily borrow, tax, or issue more paper money.

When studying the table, accompanying this article one could reach the easy and obvious conclusion that things are

U. S. Gold Reserve vs. Requirements and Potential Claims
1922-1956 (in millions of dollars)

End of Year	U. S. Gold Reserve	A U. S. Required Gold Reserves	B Foreign Short-term Dollar Balances	Total of A and B
1922	$ 3, 506	$ 1, 686	$ 1, 009	$ 2, 695
1923	3, 834	1, 652	990	2, 649
1924	4, 090	1, 599	1, 237	2, 836
1925	3, 985	1, 558	1, 193	2, 751
1926	4, 083	1, 564	1, 639	3, 203
1927	3, 977	1, 624	2, 591	4, 215
1928	3, 746	1, 621	2, 673	4, 102
1929	3, 900	1, 611	2, 673	4, 284
1930	4, 225	1, 562	2, 336	3, 897
1931	4, 052	1, 781	1, 304	3, 085
1932	4, 405	1, 967	746	2, 713
1933	4, 012	2, 166	392	2, 558
1934	8, 259	2, 729	670	3, 399
1935	10, 124	3, 610	1, 301	4, 911
1936	11, 422	4, 101	1, 623	5, 724
1937	12, 790	4, 170	1, 893	6, 063
1938	14, 591	5, 099	2, 158	7, 257
1939	17, 800	6, 354	3, 221	9, 575
1940	22, 042	7, 897	3, 938	11, 835
1941	22, 761	8, 310	3, 679	11, 989
1942	22, 739	9, 977	4, 205	14, 202
1943	21, 981	11, 902	5, 375	17, 277
1944	20, 631	14, 350	5, 820	21, 170
1945	21, 083	10, 868	7, 074	17, 942
1946	21, 706	10, 731	6, 481	18, 429
1947	22, 868	11, 294	7, 135	17, 212
1948	24, 399	11, 894	7, 756	19, 650
1949	24, 568	10, 753	7, 623	18, 376
1950	22, 820	11, 055	9, 222	20, 227
1951	22, 873	11, 720	9, 302	21, 022
1952	23, 252	12, 055	10, 731	22, 786
1953	22, 090	12, 151	11, 771	23, 922
1954	21, 793	11, 812	12, 923	24, 735
1955	21, 752	11, 975	13, 580	25, 555
1956	22, 058	12, 120	16, 428	28, 548

SALIENT STATISTICS OF THE U. S. COPPER,

LEAD AND ZINC INDUSTRIES

Years 1955, 1956 and First Half of 1957

The Arizona Department of Mineral Resources has just released some salient copper, lead and zinc statistics for the years 1955, 1956 and the first half of 1957. These statistics cover the United States as a whole as well as Arizona in particular.

Final figures for 1956 show a U. S. Mine production of 1,106,215 tons of copper, 352,826 tons of lead, and 542,340 tons of zinc; and for the first half of 1957, a production of 556,670 tons of copper, 177,717 tons of lead, and 286,789 tons of zinc. These figures indicate that for the first six months of this year, U. S. Mines were keeping up the high production rate of 1956, in spite of the marked drop in consumptive demand for all three metals. In the case of copper, production was kept high because of the appreciable increase in production at the San Manuel Mine, which was still not up to planned capacity. In the case of lead and zinc, the collapse in metal prices did not take place until May, 1957, and it takes 60 to 90 days for the mine production of these ores to be converted to metal.

Arizona's mine production of copper in 1956 was 505,908 tons and for the first half of 1957, it was 262,220 tons; lead production was 11,999 tons and 6,498 tons for the same periods; and zinc production was 25,580 tons and 16,641 tons respectively.

On January 1, 1956, copper was quoted at 44 cents per pound, was 46 cents in June, 1956, 36 cents in January, 1957 and averaged 30 cents in June, 1957. By Oct. 31, 1957, the E. & M. J. price was 26 cents, while producers were asking 27 cents. In connection with the present drive for a 4-cent tariff on copper, it might be noted that while domestic producers are asking 27 cents a pound for their copper, foreign producers are selling theirs for 23 cents.

Lead was steady throughout the year 1956 at 16 cents per pound, and continued at that price until May, 1957 when it began to drop, and at this writing(December 3) it is down to 13 cents.

Zinc was steady throughout the year 1956 at 13½ cents per pound, and continued at that price until May, 1957, when it began to drop until July 1st, when the price was 10 cents per pound. It has remained at this figure since the first of July.

Regarding lead and zinc, it also may be worthy of note that when domestic lead producers were asking 13½ cents per pound, foreign producers were selling theirs for less than 10 cents. In November, when domestic zinc producers were asking 10 cents per pound, foreign producers were selling theirs for 8 3/8 cents.

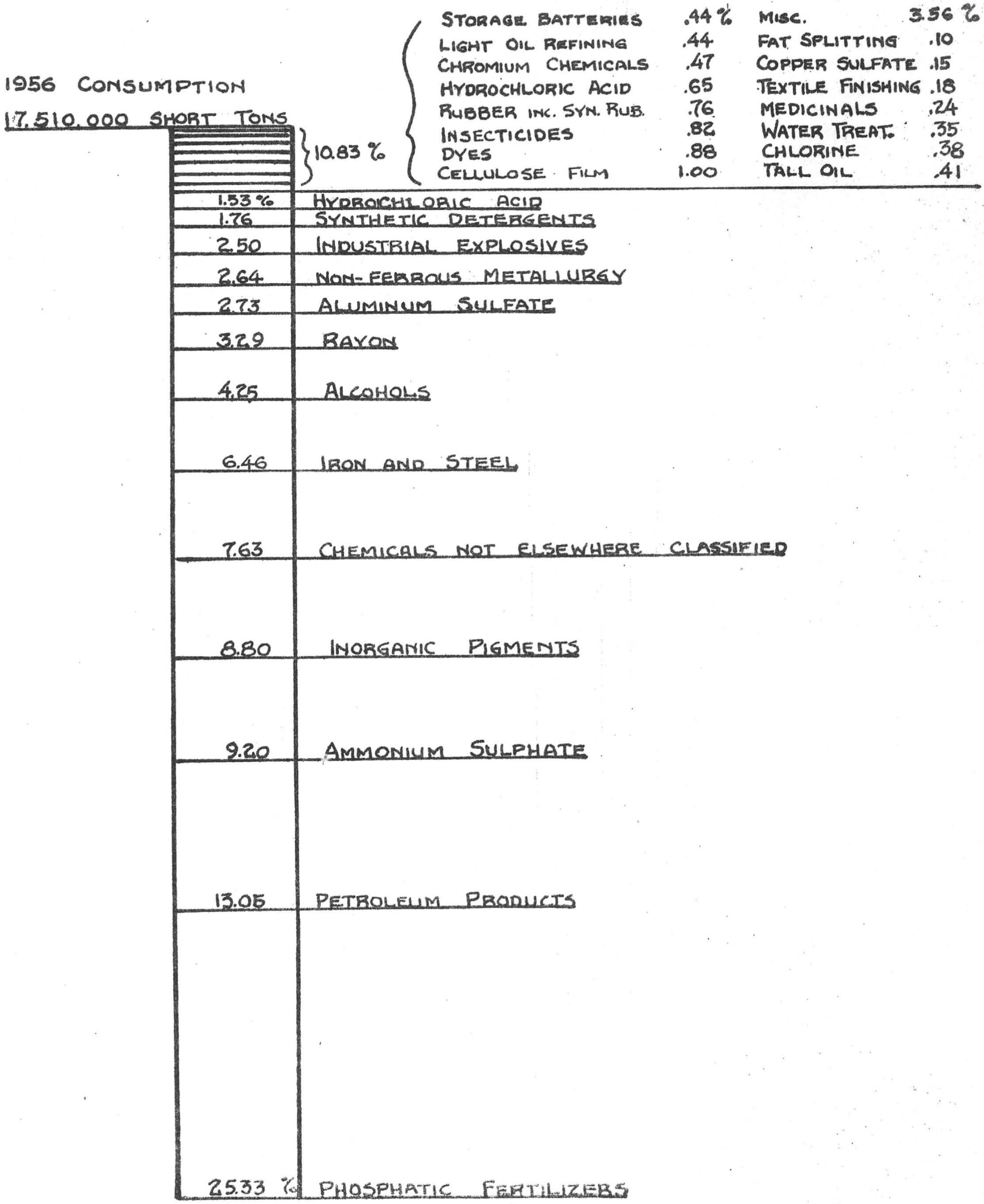
SULFURIC ACID PRODUCTION

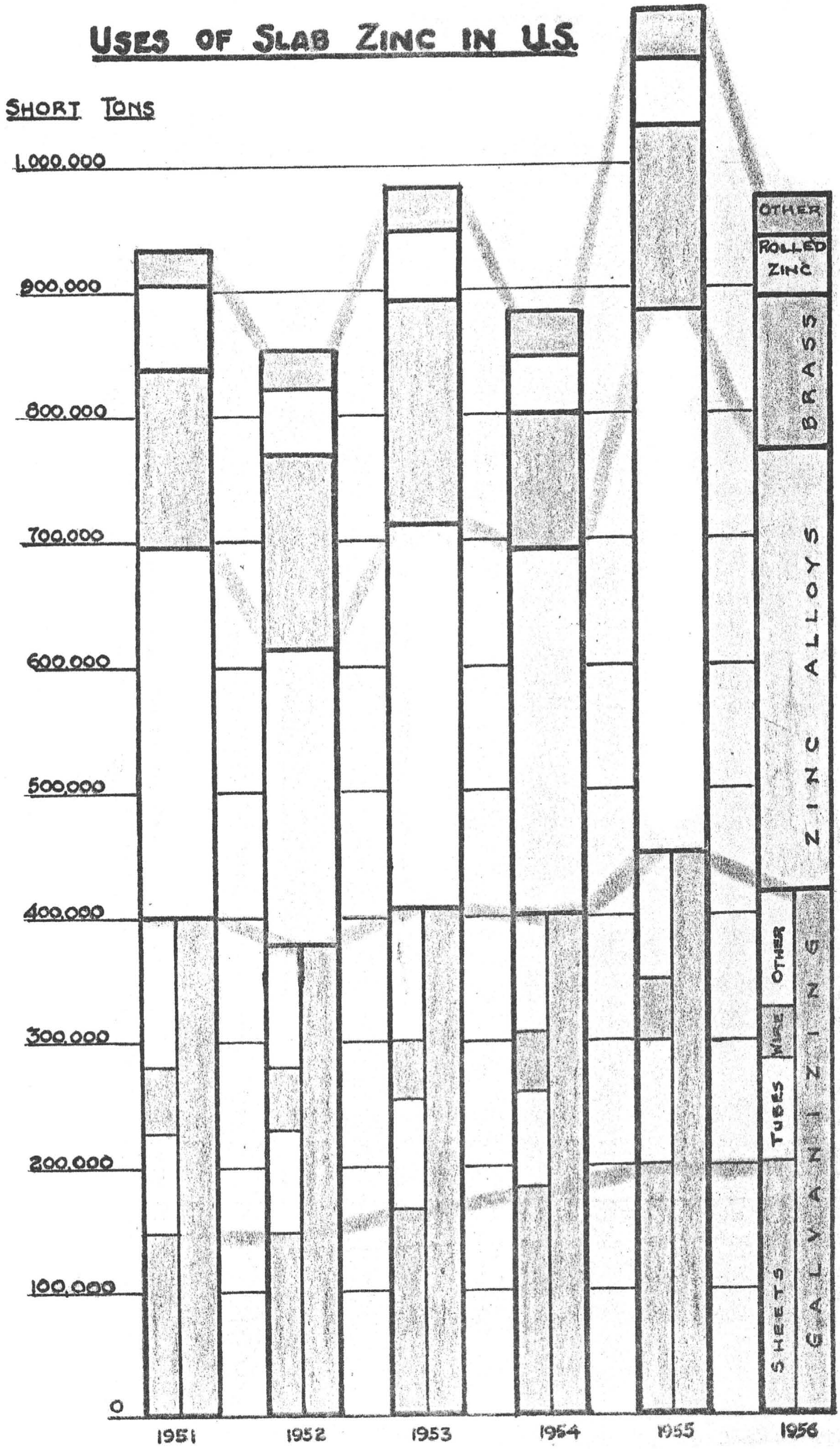
(NEW ACID)

15 737 348 SHORT TONS
1956 PRODUCTION

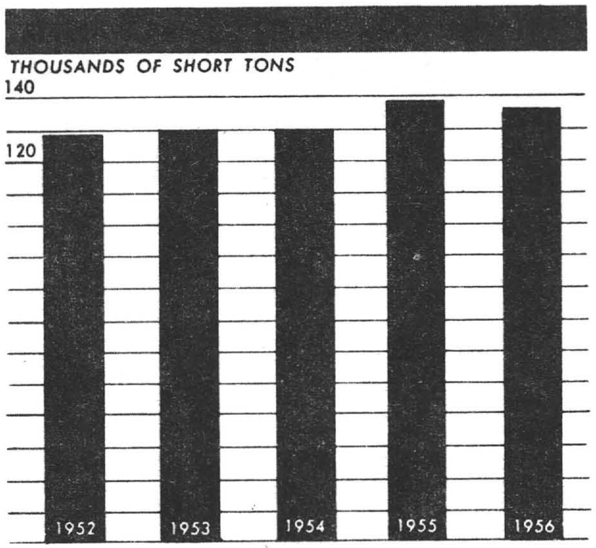
Region total	State %	States
1.3 %		NEW ENGLAND STATES
	5.2	PENNSYLVANIA
	10.0	NEW YORK + NEW JERSEY
15.3 %		MIDDLE ATLANTIC STATES
	8.1	ILLINOIS
	3.3	INDIANA
	1.4	MICHIGAN
	4.8	OHIO + WISCONSIN
	4.7	MISSOURI, IOWA, KANSAS
22.3		NORTH CENTRAL STATES
	1.5	ALABAMA
	9.5	FLORIDA
	2.2	GEORGIA
	1.8	N. + S. CAROLINA
	3.3	VIRGINIA
	6.6	KENTUCKY, TENNESSEE
	9.9	TEXAS
	8.4	DELAWARE, MARYLAND
	7.5	LOUISIANA, ARKANSAS, WEST VIRGINIA, MISSISSIPPI, OKLAHOMA
50.7 %		SOUTHERN STATES
	5.2	COLORADO, MONTANA, NEVADA, UTAH, WYOMING, ARIZONA, IDAHO, NEW MEXICO, WASHINGTON
	5.2	CALIFORNIA
10.4 %		WESTERN STATES

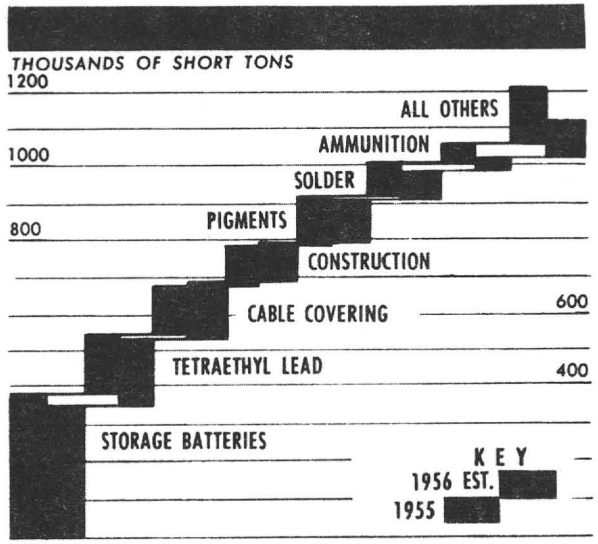
SULFURIC ACID DEMAND




USES OF SLAB ZINC IN U.S.
SHORT TONS
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1951
1952
1953
1954
1955
1956
OTHER
ROLLED ZINC
BRASS
ZINC ALLOYS
OTHER
WIRE
TUBES
SHEETS
GALVANIZING

LEAD





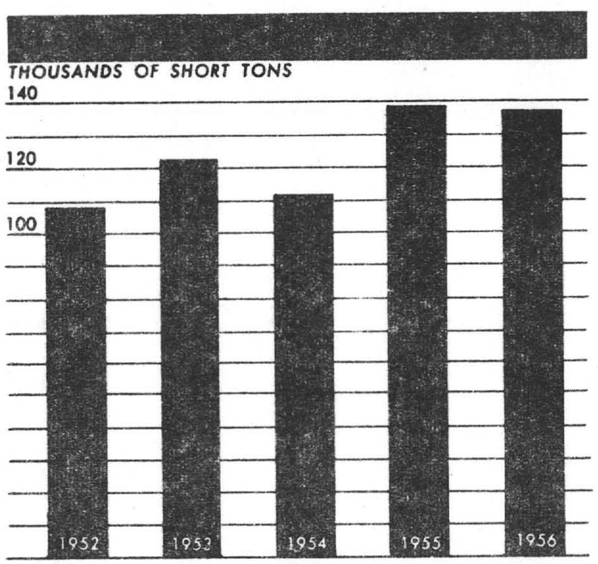
ST. JOE PRODUCTION AND SALES

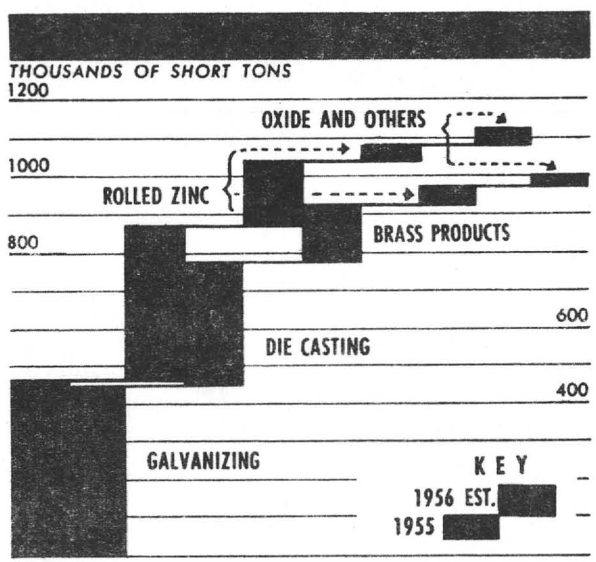
	1956	1955
	SHORT	TONS
Lead concentrates:		
From Company's mines	158,861	162,552
Purchased	44,353	43,100
Pig lead produced	137,429	138,796
Pig lead sales:		
From smelter	137,772	155,755
Purchased pig lead	61,522	56,345

Pig lead sales for 1956 about equalled output. Sales in 1955 included 17,007 tons from inventory. Note increased use of lead for cable covering as shown in diagram at left.

ST. JOE'S PRODUCTION AND NATION'S USE BY INDUSTRIES

ZINC

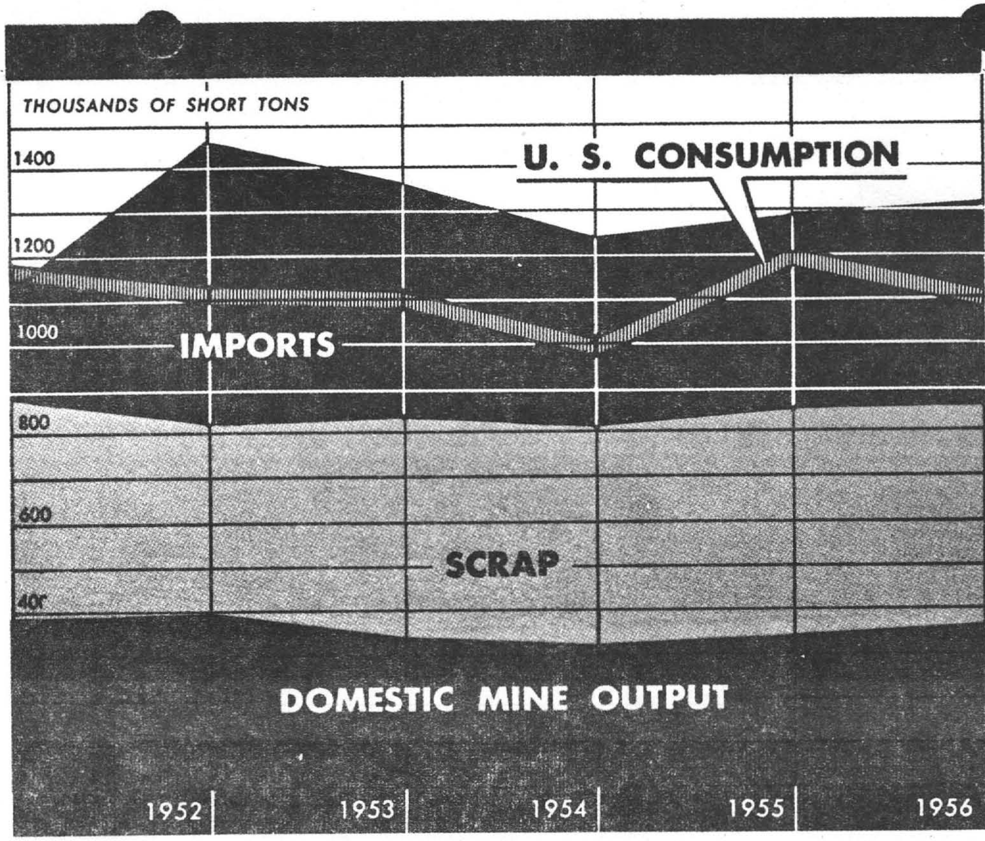




ST. JOE PRODUCTION AND SALES

	1956	1955
	SHORT	TONS
Zinc concentrates:		
From Company's mines	114,138	109,303
Purchased	126,164	111,868
Slab zinc equivalent of:		
All concentrates	146,897	134,012
Smelter production	136,879	138,201
Sales, oxide and metal	132,652	136,723
Sulfuric acid sales	190,004	183,609

St. Joe's zinc production in 1956 exceeded sales by 3,621 tons. In 1955, sales exceeded output by 1,436 tons, which came from inventory. United States zinc consumption (see diagram at left) dropped about 10.6% in 1956 as against 1955.



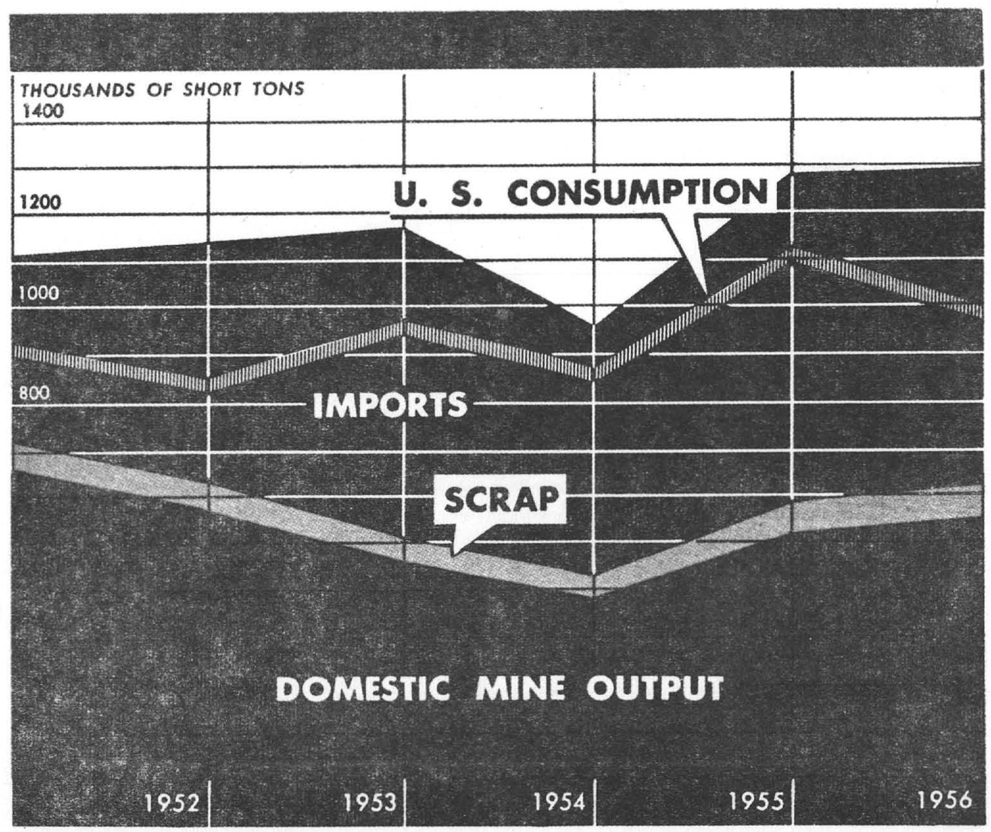
LEAD The Domestic Situation in 1956 (Est.) / 1955

	1956 (Est.) SHORT TONS	1955
From domestic mines	348,000	338,000
Scrap	500,000	502,000
Imports	478,000	471,000
From producers' metal stocks	(8,000)*	51,000
Available supply	1,318,000	1,362,000
Consumption	1,200,000	1,209,000
Surplus	118,000	153,000

*Denotes increase in stocks

ZINC The Domestic Situation in 1956 (Est.) / 1955

	1956 (Est.) SHORT TONS	1955
From domestic mines (Less zinc used for pigments)	426,000	399,000
Secondary sources	70,000	66,000
Imports	771,000	674,000
From producers' metal stocks	28,000	83,000
Available supply	1,295,000	1,222,000
Consumed and exported	997,000	1,138,000
Surplus	298,000	84,000



APPENDIX C

Value Of Arizona's Mining Output Down, Due To Decline In Metal Prices

Arizona's mining industry suffered a hard blow from declining prices during 1957 even though actual production totals were above last year's all-time high.

As it has every year since 1910, Arizona's 1957 copper production ranked first in the United States—accounting for over 47% of the domestic total. However, 1957's total production of 510,000 tons had a gross value of approximately $301 Millions while the 1956 total production of 505,908 tons was valued at $430 Millions. As one might ask, "What happened?" The answer, of course, is that a decline in copper prices from an average of 41.8¢ per pound in 1956 to 29.5¢ per pound during 1957 automatically wiped out approximately $129 Millions in gross income.

Production totals of other principal metals in 1957 also exceeded the previous year's figures. Total value of lead, zinc, gold and silver produced —despite price declines in lead and zinc prices— exceeded 1956 totals by approximately $400,000.

Arizona mineral production for 1957, including all reported metals and nonmetals, amounted to approximately $352 Millions compared with the 1956 record high of over $479 Millions. The nonmetals (primarily sand and gravel, stone, lime and cement) accounted for approximately $21 Millions during 1956 and about the same total has been estimated for 1957.

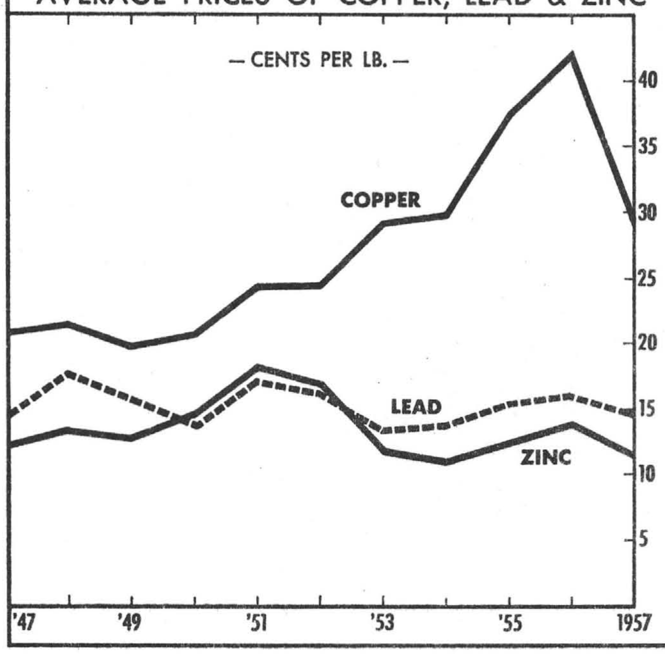
In the past ten years, Arizona mines have produced over two and one-half billion dollars worth of the five principal metals listed in the tabulation below. Copper production accounted for more than 90% of the total, adding further emphasis to Arizona's designation as "The Copper State".

Particularly at this time it may be of interest to review the history of metal prices over the past decade. The price of copper just about doubled between 1947 and 1956, then dropped to 29.5 cents per pound in 1957. Currently, copper is selling for about 25¢ per pound. Price trends of other metals, excluding the price of gold which has remained unchanged throughout the period at $35 per ounce, have been as follows:

AVERAGE PRICES OF PRINCIPAL METALS

Year	*Copper ¢ per lb.*	*Silver ¢ per oz.*	*Lead ¢ per lb.*	*Zinc ¢ per lb.*
1947	21.0	90.5	14.4	12.1
1948	21.7	90.5	17.9	13.3
1949	19.7	90.5	15.8	12.4
1950	20.8	90.5	13.5	14.2
1951	24.2	90.5	17.3	18.2
1952	24.2	90.5	16.1	16.6
1953	28.7	90.5	13.1	11.5
1954	29.7	90.5	13.6	11.1
1955	37.6	90.5	15.1	12.3
1956	41.8	90.5	16.0	13.5
1957	29.5	90.5	14.6	11.4

AVERAGE PRICES OF COPPER, LEAD & ZINC



TEN-YEAR RECORD OF PRINCIPAL METALS PRODUCED IN ARIZONA

Year	*Copper*	*Gold*	*Silver*	*Lead*	*Zinc*	*Total*
1948	$162,803,000	$3,832,000	$4,378,000	$10,704,000	$14,491,000	$196,208,000
1949	141,450,000	3,815,000	4,499,000	10,607,000	17,523,000	177,894,000
1950	167,773,000	4,141,000	4,820,000	7,123,000	17,176,000	201,033,000
1951	201,281,000	4,063,000	4,635,000	6,018,000	19,292,000	235,289,000
1952	191,528,000	3,932,000	4,255,000	5,319,000	15,651,000	220,685,000
1953	225,883,000	3,949,000	3,938,000	2,470,000	6,332,000	242,572,000
1954	224,829,000	3,973,000	3,923,000	2,421,000	4,828,000	239,974,000
1955	338,762,000	4,467,000	4,194,000	2,925,000	5,580,000	355,928,000
1956	430,022,000	5,114,000	4,687,000	3,768,000	7,009,000	450,600,000
1957	300,900,000	5,250,000	4,706,000	3,738,000	7,296,000	321,890,000
TOTAL	$2,385,231,000	$42,536,000	$44,035,000	$55,093,000	$115,178,000	$2,642,073,000

ARIZONA LEADS NATION IN RATE OF BANK DEPOSIT GROWTH

Rank	State	Deposits 12/31/46	Deposits 12/31/56	% Gain
1.	ARIZONA	$ 398,036,000	$ 859,311,000	115.9%
2.	Florida	1,741,078,000	3,687,203,000	111.8
3.	New Mexico	271,732,000	574,152,000	111.3
4.	Nevada	163,748,000	306,253,000	87.0
5.	Texas	5,627,914,000	10,375,102,000	84.4
6.	Louisiana	1,552,828,000	2,794,660,000	80.0
7.	Michigan	4,677,885,000	7,903,011,000	68.9
8.	Oklahoma	1,412,376,000	2,309,447,000	63.5
9.	Connecticut	2,626,211,000	4,199,151,000	59.9
10.	Virginia	1,786,371,000	2,790,470,000	56.2

ARIZONA FIRST IN GROWTH OF MANUFACTURING EMPLOYMENT

Rank	State	1946	1956	% Gain
1.	ARIZONA	12,200	35,700	192.6%
2.	New Mexico	8,200	19,400	136.6
3.	Nevada	3,000	5,800	93.3
4.	California	706,700	1,202,600	70.2
5.	Florida	89,800	149,800	66.8
6.	Kansas	76,600	123,900	61.7
7.	Utah	22,100	35,100	58.8
8.	Oklahoma	57,600	90,800	57.6
9.	Texas	305,600	471,600	54.3
10.	Idaho	19,400	27,200	40.2

ARIZONA LEADS NATION IN GROWTH OF NON-AGRICULTURAL EMPLOYMENT

Rank	State	1946	1956	% Gain
1.	ARIZONA	133,700	243,100	81.8%
2.	Florida	585,000	1,044,000	78.5
3.	New Mexico	114,700	193,600	68.8
4.	Nevada	53,100	85,500	61.0
5.	Texas	1,623,400	2,412,200	48.6
6.	Delaware	102,700	152,500	48.5
7.	Colorado	308,000	456,700	48.3
8.	California	2,972,600	4,348,000	46.3
9.	Louisiana	522,300	756,100	44.8
10.	Kansas	399,000	550,400	37.9

ARIZONA RANKS SECOND NATIONALLY IN RATE OF POPULATION GROWTH

Rank	State	1946	1956	% Gain
1.	Nevada	133,000	247,000	85.7%
2.	ARIZONA	596,000	1,057,000	77.3
3.	Florida	2,238,000	3,770,000	68.5
4.	New Mexico	525,000	815,000	55.2
5.	Delaware	281,000	402,000	43.1
6.	Colorado	1,134,000	1,612,000	42.2
7.	California	9,471,000	13,433,000	41.8
8.	Montana	478,000	638,000	33.5
9.	Maryland	2,123,000	2,812,000	32.5
10.	Texas	6,966,000	8,925,000	28.1

ARIZONA LEADS NATION IN GROWTH OF AGRICULTURAL INCOME

Rank	State	1946	1956	% Gain
1.	ARIZONA	$ 163,228,000	$ 372,437,000	128.2%
2.	Mississippi	305,390,000	591,063,000	93.5
3.	Georgia	412,809,000	684,229,000	65.7
4.	Florida	412,142,000	671,791,000	63.0
5.	Alabama	308,781,000	461,313,000	49.4
6.	Arkansas	437,897,000	644,969,000	47.3
7.	Louisiana	255,457,000	370,152,000	44.9
8.	New Mexico	143,144,000	202,397,000	41.4
9.	North Carolina	745,428,000	998,923,000	34.0
10.	Maine	134,629,000	179,862,000	33.6

ARIZONA ALSO FIRST IN GROWTH OF TOTAL PERSONAL INCOME

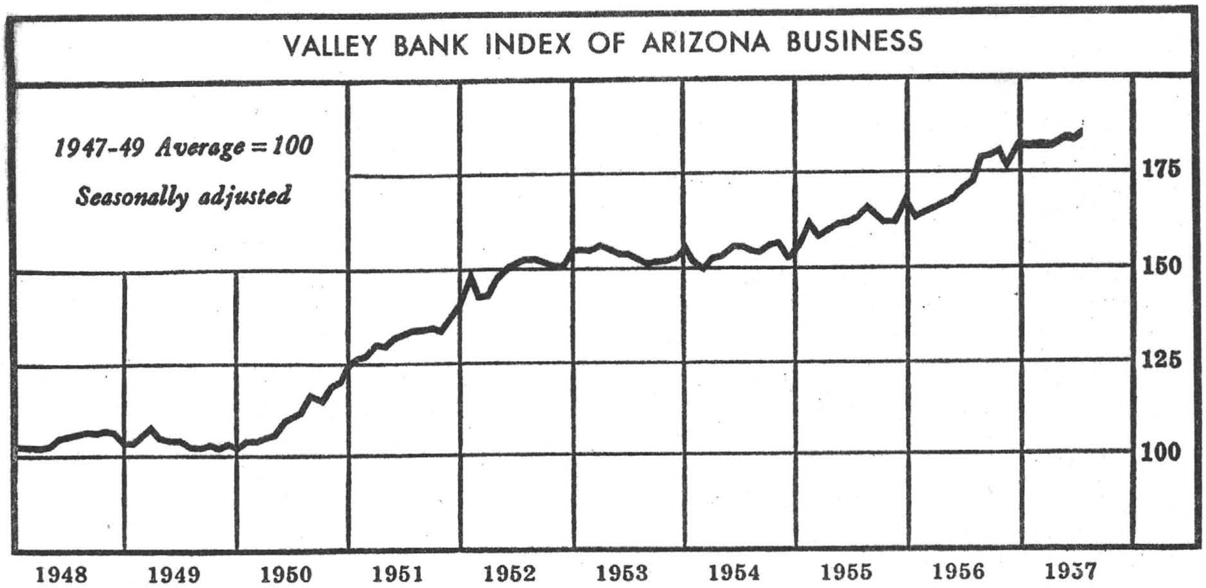
Rank	State	1946	1956	% Gain
1.	ARIZONA	$ 669,000,000	$ 1,816,000,000	171.4%
2.	Delaware	460,000,000	1,149,000,000	149.8
3.	Nevada	249,000,000	596,000,000	139.4
4.	New Mexico	509,000,000	1,218,000,000	139.3
5.	Florida	2,813,000,000	6,641,000,000	136.1
6.	Colorado	1,429,000,000	3,003,000,000	110.1
7.	Michigan	7,743,000,000	16,206,000,000	109.3
8.	Louisiana	2,106,000,000	4,338,000,000	106.0
9.	Texas	7,400,000,000	15,044,000,000	103.3
10.	Maryland	2,924,000,000	5,911,000,000	102.2

ARIZONA FIRST IN GROWTH OF LIFE INSURANCE IN FORCE

Rank	State	1946	1956	% Gain
1.	ARIZONA	$ 388,000,000	$ 1,794,000,000	362.4%
2.	New Mexico	280,000,000	1,255,000,000	348.2
3.	Nevada	112,000,000	426,000,000	280.4
4.	Florida	2,139,000,000	7,923,000,000	270.4
5.	Louisiana	1,647,000,000	5,600,000,000	240.0
6.	California	10,404,000,000	34,480,000,000	231.4
7.	Texas	6,706,000,000	19,526,000,000	191.2
8.	Georgia	2,731,000,000	7,923,000,000	190.1
9.	Wyoming	211,000,000	611,000,000	189.6
10.	Utah	624,000,000	1,784,000,000	185.9

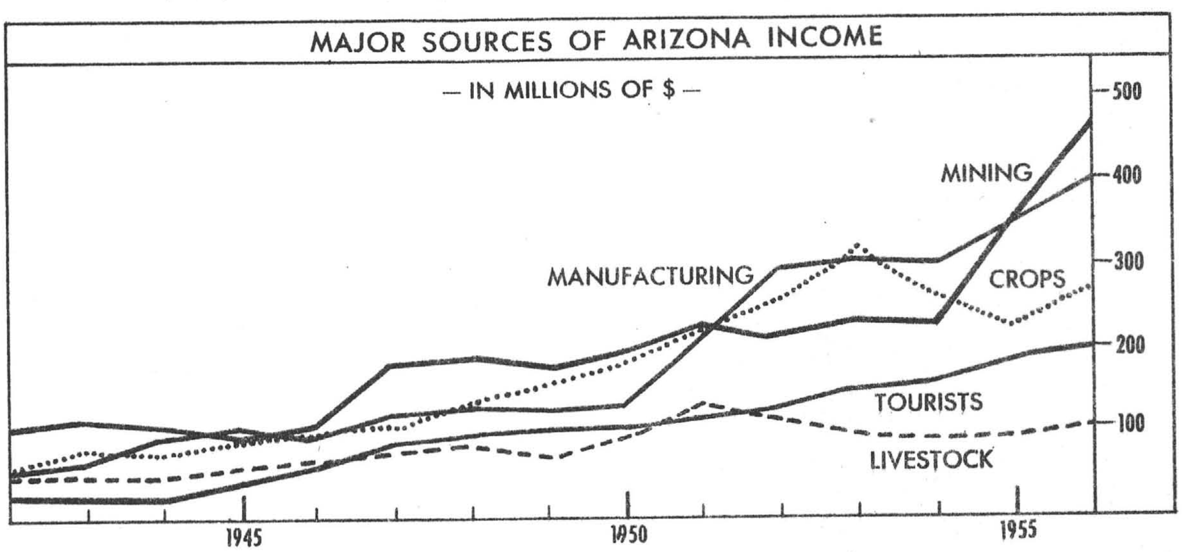
ARIZONA LEADS NATION IN NON-FERROUS MINERAL PRODUCTION

Rank	State	1955	1956	% of U.S.
1.	ARIZONA	$ 351,631,000	$ 441,329,000	34.8%
2.	Utah	217,173,000	254,382,000	20.1
3.	Montana	88,062,000	113,572,000	8.9
4.	Nevada	62,436,000	78,156,000	6.2
5.	New Mexico	52,883,000	75,153,000	5.9
6.	Idaho	48,897,000	51,978,000	4.1
7.	Missouri	40,529,000	42,223,000	3.3
8.	Colorado	22,304,000	29,663,000	2.3
9.	Tennessee	17,265,000	21,234,000	1.7
10.	South Dakota	18,685,000	20,305,000	1.6



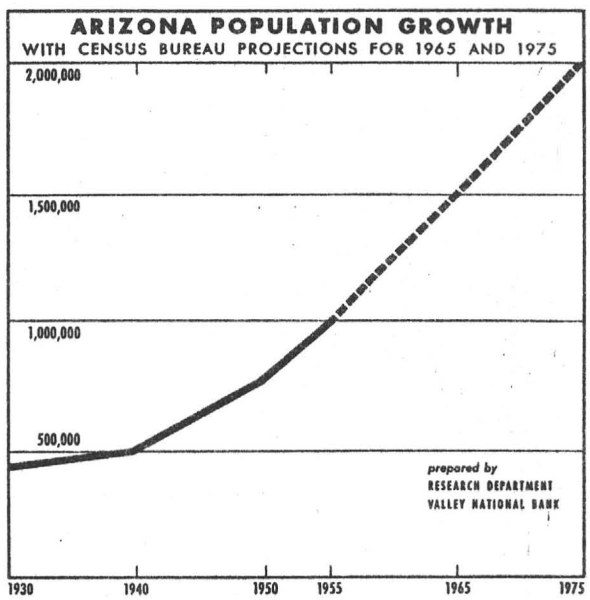
MAJOR SOURCES OF ARIZONA INCOME BY YEARS

Year	Crops	Livestock	Manufacturing	Mining	Tourists
1942	$ 52,849,000	$ 45,571,000	$ 50,000,000	$114,526,000	$ 30,000,000
1943	83,163,000	48,973,000	70,000,000	121,213,000	25,000,000
1944	80,388,000	45,167,000	94,000,000	113,095,000	25,000,000
1945	89,648,000	52,081,000	105,000,000	95,963,000	40,000,000
1946	102,955,000	60,273,000	86,000,000	114,986,000	60,000,000
1947	112,192,000	75,860,000	117,000,000	182,753,000	75,000,000
1948	143,065,000	85,894,000	136,000,000	196,208,000	90,000,000
1949	163,918,000	70,481,000	129,000,000	177,894,000	100,000,000
1950	184,654,000	94,211,000	142,000,000	201,034,000	100,000,000
1951	229,031,000	130,938,000	214,000,000	235,289,000	120,000,000
1952	267,012,000	116,932,000	292,000,000	220,686,000	135,000,000
1953	320,189,000	99,783,000	312,000,000	242,572,000	150,000,000
1954	269,550,000	94,776,000	300,000,000	239,974,000	160,000,000
1955	242,842,000	100,455,000	350,000,000	351,631,000	180,000,000
1956	264,042,000	108,395,000	400,000,000	471,104,000	200,000,000



LEADING STATES IN PROJECTED POPULATION GROWTH
(As Calculated By U. S. Census Bureau)

State	1956 Estimated Population	1975 Projected Population	19-Year % Gain
Nevada	247,000	485,000	96.4%
ARIZONA	1,057,000	2,047,000	93.7
California	13,433,000	25,661,000	91.0
Florida	3,770,000	6,665,000	76.8
Oregon	1,718,000	2,865,000	66.8
Washington	2,667,000	4,188,000	57.0
New Mexico	815,000	1,210,000	48.5
Maryland	2,812,000	4,099,000	45.8
Utah	812,000	1,173,000	44.5
Delaware	402,000	574,000	42.8



PROJECTED GROWTH OF MARICOPA COUNTY

	Population	% of State
1940 Actual (Census)	186,193	37.3%
1950 Actual (Census)	331,770	44.3
1957 Estimated (by VNB)	550,000	47.8
1965 Projected (by VNB)	750,000	50.0
1975 Projected (by VNB)	1,000,000	50.0

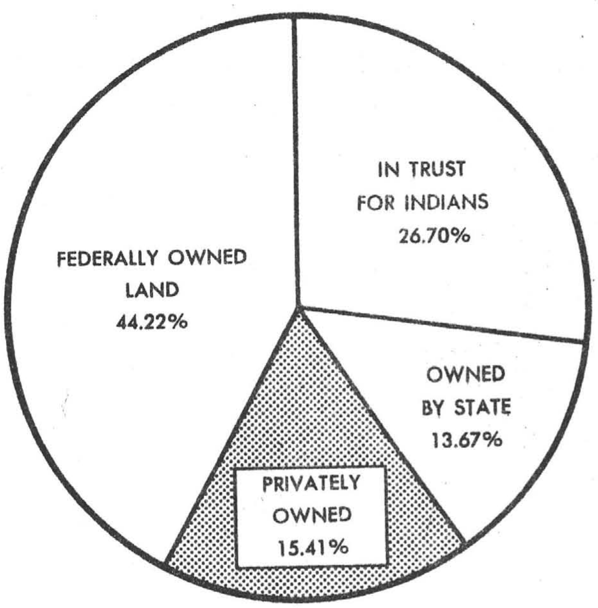
PROJECTED GROWTH OF PIMA COUNTY

	Population	% of State
1940 Actual (Census	72,838	14.6%
1950 Actual (Census)	141,216	18.8
1957 Estimated (by VNB)	240,000	20.9
1965 Projected (by VNB)	325,000	21.7
1975 Projected (by VNB)	450,000	22.5

OWNERSHIP OF ARIZONA LAND

	Number Of Acres	% Of Total
Federally Owned	32,143,087	44.22%
In Federal Trust	19,407,806	26.70
Owned By State	9,936,809	13.67
Privately Owned	11,200,298	15.41
Total Acreage	72,688,000	100.00%

WHO OWNS ARIZONA?



U. S. TRADE WITH MEXICO — ARIZONA CUSTOMS DISTRICT

Year	Value of Exports	Value of Imports	Total
1942	$ 5,537,000	$ 4,850,000	$10,387,000
1943	13,059,000	12,065,000	25,124,000
1944	19,594,000	21,007,000	40,601,000
1945	19,861,000	22,509,000	42,370,000
1946	33,285,000	23,784,000	57,069,000
1947	41,292,000	36,091,000	77,383,000
1948	30,739,000	44,013,000	74,752,000
1949	22,966,000	28,989,000	51,955,000
1950	21,935,000	24,390,000	46,325,000
1951	40,515,000	32,050,000	72,565,000
1952	41,177,000	35,791,000	76,968,000
1953	43,100,000	42,400,000	85,500,000
1954	42,300,000	25,400,000	67,700,000
1955	54,600,000	27,600,000	82,200,000
1956	51,100,000	31,500,000	82,600,000

ANNUAL CROP AND LIVESTOCK INCOME IN ARIZONA
(As Reported By U. S. Department Of Agriculture)

Year	Agricultural Crops	Livestock and Animal Products	Total Income
1942	$ 52,849,000	$ 45,571,000	$ 98,420,000
1943	83,163,000	48,973,000	132,136,000
1944	80,388,000	45,167,000	125,555,000
1945	89,648,000	52,081,000	141,729,000
1946	102,955,000	60,273,000	163,228,000
1947	112,192,000	75,860,000	188,052,000
1948	143,065,000	85,894,000	228,959,000
1949	163,918,000	70,481,000	234,399,000
1950	184,654,000	94,211,000	278,865,000
1951	229,031,000	130,938,000	359,969,000
1952	267,912,000	116,932,000	384,844,000
1953	320,189,000	99,783,000	419,972,000
1954	269,550,000	94,776,000	364,326,000
1955	242,842,000	100,455,000	343,297,000
1956	264,042,000	108,395,000	372,437,000

SOURCES OF ARIZONA CROP AND LIVESTOCK INCOME

Livestock & Products	1953	1954	1955	1956
Cattle & Calves	$ 70,825,000	$ 64,236,000	$ 70,878,000	$ 79,190,000
Dairy Products	16,191,000	18,217,000	18,209,000	18,187,000
Eggs	3,792,000	3,857,000	3,413,000	3,712,000
Hogs	1,234,000	1,091,000	911,000	909,000
Sheep & Lambs	3,344,000	3,356,000	3,734,000	2,578,000
Wool	1,652,000	1,649,000	917,000	1,380,000
Misc. Products	2,745,000	2,370,000	2,393,000	2,439,000
TOTAL	$ 99,783,000	$ 94,776,000	$100,455,000	$108,395,000

Agricultural Crops	1953	1954	1955	1956
Cotton Lint	$218,608,000	$154,549,000	$130,886,000	$136,718,000
Cottonseed	23,467,000	21,452,000	12,901,000	19,471,000
Alfalfa & Hay	9,494,000	10,846,000	11,979,000	10,059,000
Alfalfa Seed	1,353,000	1,525,000	884,000	2,254,000
Barley	8,009,000	13,908,000	8,698,000	9,172,000
Carrots	3,136,000	3,340,000	3,203,000	3,015,000
Grain Sorghums	2,441,000	5,163,000	7,353,000	5,909,000
Lettuce	18,946,000	22,757,000	29,490,000	36,581,000
Melons	17,047,000	16,937,000	15,728,000	13,255,000
Potatoes	2,438,000	2,180,000	3,084,000	4,611,000
Wheat	992,000	820,000	1,852,000	2,826,000
Grapefruit	2,604,000	2,169,000	1,575,000	2,099,000
Oranges	2,655,000	2,746,000	3,239,000	3,818,000
Misc. Crops	8,999,000	11,158,000	11,970,000	14,254,000
TOTAL	$320,189,000	$269,550,000	$242,842,000	$264,042,000

NUMBER OF ACRES DEVOTED TO ARIZONA'S PRINCIPAL CROPS

Year	Alfalfa	Citrus	Cotton	Grains	Vegetables	Total Acres
1941	205,000	20,400	250,000	171,000	63,000	708,000
1942	205,000	20,300	273,700	165,000	63,000	750,000
1943	235,000	20,500	203,000	161,000	62,000	750,000
1944	237,000	19,900	147,000	219,000	74,000	750,000
1945	232,000	20,000	155,000	206,000	75,000	775,000
1946	233,000	19,900	145,000	212,000	100,000	775,000
1947	210,000	19,500	225,000	223,000	100,000	825,000
1948	176,000	19,000	274,000	310,000	100,000	900,000
1949	201,000	20,000	373,000	277,000	100,000	1,000,000
1950	201,000	19,000	273,000	327,000	95,000	915,000
1951	195,000	19,000	557,000	192,000	97,000	1,100,000
1952	191,000	20,000	664,000	217,000	100,000	1,300,000
1953	183,000	17,700	682,000	253,000	95,000	1,300,000
1954	201,000	17,600	420,000	500,000	85,000	1,250,000
1955	223,000	18,100	353,000	462,000	81,000	1,200,000
1956	212,000	17,600	358,000	411,000	90,000	1,150,000

Note: Acreage double cropped is counted but once, and not all crops are shown.

COMPARATIVE YIELDS PER ACRE – 1956

Crop	Arizona	U. S. Average	Crop	Arizona	U. S. Average
Alfalfa seed, lbs.	250	182	Oats, bu.	60.0	34.3
Barley, bu.	60	29	Potatoes, bu.	250	176
Cotton, lbs.	1,108	409	Sorghums, bu.	45.0	21.9
Hay, tons	3.1	2.1	Wheat, bu.	30.0	20.0

DISTRIBUTION OF IRRIGATED ACREAGE BY COUNTIES – 1956

County	Alfalfa	Citrus	Cotton	Grains	Vegetables	Total(*)
Apache	4,000	—	—	7,800	200	12,000
Cochise	8,200	—	12,570	48,200	4,725	80,000
Coconino	1,000	—	—	6,800	100	4,000
Graham	6,000	—	14,100	7,600	100	35,000
Greenlee	1,600	—	1,990	2,100	250	6,000
Maricopa	100,000	11,000	132,980	183,600	50,000	465,000
Navajo	2,200	—	—	10,700	300	10,000
Pima	5,100	95	23,620	16,800	700	55,000
Pinal	36,000	80	142,380	60,000	1,000	275,000
Santa Cruz	1,600	—	1,700	1,800	50	8,000
Yavapai	5,500	—	—	6,400	200	15,000
Yuma	37,500	6,420	28,740	39,000	32,000	175,000

(*) Includes crops, pasture and estimates for Gila and Mohave Counties; acreage double cropped is counted once only and not all crops are shown.
Source: "Arizona Agriculture, 1957" and Dr. George W. Barr.

MINERAL PRODUCTION IN ARIZONA

Gross Value Of Five Principal Metals, 000 Omitted

Year	Copper	Gold	Silver	Lead	Zinc	Total
1931	$ 36,428	$ 2,828	$1,181	$ 154	$ —	$ 40,591
1932	12,672	1,381	587	68	—	14,708
1933	7,853	2,044	837	127	1	10,862
1934	14,247	5,837	2,874	254	78	23,290
1935	23,076	8,461	4,745	623	294	37,199
1936	38,875	11,284	6,495	983	359	57,996
1937	69,812	11,644	7,288	1,458	653	90,855
1938	41,316	10,676	4,835	973	558	58,358
1939	54,519	11,076	5,311	1,012	698	72,616
1940	63,544	10,318	5,031	1,327	1,947	82,167
1941	77,011	11,038	5,332	1,783	2,474	97,638
1942	95,200	8,878	5,024	1,979	3,445	114,526
1943	104,827	6,014	4,063	2,059	4,250	121,213
1944	96,742	3,926	3,124	2,673	6,630	113,095
1945	77,545	2,703	2,530	3,933	9,252	95,963
1946	93,708	2,766	2,641	5,217	10,654	114,986
1947	153,812	3,355	4,135	8,227	13,224	182,753
1948	162,803	3,832	4,378	10,704	14,491	196,208
1949	141,450	3,815	4,499	10,607	17,523	177,894
1950	167,773	4,141	4,820	7,123	17,176	201,033
1951	201,281	4,063	4,635	6,018	19,292	235,289
1952	191,528	3,932	4,255	5,319	15,651	220,685
1953	225,883	3,949	3,938	2,470	6,332	242,572
1954	224,829	3,973	3,923	2,421	4,828	239,974
1955	338,762	4,467	4,194	2,925	5,580	355,928
1956	421,011	5,093	4,627	3,808	6,791	441,330

Source: Minerals Yearbook and U. S. Bureau of Mines

Other Minerals Produced In Arizona During 1956

Mineral	Value	Mineral	Value
Sand and Gravel	$7,000,000	Clay	$920,000
Manganese	3,644,800	Tungsten	450,000
Stone	3,000,000	Pumice	442,000
Molybdenum	2,444,200	Perlite	107,000
Lime	1,472,000	Mercury	26,000

Does not include Asbestos, Barite, Beryllium, Cement, Coal, Feldspar, Fluorspar, Gems, Gypsum, Mica, Silica, Vanadium or Uranium values of which are not available.
Source: Arizona Department of Mineral Resources

SALIENT STATISTICS OF THE U. S. ZINC INDUSTRY

YEARS 1955, 1956, FIRST HALF 1957

Source: U.S.B.M. & A.B.M.S. Unit: Short Tons

	Year 1955	Year 1956	First Half 1957
Producers' Stocks, Beginning of Period --	124,277	39,264	68,622
U.S.Mine Production, Recoverable Zinc ---	514,671	542,340	286,789
Imports-Ores & Concts., Zinc Content ----	478,044	525,350	260,681
Imports-Zinc Metal ----------------------	195,696	244,978	148,362
Redistilled Secondary -------------------	66,042	72,127	40,857
TOTAL SUPPLY	1,378,730	1,424,059	805,311
Producers' Stocks, End of Period --------	39,264	68,622	133,455
Exports-Slabs, Pigs, Blocks -------------	18,069	8,813	4,886
Exports-Ore,Sheets,Plates,Scrap & Dust---	25,714	20,591	5,422
SUB-TOTAL	83,047	98,026	143,763
APPARENT CONSUMPTION --------------------	1,295,683	1,326,033	661,548
REPORTED CONSUMPTION-SLAB ZINC ----------	1,119,812	1,008,790	476,488
CONSUMED DIRECTLY IN ORES ---------------	116,364	116,040	45,502
TOTAL REPORTED ZINC CONSUMPTION	1,236,176	1,124,830	521,990
Unaccounted For(Stockpiles & Smelter Ores)	59,507	201,203	139,558
Production of Primary Slab Zinc:			
By Sources: From Domestic Ores ------	582,913	470,093	N.A.
From Foreign Ores -------	380,591	513,517	N.A.
By Methods: Electrolytic ------------	389,891	410,417	N.A.
Distilled ---------------	573,613	573,193	N.A.
ARIZONA MINE PRODUCTION -----------------	22,684	25,580	16,641
WORLD MINE PRODUCTION -------------------	3,180,000	3,330,000	N.A.
U.S.Mine Production % of Reported Consumption	41.63%	48.22%	54.94%
Avg.Price of Zinc,E.St.Louis (E.& M.J.)--	12.229¢	13.494¢	12.881¢

Arizona Department of Mineral Resources December, 1957

SLAB ZINC AVAILABLE TO CONSUMERS

YEARS 1955, 1956 AND FIRST HALF 1957

Source: U.S.B.M. & A.B.M.S. Unit: Short Tons

	Year 1955	Year 1956	First Half 1957
SUPPLY:			
Stocks at Primary Smelters Jan. 1st. ---	121,847	37,322	64,794
Stocks at Secondary Plants Jan. 1st. ---	1,549	1,942	2,081
Production - Primary ------------------	963,504	983,610	521,677
- Secondary ----------------	66,042	72,127	40,857
Imports of Slab Zinc ------------------	195,696	244,978	148,362
TOTAL AVAILABLE	1,348,638	1,339,979	777,771
WITHDRAWN:			
Exports of Slab Zinc-------------------	17,904	8,813	4,886
Shipments to Government Account --------	87,000	250,000	116,993
Stocks at Primary Smelters-End of Period	37,322	64,794	129,385
Stocks at Secondary Plants-End of Period	1,938	2,081	4,070
TOTAL WITHDRAWN	144,164	325,688	255,334
AVAILABLE TO CONSUMERS -----------------	1,204,474	1,014,291	522,437
REPORTED CONSUMPTION ------------------	1,119,812	1,008,790	476,488

U. S. CONSUMPTION OF SLAB ZINC

GALVANIZERS --------------------------	451,141	439,146	187,845
DIE CASTERS --------------------------	430,807	360,507	186,260
BRASS PRODUCTS -----------------------	146,243	124,004	56,580
ROLLED ZINC --------------------------	51,589	47,359	21,342
ZINC OXIDE & OTHER -------------------	40,032	37,774	24,461
TOTAL REPORTED CONSUMPTION	1,119,812	1,008,790	476,488

Arizona Department of Mineral Resources December, 1957

APPENDIX D

NOTE: Pages III-12 to III-14 give comment on the quality of zinc reserves in the United States. On Page III-13 is a discussion of the quality of zinc reserves in the West.

MATERIALS SURVEY

ZINC

Compiled for the

MATERIALS OFFICE
NATIONAL SECURITY RESOURCES BOARD

by the

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

with the cooperation of the

GEOLOGICAL SURVEY

March 1951

1. Relative Importance

Zinc now ranks fourth in tonnage produced among the metals in the United States, being outranked only by steel, copper, and lead. The output of the first five major metals in the United States in the peacetime year 1949 and in the peak year of World War II was as follows:

	1949 production (short tons)	Peak World War II production (short tons)	1949 production as percentage of peak wartime production
Steel	77,987,000	89,642,000 (1944)	87.0
Refined copper	1,178,000	1,529,000 (1942)	77.0
Lead	890,000	968,000 (1941)	91.9
Slab zinc	870,000	991,000 (1943)	87.8
Aluminum	784,000	1,234,000 (1943)	63.5

Zinc is indispensable to the industrial strength of the United States, both in peace and in war. It is used in the production of an extremely wide range of military and essential civilian goods. Wartime requirements for the metal include cartridge brass, copper-alloy castings used in shipyards and munitions factories, hull plates to protect steel hulls from corrosion, and zinc-coated products for innumerable uses. Zinc oxide is an important constituent of the rubber used in the tires of Army vehicles and in gas masks. Chemical derivatives of zinc are used in paints, bleaches, and other essential products. The major civilian uses of zinc overlap the military uses, particularly galvanized products and die-castings.

2. United States Supply-Distribution Pattern

Figure 1 shows zinc supply and distribution in the United States for 1935-49 and table 1 the highlights of the supply-distribution pattern of zinc for three periods: pre-World War II (1936-38); World War II (1942-44); and postwar (1947-49).

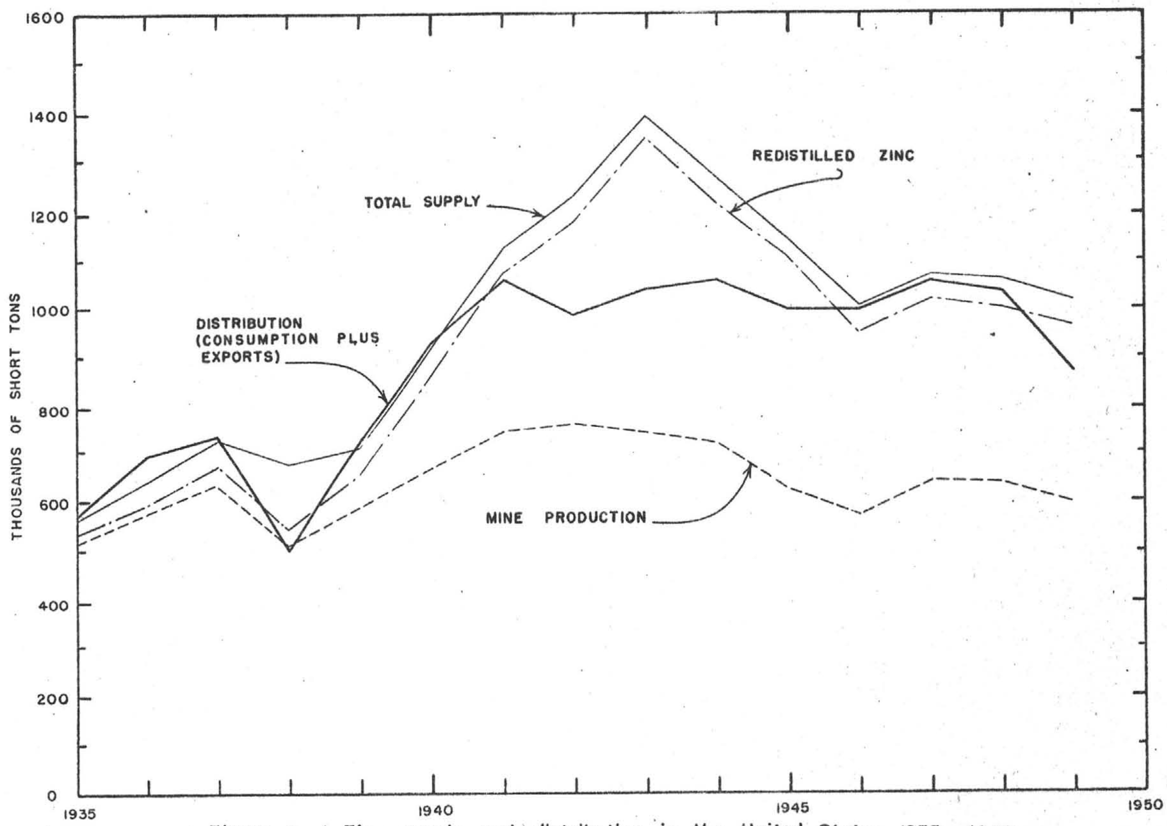


Figure S-1 Zinc supply and distribution in the United States, 1935 – 1949

3. United States Supply

The supply of zinc to the United States averaged nearly 1,300,000 tons a year in 1942-44, which was more than double the average supply in 1936-38. In the postwar period, annual supply has remained over 1,000,000 tons. Although domestic smelting capacity has grown, in response to expanding demand, domestic mine production has not been adequate to provide smelters with enough concentrates to achieve this higher level of metal production; the United States, during the past 15 years, has therefore become increasingly dependent on foreign sources of supply. During the 10-year period 1940-49, imports have averaged more than a third of the total zinc supply. Most of the imports have been obtained from Canada, principally as slab zinc, and Mexico, mainly in the form of concentrates. Minor quantities have been imported from other countries, principally Peru, Spain, the Union of South Africa, Australia, and Bolivia.

Mine production: The major factor contributing to the shortage of United States mine production in recent years is the decline of the Tri-State district. During the years 1935-44 large tonnages of old tailings in this district were reworked, which together with newly mined ore, accounted for one-third to one-half of the total domestic mine production. Since 1944, progressive exhaustion of tailings and declining grade of ore has resulted in a drop of Tri-State production from an average of 225,000 tons for 1940-44 to 79,000 tons in 1949, only 13 percent of the total United States production for that year.

Primary zinc is produced almost entirely from lode deposits by underground mining. Mechanization is well-advanced at all important United States mines; but labor productivity, whether in terms of tons of ore mined per man-day or in terms of pounds of zinc per man-day, has declined in the postwar period. Substantial expansion of mine production would require extensive development and augmented handling and hoisting facilities that would involve heavy capital investment and a considerable time lag.

Smelter production: Important changes have taken place in the zinc smelting industry during the past 15 years. In 1936-38 primary production averaged about 500,000 tons. At the wartime peak (1943) the total was about 940,000 tons a year. The proportionate output of redistilled secondary zinc is fairly constant, averaging between 6 and 8 percent of total slab production.

The United States now has a versatile zinc-smelting industry, with electrolytic plants, mainly in the Western States, producing only high-grade zinc; vertical retorts, all but one in the East, that can produce any desired grade efficiently; and horizontal retorts, primarily in the midcontinent natural-gas-producing States, producing Prime Western. In 1949, the capacity of the three sections of the primary zinc-smelting industry were approximately as follows:

	Capacity, tons of primary zinc output per year
Electrolytic	360,000
Vertical retorts	215,000
Horizontal retorts	405,000
Total:	980,000

Zinc-smelting capacity now exceeds the mine-production capacity of domestic industry by about one-third. This means that full utilization of zinc-smelting capacity in this country now depends on continued high imports of ores and concentrates.

SALIENT STATISTICS OF THE ZINC INDUSTRY IN THE UNITED STATES
SELECTED AVERAGES
(Quantities in thousands of short tons)

	1936-38 average	1942-44 average	1947-49 average
Supply: Total	643	1,294	1,051
Mine production	573	744	620
Imports, ore and concentrates	9	443	268
Imports, metal	19	57	104
Redistilled secondary	42	50	59
Distribution: Total	638	1,026	984
Slab-zinc consumption	538	811	772
Consumed directly in ores	92	124	122
Exports	8	91	90
Smelter production: Total, prm'y	497	901	802
From domestic ores	492	599	547
From foreign ores	5	302	255
Percent electrolytic	24	33	39
Percent distilled	76	67	61
Stocks at primary smelters, Dec. 31	98	161	59
Price, cents per pound, Prime Western, East St. Louis, average	5.34	8.25	12.08

INDEXES OF ACTIVITY IN THE ZINC INDUSTRY
(1925-29 = 100)

	1936-38	1942-44	1947-49
Mine production	79	103	85
Smelter production, primary	83	150	133
Consumption of slab	88	133	127
Stocks at primary smelters, Dec. 31	208	342	125
Price, cents per pound, Prime Western, East St. Louis, average	79	122	179

4. United States Distribution

Figure 2 shows the percentage of consumption of slab zinc in the United States by principal industries for the 10-year period 1940-49.

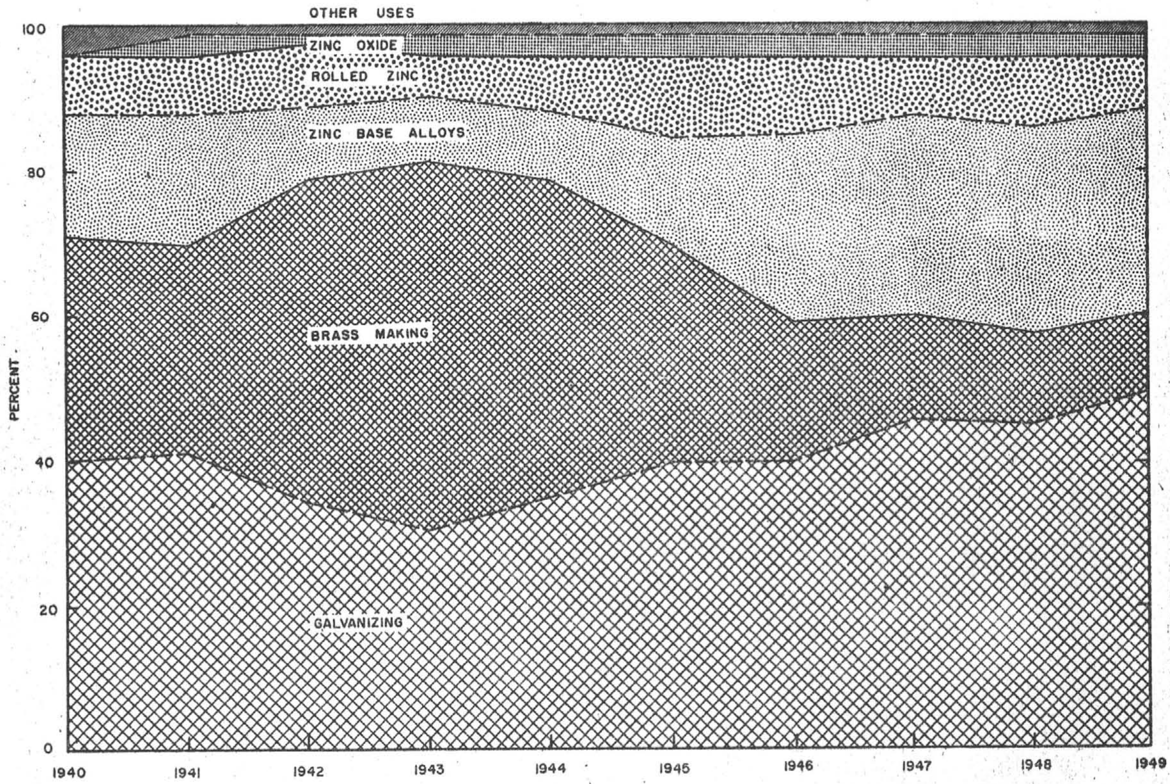


Figure S-2 Distribution of slab zinc in the United States, by principal industries, 1940 – 1949

Figure 3 shows the quantities of slab zinc consumed by various industries for the three periods selected as typical of the pre-World War II, wartime, and postwar periods.

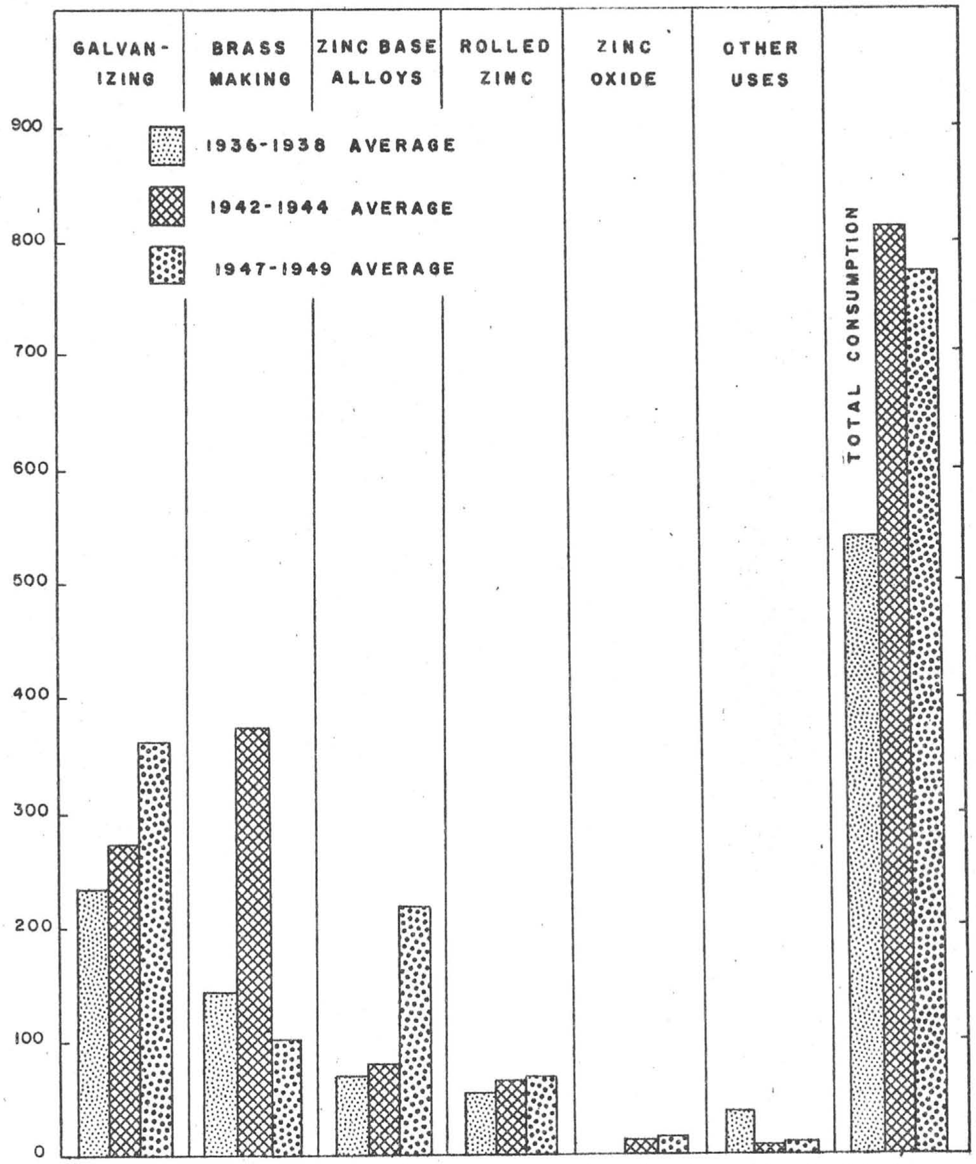


Figure S-3 Consumption of slab zinc in the United States, by industry, 1936-38; 1942-44; 1947-49

Galvanizing was the principal use of zinc both before and after World War II. During the war, the manufacture of brass products was paramount, accounting for more than 50 percent of consumption. The most impressive change in slab-zinc consumption over the past 15 years has been the sharp increase in the use of zinc for die castings during peacetime. In the postwar period, this use ranks second in importance. Zinc consumed for die castings now exceeds consumption for brass products by a considerable margin.

In addition to the requirements for slab zinc, over 120,000 tons of zinc per year is consumed directly from ores in the manufacture of pigments and salts.

As shown in figure 4, about 40 percent of all slab zinc produced in peacetime is Prime Western. During the war years, because of the demand for high-grade zinc for die casting and brass manufacture, this percentage was sharply reduced. During the postwar period, Prime Western regained its leading position, but a part of the substantial increase in the production of the higher grades was maintained.

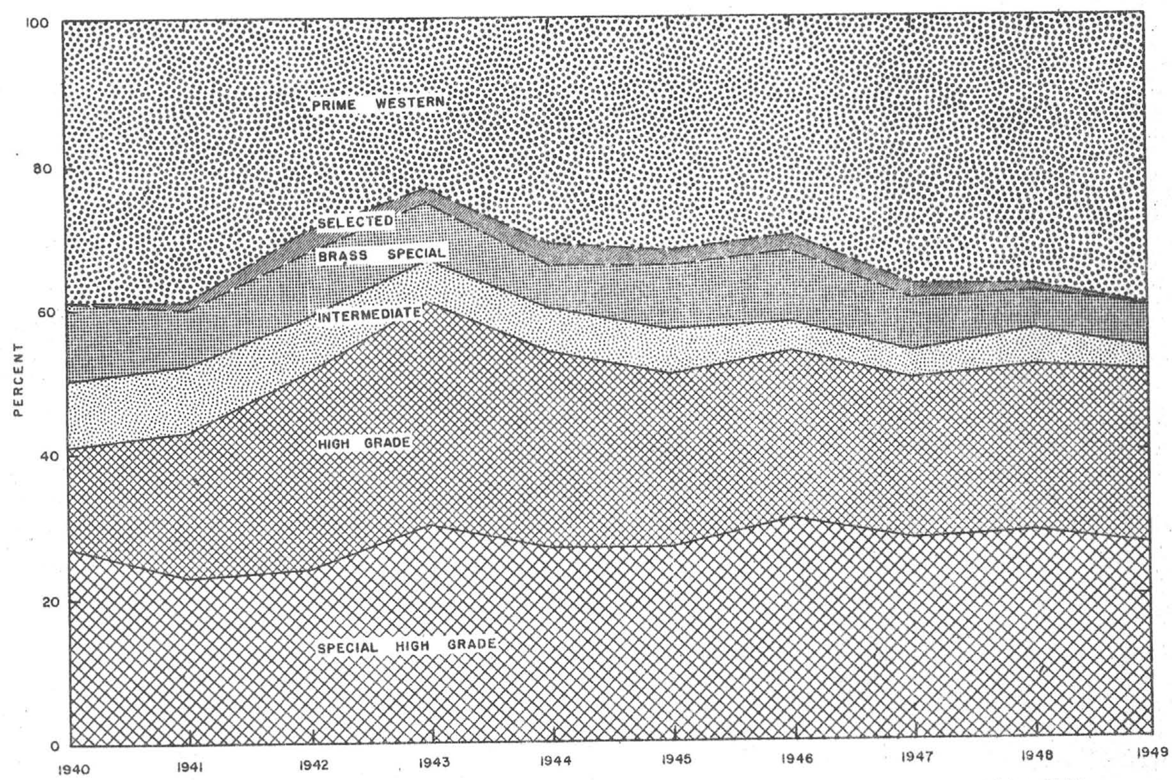


Figure S-4 Distribution of slab zinc produced in the United States, by grade, 1940-1949

5. World Supply - Distribution Position

The zinc production-consumption position for the world's leading producing and consuming nations in 1949 is indicated in the following table:

WORLD PRODUCTION AND CONSUMPTION OF ZINC, 1949

	Mine production /a		Smelter production		Consumption of slab (approx.)	
Country	1,000's of short tons	% of world total	1,000's of short tons	% of world total	1,000's of short tons	% of world total
World total	1,977		1,995		1,460	
Canada	291	14.7	207	10.4	46	3.2
Mexico	190	9.6	59	2.9	8	.5
United States	593	30.0	815	40.8	703	48.1
Argentina	11	.6	3		11	
Bolivia	16	.8				
Brazil					11	.8
Peru	71	3.6	1			
Belgium			195	9.8	36	2.5
France	11	.6	67	3.4	120	8.2
Germany	57	2.9	96	4.8	109	7.5
Italy	68	3.4	29	1.4	31	2.1
Netherlands			17	.9	22	1.5
Norway	7	.4	45	2.4	13	.9
Spain	49	2.5	22	1.1	22	1.5
Sweden	35	1.8			24	1.6
United Kingdom			72	3.6	223	15.3
India					29	2.0
Japan	44	2.2	36	1.8		
Australia	169	8.5	91	4.6	50/b	3.4
Belgian Congo	56	2.8				
N. Rhodesia	12	.6	26	1.3		
U. of S. Africa/c	26	1.1				
Undistributed	271	13.7	217	10.9	13	.9

a/ Recoverable basis for the United States, Bolivia, Canada, Germany, Italy, Australia and Union of South Africa; zinc content of ore for other countries.
b/ Includes New Zealand.
c/ South West Africa.

As indicated in the table, the United States, Canada, Mexico, and Australia are the principal producers of zinc-bearing ore. The United States and Canada are also the principal producers of slab zinc, with Belgium a close third. Belgium and Canada export most of their production. It is important to note the total dependence of the smelting industry of Belgium - and the substantial dependence of the United States, the United Kingdom, France, and Germany - on imports of concentrates. The United Kingdom imports considerable quantities of concentrates from Commonwealth countries, as does France from its dependencies.

The principal slab-consuming countries of the world, are the United States, the United Kingdom, France, and Germany. The last three countries consume all of their domestic smelter production and, in addition, import slab zinc to meet their consumption requirements. In 1949 the United States slab production somewhat exceeded consumption; but, in general, consumption has just about equaled or exceeded slab production in recent years.

The current world situation points up the need for additional sources of zinc ore. Although world prices have continued at high levels during the entire post-World War II period, concentrate shortages have hampered the world zinc-smelting industry in its attempt to realize maximum production. In 1949 world smelter production exceeded mine production. Although governments are taking measures to increase the supply of concentrates, the immediate prospect indicates continued shortages.

A few comparisons on the United States position with respect to the world position and to that of Canada and Mexico are significant. Over the past decade, the United States has produced about a third of total world mine output. Production from the United States, Canada, and Mexico has averaged nearly two-thirds of the world output. As for consumption, the United States alone has accounted for roughly half of world slab zinc consumed during the 3 postwar years 1947-49, and Canada and Mexico together for 4 to 5 percent additional.

The principal changes in world production and consumption of zinc for the periods 1936-38, 1942-44, and 1947-49, insofar as data are available, are indicated in the following table:

WORLD PRODUCTION AND DISTRIBUTION POSITION OF ZINC
Selected annual averages
(Thousands of short tons)

	Mine production	Smelter production	Consumption
	1936-38		
World total	1,884	1,709	1,710
North America	1,001	697	552
South America	39		
Europe	447	861	983
Asia	138	56	124
Australia	222	78	32
Africa	35	17	6
	1942-44		
World total	2,140	1,934/a	/b
North America	1,295	1,154	
South America	78	2	
Europe	388	511	
Asia	103	69	
Australia	186	85	
Africa	36	15	
	1947-49		
World total	1,902/a	1,873/a	1,541/c
North America	1,071	1,053	820
South America	93	4	15
Europe	390	566	618
Asia	36	26	35
Australia	165	87	49
Africa	91	25	5

a/ Estimates for the U.S.S.R. and satellite countries included in total.
b/ Data not available.
c/ Incomplete data.

The world's smelter production by principal countries in 1949 is shown in figure 6. The predominance of North America and Europe in both mine and smelter production is clearly shown.

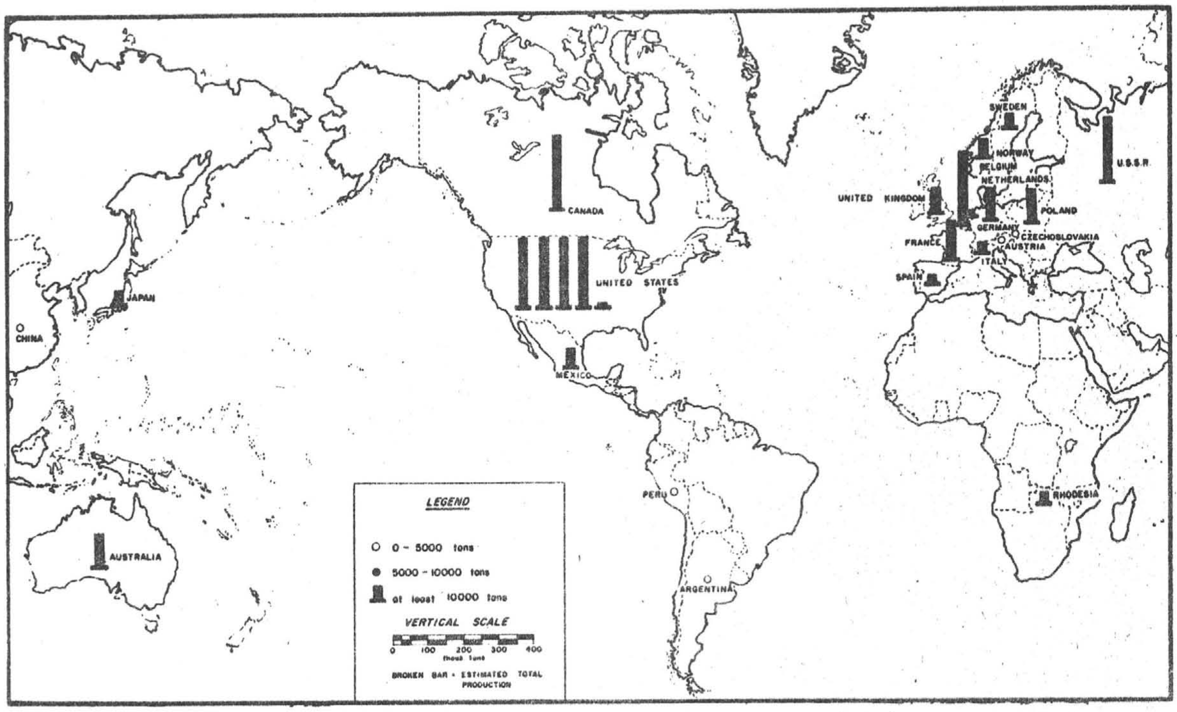


Figure S—6 World smelter production of zinc, 1949, in short tons

Average annual mine production for 1947-49 was 1,902,000 tons, approximately equal to that for the pre-World War II period. Decreases in production in Europe, Asia, and Australia and increases in output from Africa and South America were the major changes during the 15-year period. Mine production during 1942-44 averaged about 300,000 tons above the 1936-38 level. This wartime increase was attributable principally to increased production from North America.

World smelter production of zinc averaged 1,710,000 tons during 1936-38. World War II brought about substantial reductions in European production - from 861,000 tons in 1936-38 to 511,000 tons in 1942-44. North American increases more than offset this decrease, however, and the 1942-44 average was 1,934,000 tons. In the 1947-49 period, world smelter production fell somewhat to 1,873,000 tons, the major reductions occurring in Australia and North America.

The world's mine production by principal countries in 1949 is shown in figure 5.

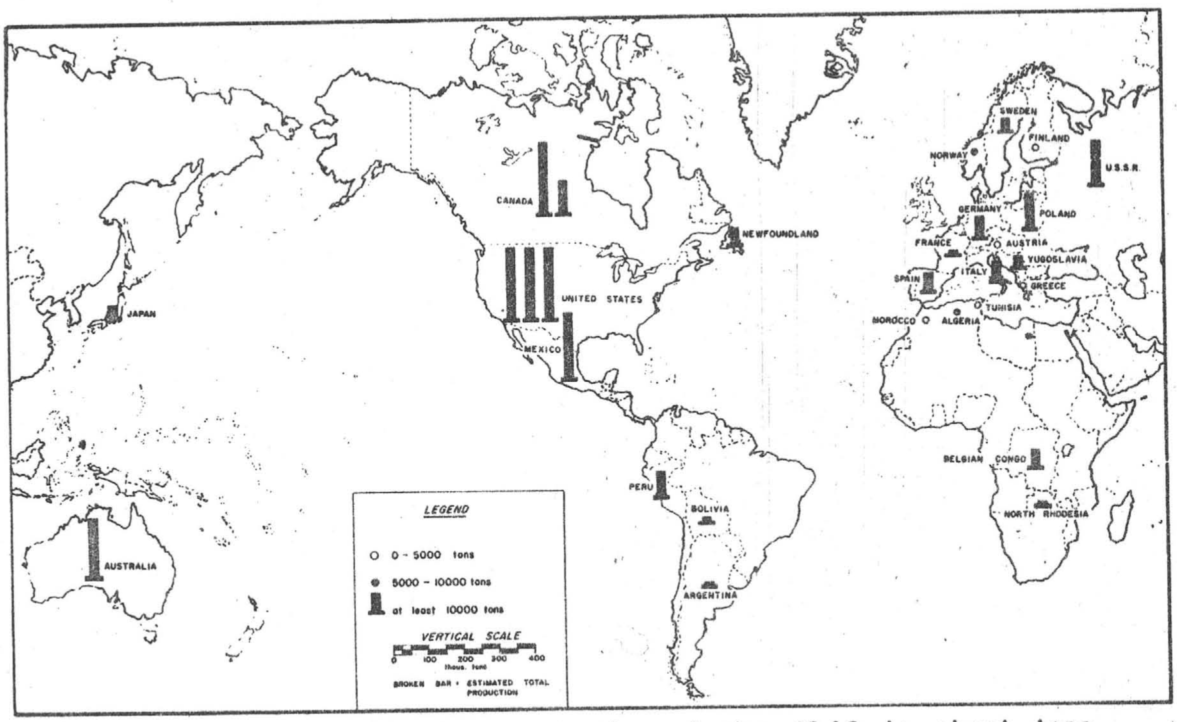


Figure S-5 World mine production of zinc, 1949, in short tons

6. Resources

Zinc deposits are widely distributed on all of the continents, and each major industrial country has access to substantial supplies of zinc, either within its own boundaries or obtainable from other countries. In 1949, 19 countries each produced more than 10,000 tons of recoverable zinc. The United States, Canada, Mexico, Australia, U.S.S.R., and Poland were the principal producers of zinc ore, followed by Peru, Italy, Germany, Belgian Congo, Spain, and Japan. These countries also contain the bulk of known ore reserves.

The estimated world zinc reserves, in terms of gross content in the ground and including measured, and indicated ore, workable under conditions similar to those prevailing in 1949, are given in the following table:

	Gross zinc content short tons
United States	8,500,000
North America, other than United States	8,000,000
South America	7,000,000
Western Europe	8,500,000
Eastern Europe	11,000,000
Africa	4,000,000
Asia	4,000,000
Australia	14,000,000
World total	65,000,000

Due to mining, milling, and smelting losses, only about three-fourths of the total world reserves of 65 million tons is estimated as recoverable. Most of the zinc is produced from lead-zinc ores, smaller amounts coming from straight zinc ores or as a byproduct of other metal mining, chiefly copper. In the United States about two-thirds of the lead and zinc produced is from lead-zinc districts.

The United States is the largest zinc-producing country in the world and annually produces approximately one-third of the total world output. The United States has large zinc-ore reserves. Measured and indicated reserves total 8.5 million tons, and, including inferred reserves, the tonnage was estimated at 21.2 million tons as of January 1950. About 16.3 million tons of this (77 percent) is recoverable. In addition, large tonnages of zinc in pyritic deposits and low-grade slag piles not classified as ore at present would become commercial ore under more favorable economic conditions.

The leading districts in the United States are the Tri-State (in Missouri, Kansas, and Oklahoma); Coeur d'Alene, Idaho; Franklin, N.J.; Butte, Mont.; St. Lawrence County, N.Y.; Eastern Tennessee; Central

New Mexico; Bingham, Utah; Pioche, Nev.; Red Cliff, Colo.; and Austinville, Va.

Except for the minerals zincite, willemite, and franklinite, unique in their occurrence in northern New Jersey, the sulfide mineral sphalerite or zinc blende is the predominant zinc-ore mineral in the United States, as elsewhere in the world.

Although unmined zinc-bearing deposits in the Tri-State district, the greatest zinc-producing area in the United States for more than 50 years, are relatively large, the ore is low-grade, and the material that can be mined profitably by present mining methods is rapidly nearing exhaustion. Another important source of zinc in recent years in which the bulk of the developed ore supply has been exhausted is the Bisbee district, Arizona.

Large reserves are being developed at Friedensville, Pa., and at Eureka, Nev., where the mines have not been worked for many years because of difficult operating conditions. The zinc deposits of Jerome, Ariz., and the Gossan Lead belt of Virginia and North Carolina are large, but so low-grade that they cannot be worked as zinc ores under present conditions.

North American reserves, exclusive of the United States, are estimated at about 8 million tons of zinc. Canada has by far the largest portion of these reserves, some of which have been developed only recently or are still undeveloped. The Sullivan and Reeves- MacDonald districts in British Columbia, Flin Flon on the Manitoba-Saskatchewan border, and Buchans, Newfoundland - the most productive districts at present - also contain large reserves. In addition to these older producing regions, large zinc deposits have been developed in many areas of Quebec. Sizable deposits, largely undeveloped as yet, have been found in the Yukon and Northwest Territories. Mexico, the third-largest zinc producer in the world, is in a less-advantageous position as to reserves. Several of the larger deposits are nearing exhaustion, and known reserves in other districts are not adequate for continued production at the present rate for many more years.

Australia has the largest zinc reserves in the world, estimated at 14 million tons, principally in the Broken Hill district of New South Wales; at Mount Isa, Queensland; Read-Roseberry, Tasmania; and Lake George, New South Wales.

South American zinc reserves are estimated at about 7 million tons. Peru, and Argentina have the largest reserves; Bolivia and Chile are the only other South American countries with significant reserves.

Western European zinc reserves are estimated at approximately 8.5 million tons, of which Germany has slightly more than half. Spain, Sweden, and Italy have important reserves, and there are small reserves in Finland, France, Greece, Norway and Austria.

The zinc reserves of eastern Europe total about 11 million tons. Russian deposits, located principally in the Ural, Altai, and Karatau Mountains, contain over half of the total eastern European reserves. Poland also has huge reserves. Yugoslavian reserves, though significant, do not approach the magnitude of those of the U.S.S.R. or Poland.

Africa has zinc reserves estimated at about 4 million tons. The Belgian Congo has the largest developed ore supply. Additional reserves are found in Nigeria, Northern Rhodesia, French Morocco, Southwest Africa, Algeria, Tunisia, and French Equatorial Africa. The Nigerian reserves, surpassed in Africa only by the Belgian Congo, were undeveloped as of January 1950.

The estimated zinc reserves of Asia are between 3.5 and 4 million tons, depending on the ultimate magnitude of the Chinese deposits, which to a large extent are unknown. The largest known reserves in Asia are contained in the Bawdwin, Burma, lead-zinc deposit. This deposit has been depleted considerably, however, and future production will probably be much less than pre-World War II levels. Japan's reserves are next in importance in Asia. French Indochina, Korea, and Turkey have small reserves.

7. Structure of the Industry in United States

The domestic zinc industry is made up of three major groups - mining companies, custom smelters, and vertically integrated producers.

Mining companies represent a wide variety of types. There are hundreds of small producers in the Central and Western States, ranging in size from one-man operations to companies controlling many mines. The bulk of zinc production, however, is from relatively few mines. Sixty percent of the total is derived from 25 mines. The industry's entire output comes from more than 750 mines. The 10 leading mines in the United States in 1949, in order of output, follow:

Mine	District and State	Operator	Type of ore
Franklin & Sterling Hill	New Jersey	New Jersey Zinc Co.	Zinc
Butte Hill mine and dumps	Summit Valley (Butte), Mont.	Anaconda Copper Mining Co.	Zinc-lead
Copper Queen	Warren (Bisbee), Ariz.	Phelps Dodge Corp.	do.
Balmat	St. Lawrence County, N.Y.	St. Joseph Lead Co.	do.
United States & Lark	West Mountain (Bingham), Utah	U.S. Smelting, Ref. and Mining Co.	do.
Eagle	Red Cliff, Colo.	Empire Zinc Div., N.J. Zinc Co.	do.
Star	Hunter, Idaho	Sullivan Mining Co.	do.
Pioche	Pioche, Nev.	Combined Metals Reduction Co.	do.
Austinville	Austinville, Va.	N.J. Zinc Co.	do.
Mascot No. 2	Eastern Tenn.	American Zinc Co. of Tennessee	Zinc

Domestic mining is centered largely in five areas: the Tri-State district; Tennessee-Virginia; Sussex County, N.J.; St. Lawrence County, N.Y.; and the Western States. The grade of ore varies from a low of about 2 percent combined zinc and lead to a high of 8 percent or better. Grade of ore alone, however, does not determine profitability. The low-grade zinc ores of the Tri-State district are characterized by simple mineralization and lend themselves to large-scale, relatively low cost mining, as do the higher-grade ores of the East. The relatively higher grade of the deposits of the Western States, which also contain silver and gold, is counterbalanced to some extent by the complexity of the ores, generally higher production costs, and remoteness from market.

Custom smelters make up the second major division of the industry. These organizations buy ores and concentrates from independently owned mines, domestic and foreign, treat them, and market the resulting slab zinc. Custom smelters also treat ores on a toll basis; ownership of these ores and of the slab produced therefrom is retained by the mining or importing company.

Following are the principal primary custom smelters in the United States:

Fairmont City and Monsanto, Ill. - American Zinc Co. of Illinois (American Zinc-lead and Smelting Co.)
La Salle, Ill. - Matthiessen & Hegeler Zinc Co.
Bartlesville, Okla. - National Zinc Co., Inc. (International Minerals and Metals Corp.)
Blackwell, Okla. - Blackwell Zinc Co. (American Metal Co.)
Amarillo, Tex. - American Smelting & Refining Co.
Dumas, Tex. - American Zinc Co. of Illinois
Meadowbrook, W. Va. - Matthiessen & Hegeler Zinc Co.
Corpus Christi, Tex. - American Smelting & Refining Co.
Anaconda and Great Falls, Mont. - Anaconda Copper Mining Co.
Kellogg, Idaho - Sullivan Mining Co.

All of the above plants are horizontal-retort smelters except the Meadowbrook installation, which is of the vertical-retort type, and the Monsanto, Corpus Christi, Kellogg, Anaconda, and Great Falls electrolytic plants.

In the United States leadership in the industry rests largely with the third type of companies - vertically integrated producers that combine substantial company-owned mine production with large-scale reduction facilities. Four of the above-named organizations are also included in this group: The American Zinc, Lead & Smelting Co.; the American Smelting & Refining Co.; the Anaconda Mining Co.; and the Sullivan Mining Co. The remaining companies include:

New Jersey Zinc Co. (smelters at Depue, Ill. and Palmerton, Pa.)
St. Joseph Lead Co. (smelter at Josephtown, Pa.)
Eagle-Picher Co. (smelter at Henryetta, Okla.)

Marketing of slab zinc: Slab zinc is sold on the standard specifications adopted by the American Society for Testing Materials and by industry generally, which provides for six standard grades of zinc.

Prices for all grades of slab zinc are generally quoted in cents per pound, f.o.b. East St. Louis. Special High-Grade and High-Grade zinc are sold at a premium of 1.50 cents and 1.35 cents, respectively above the price of Prime Western, f.o.b. shipping point with freight allowed to destination. The other grades, Intermediate, Brass Special and Selecte are sold at smaller premiums above the Prime Western grade.

Prices: Zinc prices have fluctuated widely over the past 15 years. During the 5-year period 1935-39 the price averaged 5.10 cents per pound for Prime Western, East St. Louis. The upswing in prices created by the demands of World War II was halted in October of 1941 by the Government, which set the controlled price at 7.25 cents per pound. In October 1942 the price was established at 8.25 cents per pound and remained at this level until controls were lifted in the fall of 1946. Continued heavy postwar demand raised the price up to 17.50 cents per pound by December 1948, the highest in the 15-year period. The average price of 12.08 cents per pound for the three postwar years, 1947-49, has been moderate, however, considering the active demand for zinc over most of this period.

Before World War II, the price outside of the United States was quoted on a London basis, where active trading in zinc took place on the Metal Exchange. With the outbreak of World War II, London Metal Exchange operations ceased. The British Government then initiated control of prices and supply; this control was still in effect at the end of 1949. The United States markets in East St. Louis and New York are now the principal world markets.

8. Effect of World War II on the Zinc Industry

A review of the domestic zinc industry during World War II reveals important problems that would probably be associated with future emergency conditions.

One of the first problems considered, even before the entry of the United States into the war, was how to obtain an adequate supply of zinc. It soon became evident that the domestic mine production of 573,000 tons per year could not meet the essential military and civilian requirements for zinc, which were estimated and which proved to be about a million tons a year. Also, the domestic smelting industry, which produced a record-breaking 740,000 tons of slab zinc in 1940, did not have the capacity to produce an additional 250,000 tons.

Measures were therefore taken by the United States Government to increase imports, particularly of ore, to expand or at least maintain domestic mine production, expand smelter capacity, establish a stockpile, and control consumption and exports.

Imports: The first measures taken included the expansion of imports, partly by purchase agreements (for example, with the Government of Mexico) and partly by agreement with other Allies to divert exports from Canada and Australia, which normally went to Great Britain and Belgium, to the United States. This program was a notable success. Imports of ore, which shortly before the war averaged about 9,000 tons a year, had by 1943 reached a high of 539,000 tons, and the average for the entire wartime period was over 400,000 tons annually.

Imports of metal, which in prewar years totaled about 19,000 tons, added an average of about 70,000 tons of metal a year to the total supply during the war years.

Mine production: Various measures were adopted to increase or at least to maintain domestic mine production. The most important of these was the Premium Price Plan, designed primarily to increase production from unprofitable ores by paying premiums for production above a certain quota, which was based on 1941 production. Through payment of these premiums, marginal and lower-grade ores were mined, and tailing piles - previously considered worthless - were reworked. In addition, new and idle mines were brought into production, and more extensive development work was initiated in some existing mines. Despite increasing costs and labor difficulties, mine production in the war years 1942-44 averaged 744,000 tons, an increase of about 25 percent over the 1936-38 average. On the other hand, it was principally the high-cost operators that benefitted most from the plan.

During the $5\frac{1}{2}$ years the plan was in operation, from February 1942 through June 1947, 56 percent of all the zinc produced received premiums. The average price paid per pound, that is, market price plus premiums, was 10.92 cents.

Other measures intended to increase mine production included exploration and drilling programs of the Geological Survey and the Bureau of Mines, United States Department of the Interior. These programs, though extensive, located little in the way of new deposits that could be brought into production during the war years but did indicate some deposits of future value.

A serious manpower shortage developed in lead and zinc mines during the war years owing to the drafting of skilled miners and the attraction of higher-paying jobs outside the industry. Equipment problems ordinarily were not serious, except for the difficulty of obtaining repair parts.

Smelter production: The fact that the United States now has the world's largest and most modern zinc-smelting industry is largely an outgrowth of wartime needs. In 1940 the German invasion of Belgium and northern France shut off most of Great Britain's supply of zinc metal. This created a major crisis in the supply of zinc to the Allies, even though the United States industry turned out a record-breaking 740,000 tons of slab in that year. It was soon evident that requirements for zinc metal would be about a million tons per year. Some projects were begun in 1940 and 1941. With the entry of the United States into the war, expansion of the domestic industry was rapid. By the end of 1943, the total capacity of the primary slab-zinc smelting industry slightly exceeded a million tons; actual production for 1943 was 942,000 tons. The majority of the plants built were either electrolytic plants or vertical retorts, capable of producing the high-grade zinc so greatly in demand for essential wartime uses.

Erection of the plants was financed by individual companies and through Government loans from the Defense Plant Corporation, a subsidiary of the Reconstruction Finance Corporation. In addition, the RFC negotiated purchase agreements for the metal produced.

Wartime stockpiling: The plan for the Government to purchase zinc developed into a stockpiling program dating from the spring of 1941, when the Metals Reserve Company was authorized to purchase up to 100,000 short tons of zinc concentrates from Argentina and Australia. The requirements were increased by 150,000 tons in June 1941. In May 1942 the Metals Reserve Company was authorized to purchase up to 600,000 tons of foreign zinc concentrates annually. Total stocks at the end of 1942 totaled 464,000 tons and a year later had reached 617,000 tons.

Early in 1944, further consideration was given to stockpile objectives. An over-all total of 800,000 tons was approved, comprising both Government and industry-owned stocks of slab zinc and recoverable zinc in concentrates. At the end of the year, the total objective had been exceeded, when total stocks reached 810,000 tons. Government stocks approximated the goal of 550,000 tons. From the beginning of 1945 to the end of the war, stocks were gradually reduced.

At the end of the war, with a heavy demand from industry for reconversion needs, Government stocks were made available to consumers unable to obtain normal requirements in the market, except for quantities, transferred to the Department of the Treasury, Bureau of Federal Supply, under the Stockpiling Act of 1946. Thus the wartime stockpiling program of the Government, which was generally effective in meeting wartime needs, carried over in part into a peacetime stockpile.

Wartime controls of consumption and exports: Soon after the onset of the war in Europe, it became evident that the demand for zinc by Great Britain and its Allies would exceed the resources of America. At first, voluntary allocations by industry of available supplies of zinc were tried. Due to the growing pressure of defense orders, these voluntary measures soon proved inadequate.

Control of exports had already been initiated by the Government early in 1941. In June of that year the Office of Production Management placed zinc under full priority control, with the issuance of General Preference Order M-11. This order, with subsequent modifications and additions, controlled the allocation of zinc, including dust and scrap, for essential military and civilian uses; prohibited its use for certain purposes; established inventory control; and provided for detailed reports to be filed by producers and users of zinc. It was administered after January 1942 by the War Production Board, successor to the OPM.

Through these control measures, enough zinc was provided to meet the needs of the most urgent military and civilian requirements during the war years. Controls were continued until the end of the war, although they were relaxed somewhat in September 1944, when supply appeared adequate. Full controls were reinstated in April 1945, mainly because of a shortage of the higher grades of zinc, and were continued until August 20, a few days after the end of the war with Japan.

Effect of Impurities

The principal impurities of zinc are lead, cadmium, and iron. In zinc used for ordinary fabricating purposes, up to 1.25 percent lead is not injurious, but brass made from lead-bearing zinc will crack under severe mechanical treatment, with the result that zinc used for the manufacture of deep drawing brass should contain not more than 0.07 percent lead.

Iron increases the hardness and brittleness of zinc and should be below 0.05 percent in zinc used in the manufacture of brass.

Cadmium, within the established limits of standard specifications, does not materially affect the properties of brass, but in larger quantities it is harmful. In the manufacture of zinc-base die-castings, however, a low cadmium content is required because cadmium reduces the corrosion resistance of these alloys and also promotes warping and distortion.

Grades: Slab zinc is now produced in six standard grades. The highest grade of zinc produced, Special High Grade, is 99.99 percent zinc. Other grades, specifications for which are given in the following table, vary from 98.0 to 99.9 percent.

GRADES OF SLAB ZINC

Name	Maximum percent allowed				
	Lead	Iron	Cadmium	Total Pb, Fe, Cd	Minimum % zinc
Special High Grade	0.006	0.005	0.004	0.010	99.99
High Grade	.070	.020	.070	.100	99.9
Intermediate	.200	.030	.500	.500	99.5
Brass Special	.600	.030	.500	1.000	99.
Selected	.800	.040	.750	1.250	98.75
Prime Western	1.600	.080	/a	/a	98.32

a/ Not specified.

Most of Special High-Grade zinc consumed in the United States is used in the die-casting industry. Lesser quantities are used by other industries, especially brass manufacturers and electro-galvanizers. The principal consumers of Regular High-Grade zinc are brass manufacturers, rolled-zinc fabricators, and electrogalvanizers. The demand for Intermediate, Brass Special, and Selected zinc is small, and most of the consumption is divided among zinc rollers, galvanizers, and brass manufacturers. Hot-dip galvanizers use about 95 percent of the Prime Western zinc consumption.

A list of the brands of zinc and the producers, by grades, is given in table 1.

Major Uses of Unalloyed Slab Zinc

Galvanizing: Zinc coating or galvanizing is applied to a great tonnage of steel products and is the most economical means of corrosion protection available. When exposed to the atmosphere, a coating of relatively insoluble zinc carbonate forms on the surface of zinc metal, which inhibits further corrosion. The usefulness of zinc as a protective coating on steel is further enhanced by the fact that zinc is electro-positive to iron; hence, in the presence of moist air, the two metals form a galvanic cell in which the zinc is sacrificed in favor of the iron. As long as any zinc is present on the iron, the zinc will corrode and the iron will not. This effect extends a considerable distance from the edge of the zinc, so that iron uncovered from scratches or cuts does not rust, even though the zinc does not actually coat the entire surface.

The major applications of zinc coating on steel products include roofing and siding sheets, wire and wire products for outdoor exposure, articles fabricated from sheet steel, such as range boilers, pails, cans and tanks, hardware for outdoor use, pipe and conduit, and exposed structural steel. Nails are galvanized not only to extend the life of the nail but also to prevent rotting of wood or rusting of galvanized sheet or wire mesh.

Rolled zinc in the form of sheet, strip, and plate has many uses. Various grades of slab zinc are rolled for use in the production of dry batteries, fruit-jar caps, weatherstrip, photoengraving plates, and for heavy, corrosion-resistant plates for steam boilers, ship hulls, and marine equipment. Increasing quantities of rolled zinc are being used in building construction for roof valleys and flashing. For some applications, a small quantity of copper or other hardening agent is added to stiffen the metal and increase its strength. For example, zinc-alloy sheets are used for downspouts, gutters, and other roof-drainage fittings, and some flat and corrugated alloy sheet is used for roofing. Rolled zinc in building construction gives long service at reasonable cost, and zinc does not stain house walls or paint trim.

Typical specifications of the composition of slab zinc or zinc alloys suitable for various rolled zinc products are given in table I-2.

2. Zinc-Base Alloys

Zinc-base alloys are those in which zinc is the principal metal. The brasses and bronzes, which require substantial quantities of zinc, are considered to be copper-base alloys and therefore, are not discussed in this section.

One of the more-important metallurgical advances of recent years was the development of a process in 1928 for the production of very high (99.99-percent) purity zinc. This enabled engineers to create zinc-base die-casting alloys of controlled quality. Since then the die-casting industry has grown from practically nothing to current United States consumption levels of about 200,000 tons of slab zinc a year. Die-casting, which depends on the availability of a good structural material which can be melted and used at low temperatures, is so versatile that parts as small as the elements of the "zipper"-type fastener and as large as radiator grilles can be cast with equal ease. Zinc die-cast alloys are used for complex shapes, such as gasoline-engine carburetors, which are cast to such close tolerances that little or no machining need be done after casting.

In addition to the major use of zinc-base alloys for die casting, special compositions are available for slush and permanent mold casting, special compositions are available for slush and permanent mold castings. The composition of several typical zinc-base alloys, with their trade designations and principal uses, is given in table I-3.

Uses

Automotive industry: The automotive industry uses by far the greatest number of die-castings. Some of the most important die-castings for mechanical parts made of zinc alloy include carburetors, bodies for fuel pumps, parts for windshield wipers, speedometer frames, horns, heaters, and parts for hydraulic brakes. Parts that perform both structural and decorative functions include grills for radiators and radios, lamp and instrument bezels, hubs for steering wheels, brackets, horn rings, exterior and interior hardware, instrument panels, and body molding.

Electrical industry: In the electrical industry, because of the range of products manufactured, there is probably a larger diversity of die-castings than in the automotive industry. Die-castings are employed for numerous parts of washing machines, oil burners, stokers, motor housings, vacuum cleaners, electric clocks, kitchen equipment, and utensils.

Business machines and other light machines: Die-castings are used successfully in business machines and light machines of all types, such as typewriters, recording machines, picture projectors, vending machines, accounting machines, cash registers, cameras, slicing machines, garbage disposers, gasoline pumps, hoists and drink mixers.

<u>Tools</u>: Increasing quantities of tools are being made with die-cast parts. Die-castings are not hard enough to serve as cutters, but steel elements of tools are often cast in place as parts of the tools, thus saving assembly costs. Die-castings are not limited to portable tools but are also used on such large equipment as drill presses and lathes.

<u>Building hardware, padlocks, toys, and novelties</u>: These items constitute the other major uses of die-castings. They consume about 10 to 20 percent of the total production of die-castings made of zinc alloy.

3. Compounds

The zinc content of the zinc pigments and salts produced in the United States in 1949, by source, was as follows, in short tons:

Pigment or salt	Zinc in pigments and salts produced from -				Total zinc in pigments and in salts
	Ore		Slab zinc	Secondary material/a	
	Domestic	Foreign			
Zinc oxide	48,715	13,534	10,171	14,676	87,096
Leaded zinc oxide	17,747	1,183			18,930
Lithopone	4,159	723	9	9,118	14,009
Total pigments /b	70,621	15,440	10,180	23,794	120,035
Zinc chloride				12,157	12,157
Zinc sulfate	2,003	78		4,464	6,545
Total	72,624	15,518	10,180	40,415	138,737

a/ Includes zinc recovered from byproduct sludges, residues, etc.
b/ Excludes zinc sulfide.

Of a total zinc content of 138,737 tons, 87,142 tons or 62.8 percent was derived directly from ores, including fumed slags, 10,180 tons or 7.3 percent from slab zinc, and 40,415 tons or 29.1 percent from secondary materials.

Zinc residues play a large role in the manufacture of compounds. It is important to note that the quantity of secondary materials used for this purpose depends on its availability. Residues are not produced for sale; they are a byproduct of other operations. The volume of byproduct residues accumulated is not influenced by the demand for their use, as is the normal production practice, but rather by the demand for the prime materials produced in the same operation in which the residues are generated.

In addition to the foregoing list, a number of other zinc compounds are used commercially, most of these being derived from zinc oxide, and typical uses of the principal zinc compounds are given in table I-3.

Small amounts of certain impurities in zinc pigments have a pronounced influence on color. For example, the best grades of zinc oxide for use as a whole pigment should contain less than 0.01 percent cadmium, and manganese; copper, or iron should not be present in quantities exceeding a few thousandth of 1 percent.

Zinc Oxide

Zinc oxide is produced by the American process and the French process. In the American process, the zinc oxide is produced directly from the ore, the ore being mixed with carbon (coal) and the zinc vaporized by burning the mixture. The oxidized zinc fume gives American process zinc oxide. In the French process, metallic zinc is converted into zinc oxide by vaporizing and burning the zinc in air.

Zinc oxide is marketed in a wide range of grades based upon specific uses and varying principally in chemical purity, and particle size and shape. The American Society for Testing Materials specifications (D-79-44) for zinc oxide are as follows:

	American process	French process
Zinc oxide, minimum percent	98.0	99.0
Sulfur, maximum percent	.2	.1
Moisture and other volatile matter, maximum percent	.5	.5
Total impurities, maximum percent	2.0	1.0
Retained on 325-mesh (44 micron) sieve, maximum percent	1.0	1.0

The major applications of zinc oxide are in the rubber, paint and ceramic industries, which used 83.2 percent of the United States consumption in 1949. 1/ Zinc oxide is also used extensively in coated fabrics and textiles (including manufacture of rayon) and in floor coverings. Other uses include pharmaceutical chemicals, printing ink, dental cements, soap, glue, lubricants, matches, tailors chalk, etc.

1/ See table IV-26 and page IV-151, for statistical data on distribution by industries.

There are a number of producers of zinc oxide which will meet the specification indicated above. While this specification covers the more essential properties, other factors which in special applications of zinc oxide may come up for consideration are specific surface (usually expressed as sq. meters of surface per gram of oxide), apparent density (lbs. per cu. ft.) and particle shape (nodular or acicular). Further details on why zinc oxide is essential in the rubber, paint and ceramic industries are indicated in the following paragraphs.

Zinc oxide is used in natural and synthetic rubber for the following important reasons: (1) As an activator of organic accelerators in the vulcanization of natural and synthetic rubber. In certain types of synthetic rubber zinc oxide functions as the accelerator; (2) Reinforcement of natural and synthetic rubber in applications where heat resistance, heat conductivity and high resilience are primary factors; (3) Reinforcement of white compounds, especially where weathering resistance is involved. Zinc oxide is opaque to ultra-violet light; (4) Reinforcement in insulated wire and cable compounds because of its desirable electrical properties; (5) Latex compounds; (6) Pressure sensitive adhesives (surgical and industrial tapes); (7) Rubber to metal adhesion compounds.

In the manufacture of paint products, zinc oxide is used to contribute properties such as hardening the paint film, thus reducing chalking, also it adds hiding power and helps in preventing the formation of mildew in exterior paints. Other properties of zinc oxide in paint are to reduce yellowing of white films and improve washing properties.

American process zinc oxide is used both in exterior and interior paints whereas the French process oxides are used largely for interior paints where their high purity and excellent color are desirable for architectural enamels as well as industrial enamels of the refrigerator type.

The ceramic industry can use either the American or French process type of zinc oxide with due consideration to minor impurities which are known to discolor vitreous enamel and glazes. Recent years have seen an increase of interest in the more dense types of zinc oxide for ceramics due to these oxides flowing more easily in hoppers and bins. The dense zinc oxides also dust less and occupy less space in the furnace during the melting operations.

Leaded Zinc Oxide

Leaded zinc oxide is a pigment consisting of zinc oxide and basic lead sulfate. According to the Bureau of Mines, zinc oxide containing 5 percent or more of lead is classified as leaded-zinc oxide.

Leaded zinc oxide affords the paint manufacturer an opportunity to add both zinc oxide and a lead compound to his paint at the same time. It is used almost exclusively for formulating exterior house paints.

There are several leaded zinc oxide brands being marketed. They are referred to as 5 percent leaded zinc oxide or 35 percent leaded oxide or 50 percent leaded zinc oxide, where the figures 5, 35 and 50 refer to the approximate percentage of basic lead sulfate which the respective pigments contain. In some cases manufacturers prepare their product by blending zinc oxide and basic lead sulfate while in others they fume the lead and zinc fractions at the same time. Some 35 percent leaded zinc oxide is prepared by blending an acicular type of zinc oxide with basic lead sulfate.

Federal specifications for high-leaded and low-leaded zinc oxide (TT-Z-321a) are as follows:

	5% Leaded		35% Leaded	
	Minimum percentage	Maximum percentage	Minimum percentage	Maximum percentage
Zinc oxide (ZnO)	92	96	61	67
Basic lead sulfate (containing 15 to 28% PbO)	4	6	33	37
Total zinc oxide and basic lead sulfate	98	-	98	-
Matter soluble in water	-	1.0	-	1.0
Moisture and other volatile matter	-	0.5	-	0.5

The coarse particles (total residue retained on a No. 325 standard sieve) may not exceed 1.0 percent.

The color when specified shall equal that of a sample mutually agreed upon by buyer and seller.

Zinc Sulfate

Zinc sulfate is used in the manufacture of glue, rayon, electrogalvanizing solutions, insecticides and fungicides, zinc soaps and salts, fertilizers, pigments and dry colors, and as a preservative in casein products. Zinc sulfate is generally made directly from sphalerite concentrates.

Zinc sulfate is produced commercially in three grades - the monohydrate or powder, the pentahydrate or flake form, and the heptahydrate or crystalline form. These are blended in various proportions for special uses. The pure monohydrate powder contains 90.0 percent zinc sulfate or 36.4 percent zinc. The commercial specifications of the technical grades of crystal and flake are as follows. /2

Zinc Sulfate Crystal-Technical ($ZnSO_4 \cdot 7H_2O$)		Specifications (percent)	Typical average analyses (percent)
Total zinc as Zn	Min.	22.10	22.4
Zinc sulfate ($ZnSO_4 \cdot 7H_2O$)	Min.	97.00	98.5
$ZnSO_4$ equivalent	Min.	54.46	55.3
Total iron as Fe	Max.	.003	.0014
Basicity as zinc oxide (ZnO)	Max.	.04	.02
Color - white Approximate pounds per cubic foot: Loose - 61 Packed - 75			

Screen Size Requirements		Percent
Crystal on #8 U.S.S.	No specifications	0.0
Through #8 on #20 U.S.S.		15.0
Through #20 on #30 U.S.S.		20.0
Through #30 on #40 U.S.S.		35.0
Through #40 U.S.S.		30.0

Zinc Sulfate Flake-Technical ($ZnSO_4 \cdot 5H_2O$)		Specifications (percent)	Typical average analyses (percent)
Total zinc as Zn	Min.	25.50	25.65
Zinc sulfate ($ZnSO_4 \cdot 5H_2O$)	Min.	96.75	97.72
$ZnSO_4$ equivalent	Min.	62.09	62.72
Manganese as Mn	Max.	.012	.002
Total iron as Fe	Max.	.006	.002
Chlorides as Cl	Max.	.25	.17
Basicity as zinc oxide (ZnO)		0.10 to 0.15	.11
Color - white Approximate pounds per cubic foot: Loose - 64 Packed - 69			

2/ Letter to the Bureau of Mines, Sept. 19, 1950, from W. C. Long, comptroller, E. I. duPont de Nemours & Co.

Zinc Dust

Zinc dust is derived as a byproduct in the distilling of zinc from ore and condensing the vapor for spelter. In general, it is returned for redistilling. Domestic production is derived mainly from the redistillation of dross and other secondary material in the form of scrap zinc and alloys. Commercial zinc dust is also known as "zinc gray," and it is virtually 100 percent zinc.

Zinc dust is used as a reducing agent in the synthesis of dye intermediates and other organics and in the manufacture of sodium and zinc hydrosulfite and other chemicals; in sherardizing iron and steel products; as an ingredient in soot removers, in pipe-joint lubricants, in metallic zinc paints, and in fireworks; as a deoxidizer for bronzes; in the precipitation of heavy metals from solutions; in the recovery of gold and silver in cyaniding processes; in purifying fats and oils; in bleaching mechanical paper pulp; and in metallizing paper.

Perhaps the most important of these uses in the United States is in sherardizing - a process of coating other metals with zinc. Sherardizing differs from galvanizing in that the articles to be coated are heated with zinc dust in a closed vessel. Zinc vapor is given off below the melting point of zinc and combines with the surface of the article to be coated. A firmly adherent, very uniform coating results.

Lithopone

Lithopone, also known under various trade names as Ponolith, Albalith, Sunolith, Beckton white, Zincolith, and others, is a white pigment used as a substitute for white lead. The product sold most widely contains slightly less than 30 percent zinc sulfide, but other grades are sold in smaller quantities, containing 50 percent and 60 percent of zinc sulfide, respectively.

Lithopone is made by introducing barium sulfide into a weak solution of zinc sulfate. A double decomposition takes place, forming an intimate, finely divided mixture of zinc sulfide and barium sulfate. The zinc sulfate is made by dissolving a zinc material in sulfuric acid. Skimmings, fume dust, and zinc sludges or other secondary sources of zinc are used, when available, otherwise roasted zinc concentrates must be used. The barium sulfide is obtained by the calcination of barite (barium sulfate) with a carbonaceous reducing agent, usually coke or coal.

The largest consumer of lithopone is the paint industry. It is one of the important ingredients of white and tinted house paints, both for exterior and interior application, and of industrial enamels. Road-marking paints also consume large quantities of lithopone.

Another large consumer is the floor-covering industry, where lithopone is used as an opaque filler in battleship and inlaid linoleums to mask the dark color of other ingredients and to permit more attractive color designs. In the less-expensive felt-base or printed floor coverings, it is the principal white pigment used in the coating that contributes to durability and color design. In addition, lithopone is used for its pigment properties in coated fabrics, such as oilcloth and shade cloth, in printing inks, paper, rubber, leather dressings, etc.

There are five lithopone producers in the United States, operating eight plants. Although the industry is relatively small, it is important because lithopone is one of only three types of opaque white pigment available for the many essential requirements, the other two being white lead and titanium dioxide. Besides the competition between lithopone producers, there is also competition between lithopone and these other white pigments. If the shortage of these pigments is alleviated, the lithopone industry will undoubtedly feel internal competition more strongly.

Zinc Chloride

Zinc chloride is manufactured from sal ammoniac skimmings, zinc ash, and galvanized scrap. Its use is widespread, including numbeous medicinal and industrial applications. It is consumed primarily in manufacturing tinning, galvanizing, and soldering fluxes; as an ingredient in dry batteries; for the preservation and flameproofing of railway ties, telephone poles, and other wood products; and in the manufacture of vulcanized hard fiber, intermediates, dyestuffs, and zinc soaps. Fluxes, primarily in the form of zinc chloride solution, are essential to the production of tinplate.

Five firms in the United States regularly produce zinc chloride. Production has increased 50 percent above prewar requirements; therefore, keen competition on the domestic market is in sight. United States producers may face serious foreign competition. Imports increased from 382 to 2,650 tons in the period 1934-49.

Zinc ammonium chloride is produced from sal ammoniac skimmings and zinc ash. It is used as fluxing salt for hot-dip galvanizing of pipe, tubes, tanks, malleable iron fittings, wire, etc. It is also used as a flux in metal soldering and tinning, in electric batteries, and in the manufacturing of soldering compounds.

Other Zinc Compounds

Zinc borates: Unlike other white products, zinc borate pigments are of low refractive index and do not impart hiding power or brightenin properties to oil, rubber, or plastic compositions. They do, however, provide special catalytic properties in flame-resistant materials based on chlorinated organic products, impart a slower setting rate to portland cements, and furnish desirable fungistatic characteristics in certain cosmetic and pharmaceutical products.

Zinc chromate: The specific chemical and physical requirements of zinc chromate pigments must conform to those of each color manfacture. Zinc chromates are made by reacting zinc oxide with chromate solutions.

Zinc hydrosulfite: Zinc dust provides zinc metal in the most convenient form for the production of the zinc hydrosulfite compound itself or for forming it in special applications, such as bleaching of textiles or wood pulp.

Zinc resinate: The manufacture of zinc resinate varies with the oxide used and with the requirements of the product and process requirements. It has a metallic content of 5.6 percent metallic zinc.

Zinc soaps: Zinc oxide offers an effective base for the preparation of zinc soaps and other zinc organic compounds, as it does not introduce water-soluble compounds that must be washed out.

Zinc stearate: A white zinc compound used for flatting paints. It has the composition $Zn(C_{18}H_{35}O_2)_2$ and is a white agglutinating powder, marketed in 300- and 325-mesh; it is also used in face powders.

Zinc peroxide: A white powder of the composition ZnO_2, used in medicinal and dental powders. It contains 8.5 percent of active oxygen, which is released in contact with body tissue.

4. Substitutes

Suitable substitutes for zinc in its major uses are few, and most of them are in short supply. For galvanizing iron and steel products, the largest single use for zinc, there is no adequate substitute. Ceramic or plastic coatings are now employed in a narrow field, which may gain in future importance. Cadmium may be used for plating, but high costs make its use uneconomical except for a few special purposes. Other metals, such as aluminum, may be substituted for galvanized products in some instances but cost and performance inhibit their use. Sheet aluminum is a strong competitor of galvanized sheet metal when the prices of aluminum and zinc are about the same.

Aluminum and magnesium are replacing substantial quantities of brass, saving at least 75,000 tons of zinc a year. Aluminum is also a substitute for zinc in the die-casting field. Any long-term lessening of the (approximately) 3 cents a pound differential in price would throw a large share of die-casting production to aluminum.

Magnesium has some advantages over zinc in the manufacture of dry-cell battery cans and may eventually release more than 50,000 tons of zinc a year now used in the United States in producing dry batteries. The advantages of magnesium over zinc in the production of photoengraving plates have been amply demonstrated. This development could result in savings approaching 10,000 tons of zinc a year.

Few substitutions for zinc are possible in chemical applications. Aluminum and magnesium could replace zinc to some extent as reducers in chemical reactions. In the paint industry, it would be possible to use lead and titanium pigments on a larger scale, except that prices and relative availability reduce the area of substitution. Zinc oxide as an opacifier in ceramic glazes and enamels could be largely replaced by zirconium compounds.

C. MINERALS AND ORES

Only six zinc minerals have commercial importance. Lead and zinc minerals are closely associated and almost always occur together, but in a few districts the ore bodies are characterized by a very simple mineralization, the minerals of one metal being present to the virtual exclusion of all others.

In addition to lead, the primary ores of zinc are often accompanied by silver, gold, copper, iron, and other metals. Various combinations of these minerals occur in complex deposits, wherein zinc may have paramount, secondary, or only minor commercial importance.

1. Minerals

The principal zinc minerals are as follows:

Zinc minerals	Composition	Zinc, percent	Specific gravity
Sphalerite (zinc blende)	ZnS	67.0	3.9-4.1
Smithsonite	$ZnCO_3$	52.0	4.3-4.5
Hemimorphite (calamine)	$(ZnOH)_2SiO_3$	54.2	4.3-4.5
Zincite	ZnO	80.3	5.4-5.7
Willemite	Zn_2SiO_4	58.5	3.9-4.2
Franklinite	$(Fe, Zn, Mn,)O: (Fe, Mn)_2O_3$	15-20	5-5.2

The most important zinc minerals are sphalerite and its oxidation products, smithsonite and hemimorphite. 3/ Zincite, willemite, and franklinite, exceptional in their occurrence in northern New Jersey, form a separate subordinate group.

Zinc is one of the most soluble of the common metals, hence does not occur in nature as such. Even though the carbonate and silicate are quite stable, the sulfate is so soluble that the oxidized zinc minerals rarely appear at the surface.

2. Ores

Ore is defined as an aggregate of minerals from which one or more mineral products may be extracted profitably. This definition includes not only mineral in its natural place in the earth's crust but also mine dumps, tailings piles, old slags, and other materials that can be reworked at a profit. No distinction is made between metals and nonmetals. The consideration of commercial extraction implies that the unworkable materials of today may become the ores of tomorrow if decreased costs or increased prices enable currently submarginal mineral

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3/ Hemimorphite is preferred as the mineral name, as "calamine" is used in the industry to refer to all oxidized ores of zinc.

aggregations to be treated profitably.

Zinc ores are precipitated from metal-bearing solutions and commonly fill open spaces in zones of brecciation, or in crevices, joints, fissures and bedding planes that have been enlarged by ground waters or regional stresses.

In deposits closely related to igneous rocks, the associated minerals or gangue always contain some quartz; and in deposits formed at great depths in association with igneous rocks, as in the Coeur d'Alene district of Idaho, tourmaline, pyroxenes, and magnetite are commonly found. When the country rock is limestone or dolomite, carbonate minerals are usually abundant, often including some barite. Marcasite and pyrite are also common gangue minerals.

The principal zinc ores in the United States occur in deposits of one of the following types:

1. Cavity fillings and replacements in flat-lying or low-dipping beds of limestone, dolomite, or chert, typified by the deposits of the Tri-State (Missouri-Oklahoma-Kansas) and Eastern Tennessee districts.

2. Steep-dipping tabular deposits in the form of fissure veins or occupying wide fault or shear zones, typified by the deposits of the Coeur d'Alene district in Idaho.

3. Replacement deposits, usually in carbonate rocks and genetically related to igneous activity. The ores of Edwards, N. Y., are well-known examples of this type.

4. Deposits due to igneous metamorphism, usually remote from contacts. The Franklin and Sterling Hill ore bodies in New Jersey are the best-known examples.

The outcrops of zinc deposits differ rather widely in aspect and general character, according to variations in the type of mineralization of the primary ores, the climate, topography, and general geologic conditions. The two most important factors are the relative susceptibility to weathering, the erosion of the ore and of the enclosing country rock, and the nature and visual appearance of the minerals in the ore after they have been altered by oxidation and other weathering processes.

If the ore occurs in soft, easily eroded country rock, in rugged, arid regions the outcrop is apt to be conspicuous. However, in moist, level districts like Missouri, where flat-lying ore bodies are not more resistant than the enclosing rock, outcrops are often inconspicuous and are frequently masked by a thick overburden of soil and unconsolidated material.

The average recovery from all zinc and lead ores mined in the United States in 1949 was as follows:

	Lead, percent /a	Zinc, percent/a	Lead and zinc, percent /a
Western States /b	3.20	4.86	8.06
Tri-State District /c	.69	1.66	2.35
Southeastern Missouri /d	1.82	-	1.82
East of the Mississippi River /e	.32	4.87	5.17
United States, average	1.81	2.63	4.44

a/ Calculated by dividing the crude ore milled by 1949 production.
b/ Includes lead ore, zinc ore, lead-zinc ore, lead-copper ore, and lead-zinc-copper ore.
c/ Excludes old tailings; includes lead ore, zinc ore, and lead-zinc ore.
d/ Includes old tailings remilled and lead-copper ore.
e/ Includes zinc ore, zinc-lead ore, and lead ore.

The Tri-State ores are the lowest-grade zinc-lead ores that are being mined in the United States, and the Southeastern Missouri ores are the lowest grade lead ores. The western ores have a higher content of lead and zinc than those from other regions and also contain on the average nearly $4.00 per ton in recoverable gold, silver, and copper; but, on account of the complexity of the ores and the form of occurrence, operating costs are high. The eastern ores are intermediate in tenor, but production costs are low because these ores occur in relatively large deposits that are easily mined and concentrated, and furthermore are near the major centers of consumption in the United States.

A further discussion of grade and type of ore in relation to industry structure, labor productivity, technologic progress, and related factors is given in chapter VI.

The mineralogy and general geology of ores in the principal districts of the world are given in chapter III, with ore-reserve estimates.

A. ZINC RESOURCES OF THE WORLD

by

E. T. McKnight 1/ and Gwendolyn Luttrell 2/

1. United States

Zinc production in the United States comes from many districts which at present are graduated in annual output so that no sharp break separates major from minor producers. Table 1 lists all the districts or regions that have produced more than 1,000 short tons of recoverable metal during 1 or more of the last 5 years. These districts in 1949 produced 98 percent of the total domestic output. The first 4 districts supplied 42 percent and the first 15, 82 percent. Most of the leading zinc districts yield a variable, though usually subordinate, production of lead which has to be considered in studying the economics of the different districts.

Table 2 estimates the reserves left in the ground and figure 1 shows where these reserves are located. By and large, the reserves are contained in the producing districts in table 1, but there are some notable exceptions, such as Eureka, Nev., and Friedensville, Pa., where large reserves, not worked in recent years, are being developed, but under difficult conditions. In a different category are the zinc reserves of Jerome, Ariz., the Gossan Lead belt of Virginia, and similar deposits in North Carolina. These are large deposits but so low in grade that they cannot be worked as zinc ores under present technologic and economic conditions. If a demand should be created that would make recovery of the associated pyrite or pyrrhotite economically attractive, the zinc should be recoverable as a byproduct. Likewise, the zinc in the lower-grade slag piles at certain lead smelters, particularly abandoned smelters, is classed as not recoverable under present industrial conditions.

Under a free economic system, the tonnage of reserves in a given deposit depends upon the price-cost differential, which determines the cut-off grade as well as the average mining grade. What may be a large reserve of low-grade ore under favorable conditions will become a smaller reserve if the higher-grade material has to be selectively mined under less favorable conditions. Once a deposit is mined under such conditions, the total reserve cannot revert to the original tonnage by achieving a more favorable price-cost differential that initially would have allowed mining of the whole tonnage; instead, much more favorable conditions, usually in the form of a much higher price, have to prevail. Thus, irrespective of changes due to mining, the quantity of recoverable metal in a given district will vary from time to time, depending on economic conditions.

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Table

MINE PRODUCTION OF RECOVERABLE ZINC IN THE UNITED STATES 1940-44 (AVERAGE
BY DISTRICTS THAT PRODUCED 1,000 TONS OR MORE DURING ANY YEAR 1945-49 /a
(In short tons)

District	State	1940-44 Average	1945	1946	1947	1948	1949
Tri-State Region	Kansas, southwestern Missouri, Oklahoma	223,999	139,274	139,038	109,338	84,839	78,628
Coeur d'Alene Region	Idaho	74,889	78,030	67,429	79,251	83,801	74,370
Franklin	New Jersey	90,476	81,392	64,454	76,871	76,332	50,984
Butte	Montana	23,807	8,364	7,108	40,712	52,625	47,982
St. Lawrence County	New York	40,296	24,978	32,515	34,116	34,566	37,973
Bisbee	Arizona	2,889	18,078	22,374	32,546	27,669	35,393
Eastern Tennessee /b	Tennessee	39,507	33,824	24,614	31,212	29,524	29,788
Central	New Mexico	40,692	36,245	32,279	38,155	35,140	26,376
Bingham	Utah	21,500	14,670	7,593	20,446	22,077	22,311
Pioche	Nevada	12,819	16,575	15,764	14,362	18,612	18,651
Upper Mississippi Valley	Northern Illinois, Iowa /c, Wisconsin	11,528	19,318	18,344	17,077	14,061	17,846
Red Cliff	Colorado	16,621	15,805	16,437	17,375	16,355	17,450
Austinville	Virginia	18,206	16,000	16,905	16,788	15,882	13,166
Ten Mile (Kokomo)	Colorado	633	2,142	2,490	4,587	10,338	9,716
Big Bug	Arizona	2,599	4,922	5,234	4,991	5,832	8,798
Park City Region	Utah	13,569	7,435	8,876	10,956	10,320	8,359
Pima (Sierritas, Papago, Twin Buttes)	Arizona	1,312	3,697	3,948	4,727	5,758	7,177
Kentucky-Southern Illinois	Kentucky, Southern Illinois	6,727	4,735	5,044	5,728	7,422	6,541
Metaline	Washington	11,582	7,794	7,685	9,754	5,985	6,496
Leadville	Colorado	3,412	7,419	5,996	4,809	5,726	6,455
Tintic	Utah	1,702	2,928	3,710	3,969	3,680	6,082
Upper San Miguel	Colorado	486	1,458	1,963	2,067	3,486	6,004
Old Hat (Oracle)	Arizona	1,110	4,750	4,235	3,427	3,796	5,195
Verde (Jerome)	Arizona					459	4,350
Coso (Darwin)	California	165	996	854	603	4,497	4,062
Harshaw	Arizona	3,304	1,666	1,128	2,006	2,875	2,947
Chelan Lake /d	Washington	601	2,419	1,730	1,000	3,289	2,724 /d
Eureka (Bagdad)	Arizona	235	425	325	257	2,321	2,304
Magdalena	New Mexico	3,147	3,044	3,474	5,013	4,856	2,263
Rush Valley and Smelter (Tooele County)	Utah	6,614 /e	7,720	6,365	5,642	3,552	2,188
Heddleston	Montana	859	1,878	1,516	1,482	1,437	2,026
Cochise	Arizona	66	1,300	2,877	3,143	2,875	1,760
Warm Springs	Idaho	6,128	2,797	2,161	2,791	1,545	1,635
Smelter (Lewis and Clark County)	Montana	19,638	2,235	4,995	748	3,417	1,463
Tomichi	Colorado	169	430	440	1,684	1,983	1,456
Northport	Washington	628	1,410	1,790	2,788	3,271	1,412
Rico	Colorado	3,318	3,920	3,435	3,433	3,180	1,354
Smelter (Cascade County)	Montana						1,278
Sneffels	Colorado	225	361	/f	/f	815	1,053
Animas	Colorado	731	795	1,590	1,310	748	1,029
Ophir	Utah	234	54	294	987	786	1,004
Aravaipa	Arizona	68	333	152	20	1,098	783
Campo Seco	California	142	2,134	3,301	2,350		363
Breckenridge	Colorado	116	723	1,110	1,279	171	362
Pinos Altos	New Mexico	393	298	81	724	1,056	243
Eureka	Nevada	48	1,204	3,705	897	19	108
Cow Creek	California		178			/f	/g
Flat Creek	California	352	1,714	1,926	1,707		
Hunter Valley	California	669	3,311				
Pioneer (Superior)	Arizona	3,824	2,297				
Yankee Hill	California	370	1,251				

a/ From Minerals Yearbook, 1949; slightly modified
b/ Includes very small quantity produced elsewhere in State
c/ No production in Iowa since 1917
d/ Includes Peshastin Creek and Wenatchee River districts in 1949
e/ 1941-44 average
f/ Bureau of Mines not at liberty to publish
g/ Bureau of Mines not at liberty to publish; not listed in order of output

The reserves shown in table 2 include metal from low-grade or high-cost districts that can be produced only under the most favorable mining conditions In an earlier estimate of reserves, (2)3/ a breakdown was made into three categories showing the reserves that could be worked under normal economic conditions, under somewhat more favorable economic conditions, and under emergency price conditions. Reserves in the last category were believed to be small. At present, available detailed information does not justify a thorough reappraisal of this economic factor. However, the reserves in high-cost deposits of the type that ceased operation on discontinuance of the Premium Price Plan in mid-1947 which provided above-market prices for lead, zinc, and copper are still believed to be comparatively small.

The present estimate of reserves represents a revision of the earlier estimate (see footnote 3) which was made as of January 1, 1944. For that estimate, many data on reserves were available in the files of such World War II agencies as the War Production Board; these had been completed as a part of the wartime concern of Government agencies with mineral matters. This source of current information no longer exists, hence the present revision is not up to date for many districts. In such instances the earlier estimate is modified by recent production to give the new figure. As a large allowance has been made for inferred reserves, such districts are now mining and will continue for some time to mine, ore that was originally in the inferred category. On the other hand, reappraisals have been made for half of the 66 considered districts that are believed to contain the major domestic reserves.

Table 2 shows that about 21,200,000 short tons of zinc - measured, indicated and inferred - is in ore, tailings, or old slag piles workable under economic conditions that have prevailed in recent years; about 77 percent of this zinc (16,300,000 tons) is recoverable. Zinc in pyritic deposits and in the lower-grade slag piles constitutes the material that would become available only under improved technologic or changed industrial conditions. The estimate does not include inferred reserves in areas whose zinc potentialities have not yet been realized, hence it is a minimum that will undoubtedly be augmented to an unknown extent.

For many years before 1947 the Tri-State region dwarfed all other districts in annual zinc output, and in most years since 1917 produced more than twice the output of the next most productive district. In 1947 and later, because of depletion in reserves, Tri-State production has dropped nearly to the level of other leading zinc districts. Depletion of this district, with consequent high-cost production from the remaining low-grade reserves, constitutes one of the chief problems in current zinc supply. A recent extensive study by Bureau of Mines engineers (5) shows

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3/ Numerals in parenthesis refer to items in the selected references section of the bibliography at the end of the chapter.

Table 2 Estimated zinc reserves of the United States as of January 1950
(In short tons of metallic zinc)

	Measured and indicated /a		Inferred /b		Total /b	
	Gross content in ground	Recoverable content /c	Gross content in ground	Recoverable content /c	Gross content in ground	Recoverable content /c
(a) Zinc in deposits that could be worked under technologic conditions similar to those in 1950	8,480,000	6,530,000	12,700,000	9,800,000	21,200,000	16,300,000
(b) Zinc in deposits workable under possible future technologic or industrial conditions	3,440,000		400,000		3,800,000	

a/ This includes individual estimates of measured and indicated ore in some properties where such ore is known, but for which the tonnage figures are unavailable.

b/ Figures rounded.

c/ Milling and smelting losses are considered to be roughly 23 percent.

that if a cut-off grade of 1.5 percent metal is used and a liberal allowance made for inferred ore, there were, as of January 1, 1948, 66,100,000 short tons of minable ore in the Tri-State district containing 2.18 percent zinc and 0.38 percent lead in recoverable concentrates. This amounts to 1,441,000 tons of metallic zinc and 251,000 tons of metallic lead. However, 35 percent of this zinc and 21 percent of the lead are in low-grade ore (average, 1.91 percent zinc, 0.20 percent lead) that is under water in Missouri and Kansas, and most of it has been under water since 1918. To recover this low-grade material will require a large investment in pumping and milling plants.

If the cut-off grade is raised to 2 percent metal, only 61 percent of this Tri-State ore will be minable, but it will contain 74 percent of the zinc and 73 percent of the lead that is contained in the ore at the lower cut-off. Thus, raising the cut-off grade to the higher figure will lose a little more than one-fourth of both the zinc and lead.

Pumping of mine water in that part of the field currently worked, chiefly around Picher, Okla., and Baxter Springs, Kan., is a great financial burden that is, in most instances, shared by a large number of operators. Any adverse economic condition that forces some of the operators to shut down throws a larger pumping burden on the remainder. Thus, if too many operators cease contributing, it is within the realm of possibility that the remaining operators will find mining unprofitable and will have to close. Once the mines are allowed to flood, the remaining reserves will probably be lost. However, the current (1950) rearmament program should create a demand for zinc that should keep the mines open for several years, provided the price is maintained at or near the current level ($17\frac{1}{2}$ cents per pound). It is conceivable that during the present emergency most of the reserve calculated on a 1.5 percent cut-off might be extracted from that part of the field that is at present drained and ready to produce. Ground now flooded, particularly in the Joplin-Webb City area, constitutes a low-grade reserve that could be dewatered and mined if need becomes great enough. It would seem that depletion of ore in the Picher area should release milling capacity that could be moved back to Joplin, reversing the movement of 1914-18.

Another important source of zinc in recent years that has nearly exhausted its ore supply is the Bisbee district, Ariz. Although its output of zinc was negligible before 1940, from 1945 to 1949 this district (essentially the Copper Queen mine of Phelps Dodge Corp.) produced 18,000 to 35,700 tons of recoverable zinc annually. However, the developed lead-zinc ore reserve is expected to be substantially exhausted in the near future, unless recent price increases should prolong the life of these deposits.

Other districts of moderate recent production where output has recently decreased or will decrease in the near future owing to exhaustion of certain deposits are the Ten Mile district, Colo., and the Magdalena district, N. Mex. Output can continue from other deposits in these districts for some time, but will probably be at a lower rate.

Most of the other recently productive districts listed in table 1, including all of the more productive ones except as previously mentioned, are believed to have ample reserves for production at current rates for at least several years. Such reserves are not proved in all districts. In deep deposits that can be explored only through drill or tunnel extensions from mine openings in blocks of ground previously mined out, good engineering practice is to stay only 1 to 5 years ahead in development work. In such deposits, large tonnages of ore can be inferred that should prove productive as soon as they can be developed. If the Friedensville district, Pa., and Eureka district, Nev., can be brought into production soon, they will partly compensate for the exhaustion expected in the Tri-State district.

Annual production of the various districts, with information on development, plant capacity, grade of ore at certain operations, etc., are given in the annual chapters of Bureau of Mines Minerals Yearbooks dealing with gold, silver, copper, lead, and zinc in the various States.

Grade of Reserves

Large but very low-grade zinc reserves from which the zinc can be recovered only as a byproduct of pyrite or pyrrhotite mining are in the Jerome district, Arizona, the Ducktown district, Tennessee, in the Gossan Lead belt of Virginia, and in similar pyrrhotite deposits in North Carolina, Georgia and Alabama. The zinc content averages 1.9 percent at Jerome, 1-1.5 percent at Ducktown, 0.6-2.0 percent in the Gossan Lead belt, and perhaps 1.5-2.0 percent in some of the other southeastern pyrrhotite deposits. Some of the pyrrhotite deposits are currently being worked in Virginia but without recovery of the low-grade zinc.

The Tri-State ores are the lowest-grade of the domestic reserves currently worked for zinc and, with a cut-off grade of 1.5 percent metal, should be classed as marginal. Total production from the whole field in 1946, when price-cost relations were most favorable, averaged 1.63 percent zinc and 0.30 percent lead. Since then, the grade of ore mined has risen, owing to selective mining. Eastern Tennessee is the next-lowest-grade district, the ore for certain large operations in recent years averaging 2.5 percent zinc. Although zinc is the only metal recovered, the tailings from this district are sold as agricultural lime. The cut-off grade for most of the ore reserve estimated in this district has been placed at 2 to 2.5 percent. Reserves in other districts in the East generally run 4 to 5 percent or more of combined zinc and lead. Some of the highest-grade domestic zinc ores, averaging 14 to 21 percent zinc, are mined near Franklin, N. J. In the Southern Illinois-Kentucky district, the zinc is closely associated with fluorspar, whose value is comparable with that of the zinc. The zinc content of these deposits is variable, ranging from 25 percent in one mine to little more than a byproduct of fluorspar mining in others.

In the West, the zinc deposits commonly contain a larger proportion of lead than in the East, although there is much variation in this respect. In the more productive Idaho and Utah districts, the quantity of lead usually equals or exceeds the zinc. Some deposits also carry subordinate copper, and a few are essentially copper-zinc deposits. A combined metal content of about 10 percent is usually necessary for profitable mining, although with appreciable copper content a lower percentage may be allowable. The lowest grade of ore mined in the West is at the Bunker Hill and Sullivan mine, in the Coeur d'Alene region, Idaho, where block caving of large tonnages in old workings yields a mill product averaging only 3 percent combined lead and zinc and 0.5 fine ounce of silver per ton of ore. This operation is experimental and is carried on supplementary to mining of higher grade ores. In the Metaline district, Wash., the total output of one of the largest operators in recent years has averaged between 4 and 5 percent of combined zinc and lead; however, in 1946 the average was less than 4 percent with zinc predominating over lead in a ratio of about $4\frac{1}{2}$:1. These ores contain only 0.04 to 0.10 fine ounce of silver per ton, which is very low for western ores. Most western zinc-lead ores contain substantial amounts of silver and a little gold; with increase in the silver and gold content, the base-metal content can diminish proportionately and the ore still be commercial. The San Juan region of Colorado has typical deposits of this type. The mill head of one of the largest producers of base metal in this region contains 1.40 percent lead, 2.70 percent zinc, 0.70 percent copper, 0.07 fine ounce of gold and 2.70 fine ounces of silver per ton of ore. The large production of zinc from the Chelan Lake district, Washington, comes from ore containing about 0.95 percent copper, 0.70 percent zinc, 0.08 fine ounce of gold and 0.33 fine ounce of silver per ton of ore.

The zinc sulfide associated with pyrite and copper in Shasta County, Calif., contains much iron and is difficult to treat under present smelting practices.

The average recovery from all zinc and lead ores mined in the United States in 1949, calculated by dividing the crude ore milled by metal production, was as follows:

	Lead, percent	Zinc, percent	Lead and zinc, percent
Western States/a	3.20	4.86	8.06
Tri-State district/b	0.69	1.66	2.35
Southeastern Missouri/c	1.82	--	1.82
East of the Mississippi River/d	0.32	4.87	5.17
United States, average	1.81	2.63	4.44

a/ Includes lead ore, zinc ore, lead-zinc ore, lead-copper ore, and lead-zinc-copper ore.
b/ Excludes old tailings; includes lead ore, zinc ore, and lead-zinc ore.
c/ Includes old tailings remilled and lead-copper ore.
d/ Includes zinc ore, zinc-lead ore, and lead ore.

NOTE:

A description of producing districts in the United States is included in Section B of this chapter.